# 2020 CMS Winter Meeting
# Reunion d'hiver de la SMC 2020

**VIRTUAL MEETING | RÉUNION VIRTUELE**

## DECEMBER 3-8 DÉCEMBRE

### PLENARY SPEAKERS
### CONFÉRENCES PLÉNIERES

Nicolas Bergeron (École Normale Supérieure)
Irene Fonseca (CNA)
Yvan Saint Aubin (Université de Montréal)

### MITACS PUBLIC LECTURE
### CONFÉRENCE PUBLIQUE MITACS

Alicia Carriquiry (Iowa State)

### PRIZES | PRIX

**DOCTORAL PRIZE LECTURE | CONFÉRENCE DE PRIX DE DOCTORAT**
Duncan Dauvergne (Princeton University)

**COXETER JAMES PRIZE**
**CONFÉRENCE DE PRIX DE COXETER-JAMES**
Jacopo De Simoi (University of Toronto)

**ADRIEN POULIOT PRIZE**
**CONFÉRENCE DE PRIX ADRIEN-POULIOT**
Veselin Jungic (Simon Fraser University)

**GRAHAM WRIGHT AWARD FOR DISTINGUISHED SERVICE**
**PRIX GRAHAM-WRIGHT POUR SERVICE MÉRITOIRE**
Claude Levesque (Laval)

### SCIENTIFIC DIRECTORS | DIRECTEURS SCIENTIFIQUES

Michael Lipnowski (McGill Univeristy) Brent Pym (McGill University)

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# Schedule / horaire

| CMS Winter Meeting 2020– VIRTUAL MEETING–All Times are Eastern Time | | | | | | |
|---|---|---|---|---|---|---|
| **Thursday \| Jeudi**<br>Dec 3 déc | **Friday \| Vendredi**<br>Dec 4 déc | | **Saturday \| Samedi**<br>Dec 5 déc | **Sunday \| Dimanche**<br>Dec 6 déc | **Monday \| Lundi**<br>Dec 7 déc | | **Tuesday \| Merdi**<br>Dec 8 déc |
| 11:00–14:00<br>CMS Mini-Courses<br>Mini-cours de la SMC | 11:00–11:15<br>Opening and Welcome<br>Ouverture et bienvenue | | 11:00–12:00<br>Yves Saint-Aubin<br>Plenary Lecture<br>Conférence plénière | 11:00–12:00<br>Irene Fonseca<br>Plenary Lecture<br>Conférence plénière | 11:00–12:00<br>Nicolas Bergeron<br>Plenary Lecture<br>Conférence plénière | | 11:00–12:30<br>Scientific Sessions<br>scientifiques |
| | 11:15–12:45<br>COVID-19 Panel Discussion | | 12:00–12:30<br>Break \| Pause<br>Online Lounge | 12:00–12:30<br>Break \| Pause<br>Online Lounge | 12:00–12:30<br>Break \| Pause<br>Online Lounge | | 12:00–12:30<br>EDI Committee<br>Breakout |
| 11:00–12:00<br>CMS Development Group Meeting<br>Réunion du Groupe de développement SMC | 12:45–13:00<br>Break \| Pause<br>Online Lounge | 12:45–13:00<br>EDI Committee<br>Breakout | 12:30–13:30<br>Veselin Jungic<br>Adrien-Pouliot Lecture<br>Conférence de prix Adrien Pouliot | 12:30–13:30<br>Jacopo De Simoi<br>Coxeter-James Lecture<br>Conférence de prix Coxeter-James | 12:30–13:30<br>Duncan Dauvergne<br>Doctoral Prize Lecture<br>Conférence de prix de doctorat | | 12:30–13:00<br>Break \| Pause<br>Online Lounge |
| 12:30–17:30<br>CMS Board of Directors Meeting<br>Réunion du Conseil d'administration SMC | 13:00–15:00<br>Scientific Sessions<br>scientifiques | | 13:30–14:00<br>Break \| Pause<br>Online Lounge | 13:30–14:00<br>Break \| Pause<br>Online Lounge | 13:30–14:00<br>Break \| Pause<br>Online Lounge | 13:30–14:00<br>EDI Committee<br>Breakout | 13:00–15:00<br>Scientific Sessions<br>scientifiques |
| | 15:00–15:30<br>Break \| Pause<br>Online Lounge | | 14:00–17:00<br>Scientific Sessions<br>scientifiques | 14:00–17:00<br>Scientific Sessions<br>scientifiques | 14:00–17:00<br>Scientific Sessions<br>scientifiques | | 14:00–14:30<br>Break \| Pause<br>Online Lounge |
| 14:30–17:30<br>CMS Mini-Courses<br>Mini-cours de la SMC | 15:30–16:30<br>Scientific Sessions<br>scientifiques | | | | 17:00–18:00<br>Equity, Diversity and Inclusiveness Committee Panel / Social Table ronde/ Cocktail du Comité d'équité, de diversité et d'inclusivité | | 14:30–17:30<br>Scientific Sessions<br>scientifiques |
| | 16:30–17:30<br>MITACS Public Lecture<br>Conférence publique | | | | | | |
| | 17:30–18:30<br>Student Social<br>Soirée étudiante | | | | | | |

# Sessions / Sessions

| | |
|---|---|
| **PLENARY** | |
| Plenary | Plenary Lectures / Conférences plénières |
| **PRIZE** | |
| APAward | Adrien Pouliot Award / Prix Adrien-Pouliot |
| CJPrize | Coxeter-James Prize / Prix Coxeter-James |
| DocPriz | Doctoral Prize / Prix de doctorat |
| **PUBLIC** | |
| PubLec | Public Lecture / Conférence publique |
| **REGULAR** | |
| AddComb | Additive Combinatorics and Discrete Geometry / Combinatoire Additive et Géométrie Discrète |
| AlgComb | Algebraic Combinatorixx (Women in Algebraic Combinatorics) / Combinatoire AlgébriXX (Les Femmes en Combinatoire Algébrique) |
| AlgGeom | Algebraic Geometry of Integrable Systems / Géométrie Algébrique des Systèmes Intégrables |
| DisDynS | Applications and Recent Developments in Discontinuous Dynamical Systems / Applications et Avancées Récentes dans la Théorie des Systèmes Dynamiques Manifestant des Discontinuités |
| ArStat | Arithmetic Statistics / Statistique Arithmétique |
| CombDes | Combinatorial Designs / Design combinatoire |
| ArithGr | Computations with Arithmetic Groups / Approche Calculatoire aux Groupes Arithmétiques |
| CAssess | Creative Assessments in the COVID-19 times / L'Évaluation Créative au Temps de la COVID |
| DerCat | Derived Categories and (Non)commutative Algebraic Geometry / Catégories Dérivées et Géométrie Algébrique (Non) Commutative |
| DiscAna | Discrete Analysis / Analyse Discrète |
| EnComb | Enumerative Combinatorics / Combinatoire Énumérative |
| EqArMan | Equidistribution on Arithmetic Manifolds / Équidistributions sur les Variétés Arithémtiques |
| FibratD | Fibrations and Degenerations in Algebraic Geometry / Fibrations et Dégénérations en Géométrie Algébrique |
| SpectTh | Geometric and Computational Spectral Theory / Théorie Spectrale Géométrique et Computationnelle |
| GraphTh | Graph Theory / Théorie des graphes |
| CMESG | Hacking COVID-19: Share your innovative ways to deal with teaching online / Passer à travers la COVID-19 : Partage d'expériences d'enseignement à distance. |
| HistMat | History and Philosophy of Mathematics / Histoire et philosophie des mathématiques |
| HomotTh | Homotopy Theory / Théorie de l'Homotopie |
| LogicAp | Logic and Applications / Logique et Applications |
| MathBio | Mathematical biology / Biomathématiques |
| NLinPDE | Nonlinear PDEs and kinetic problems / ÉDP non linéaires et problèmes cinétiques |
| OpAlg | Operator algebras, (semi)groups, and dynamics / Algèbres d'opérateur, (semi)groupes et dynamiques |
| OpTrans | Optimal Transport and Applications / Transport Optimal et Applications |
| OptimDS | Optimization and Data Science / Optimisation et Science des Données |
| ProbNTh | Probability in Number Theory / Applications des Probabilités en Théorie des Nombres |
| HarmAna | Recent Advances in Harmonic and Complex Analysis / Développements récents en analyses harmonique et complexe |
| SpectrM | Spectral Methods and Singular Integral Equations / Méthodes Spectrales et Équations Intégrales Singulières |
| StudRes | Student Research Talks Session / Session de présentations de recherche des étudiant.e.s |
| SympTop | Symplectic Topology / Topologie Symplectique |
| Mindst | The legacy of Mindstorms / L'héritage de Mindstorms |
| VarAna | Variational Analysis: Theory and Applications / Analyse Variationnelle : Théorie et Applications |
| **MINI-COURSE** | |
| | An Introduction to Programming in Maple |
| | Filtrations on cohomology in mirror symmetry |
| | Student Committee Mini-Course |
| | Symplectic Reduction and Geometric Invariant Theory |
| | The Lovász Local Lemma and its applications in ergodic theory and descriptive set theory |
| **POSTER** | |
| Poster | AARMS-CMS Student Poster Session / Présentations par affiches des étudiants - AARMS-SMC |
| **BUSINESS MEETING** | |
| | Business Meetings / Séances de travail |
| **SOCIAL/OTHER** | |
| | Related Activities / Activités sociales |
| **UNLISTED** | |
| | Non-public activities |

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- » Up to 50% off publications
- » Includes CMS newsletter: *CMS Notes*

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Visit our virtual CMS booth for more information or leave a message in the chat.

## Devenez un nouveau membre aujourd'hui !

Saviez-vous que l'adhésion à la SMC offre plusieurs avantages, notamment des réductions?

- » Les départements de mathématiques peuvent parrainer l'adhésion de leurs étudiants
- » Les frais sont une dépense admissible pour les Subventions à la découverte du CRSNG
- » Réductions sur les frais d'inscription aux Réunions de la SMC
- » Économies substantielles pour les résidents canadiens qui souhaitent également se joindre à d'autres sociétés ayant un accord de réciprocité avec la SMC – AMS, MAA, etc.
- » Jusqu'à 50 % de réduction sur les publications
- » Abonnement inclus à notre bulletin, les *Notes de la SMC*

Saviez-vous que la SMC offrait l'adhésion à deux ans pour un an aux nouveaux membres? Adhérez dès aujourd'hui!

Veuillez visiter le kiosque virtuel de la SMC pour plus d'informations ou laissez un message dans le chat.

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# Welcome to the 2020 CMS Winter Meeting!

### Message from Javad Mashreghi, President, CMS

On behalf of the Canadian Mathematical Society, it is my great pleasure to welcome you to the 2020 CMS Online Winter Meeting. This conference, hosted by McGill University, will cover a wide variety of topics reflecting the scope and diversity of the Canadian mathematical sciences community. Despite the pandemic, the turnout is remarkable and there will be tremendous opportunities for collaborations and renewal of contacts with colleagues from Canada and around the world. The CMS profoundly thanks its members and allies for their constant support and dedication.

# Bienvenue à la Réunion d'hiver 2020 de la SMC!

### Message de Javad Mashreghi, Président, SMC

Au nom de la Société mathématique du Canada, j'ai le grand plaisir de vous accueillir à la Réunion virtuelle d'hiver 2020 de la SMC. Organisé en partenariat avec l'Université McGill, cet évènement contient des discussions sur une grande variété de sujets mathématiques, reflétant la portée et la diversité de la communauté mathématique du Canada. Malgré les restrictions imposées par la pandémie hygiénique, le taux d'inscription est impressionnant. Les participant.e.s y trouveront de nombreuses occasions de collaborer et de renouer le contact avec des collègues du Canada et du monde entier. La SMC tient à remercier ses membres et ses allié.e.s pour leur soutien et leur dévouement continus.

Le programme de la Réunion comprend trois conférences plénières, présentées par Nicolas Bergeron (École normale supérieure), Irene Fonseca (Carnegie Mellon's Center for Nonlinear Analysis) et Yvan Saint Aubin (Université de Montréal), et la première conférence de la série de Conférences sur l'innovation par Mitacs, prononcée par Alicia Carriquiry (Iowa State).

The meeting program features three plenary lectures, by Nicolas Bergeron (École normale supérieure), Irene Fonseca (Carnegie Mellon's Center for Nonlinear Analysis), and Yvan Saint Aubin (Université de Montréal) as well as our new MITACS Innovation Lecture featuring Alicia Carriquiry (Iowa State).

The Winter Meeting's program features over 30 sessions and 4 mini courses with talks relating to all aspects of mathematical sciences, including a number of sessions on mathematics education and a scientific session organized and delivered entirely by graduate and undergraduate students. The meeting will also include events by our new Equity, Diversity and Inclusiveness Committee including a social and breakouts.

The meeting will also provide further opportunities for celebrating excellence in mathematics by honouring the recipients of the Adrien Pouliot award, Veselin Jungic (Simon Fraser University), the Coxeter-James prize, Jacopo De Simoi (University of Toronto), the CMS Doctoral Prize, Duncan Dauvergne (Doctoral Prize) the G. de B. Robinson award, Chao Zhang (Shing-Tung Yau Center of Southeast University), and the Graham Wright Award for Distinguished Service, Claude Levesque (Université Laval). All prizes will be recognized at the opening ceremony on Thursday, December 3, 2020 on the meeting platform.

This year will be the third time we honour the CMS fellows who have made excellent contributions to mathematical research, teaching, or exposition; as well as having distinguished themselves in service to Canada's mathematical community. Please tune into our opening ceremony for recognition of our 2020 fellows.

On behalf of the CMS, I would like to express the gratitude of the CMS to all the sponsors of the Winter Meeting: AARMS, CRM, Fields, PIMS, McGill University.

Michael Lipnowski, and Brent Pym (McGill University), the Scientific Directors, have put a tremendous amount of hard work into bringing you an attractive and varied program and greatly deserve our thanks. Putting on such a meeting requires much dedication and hard work and would not be possible without the efforts of the scientific directors, the session organizers, and the CMS staff.

Finally, to all participants, I would like to wish you a very productive and pleasurable meeting. Welcome to our first online winter meeting!

Javad Mashreghi
President, CMS

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Le programme de la Réunion d'hiver comprend aussi plus de 30 sessions et 4 mini-cours avec des communications portant sur tous les aspects des sciences mathématiques, dont des sessions sur la pédagogie et une session organisées entièrement par et pour les étudiant.e.s du premier, deuxième et troisième cycles. Le Comité d'équité, de la diversité et de l'inclusivité tiendra aussi plusieurs sessions et activités sociales dans le cadre de la Réunion.

La Réunion d'hiver de la SMC est aussi une occasion de célébrer l'excellence en mathématiques en honorant les lauréats des prix de la SMC dont Veselin Jungic (Simon Fraser), lauréat du Prix Adrien-Pouliot; Jacopo De Simoi (University of Toronto), le lauréat du prix Coxeter-James; Duncan Dauvergne (Princeton), lauréat du Prix de Doctorat de la SMC; Chao Zhang (Shing-Tung Yau Center of Southeast University), lauréat du Prix G. de B. Robinson; et Claude Levesque (Université Laval), lauréat du prix Graham Wright pour le service méritoire. Ceux-ci seront reconnus lors de la cérémonie d'ouverture le jeudi 3 décembre 2020 sur la plateforme virtuelle de la Réunion.

Nous rendrons également hommage, pour la troisième année consécutive, aux fellows de la SMC qui se sont distingué.e.s par leurs excellentes contributions à la recherche, à l'enseignement ou à l'exposition des mathématiques ainsi que par leur service à la communauté mathématique du Canada. Je vous invite à vous connecter à la plateforme virtuelle lors de la cérémonie d'ouverture pour la reconnaissance des fellow 2020.

Au nom de la SMC, je voudrais exprimer ma gratitude envers les partenaires de la Réunion d'hiver : l'AARMS, le CRM, l'Institut Fields, le PIMS et l'Université McGill.

Les directeurs scientifiques, Michael Lipnowski et Brent Pym (Université McGill), ont investi beaucoup de travail acharné pour vous offrir un programme intéressant et divers et méritent notre reconnaissance et nos remerciements. Organiser un évènement scientifique d'une telle ampleur exige beaucoup de travail et de dévouement et cela n'aurait pas été possible sans les efforts des directeurs scientifiques, des organisateurs et organisatrices des sessions et des membres du personnel de la SMC.

Enfin, je souhaite une Réunion fort stimulante et agréable à toutes et tous les participant.e.s. Bienvenue à notre première Réunion d'hiver virtuelle !

Cordialement,

Javad Mashreghi

Javad Mashreghi,
Président, SMC

# Welcome Letter from the Scientific Directors

**Mike Lipnowski**
(McGill University)

Dear participants,

It is our great pleasure to welcome you to the 2020 CMS Winter Meeting! We are delighted that so many of you are joining us on this occasion, to celebrate the breadth of mathematics in Canada.

This meeting is rather exceptional, being the first of the biannual CMS meetings to be held remotely. The scientific program reflects the circumstances that have brought us to this point, with several activities explicitly addressing the impact of the COVID-19 pandemic, including a panel discussion organized by the Canadian Mathematics Education Study Group (CMESG) immediately following the opening remarks. At the same time, the CMS Meetings' tradition of scientific diversity and excellence remains, with a varied program of plenary lectures, prize lectures, mini-courses and special sessions—a testament to our community's commitment to keeping science and education moving forward.

**Brent Pym**
(McGill University)

# Mot de bienvenue de les Directeurs scientifique

Cher et chère participant.e.s,

Nous avons le grand plaisir de vous accueillir à la Réunion d'hiver 2020 de la SMC ! Nous sommes ravis que vous soyez nombreux à vous joindre à nous pour célébrer l'étendue des mathématiques au Canada.

Cette réunion est plutôt exceptionnelle en ce qu'elle est la première réunion semi-annuelle de la SMC à se tenir à distance. Le programme scientifique reflète les circonstances qui marquent ce moment, avec plusieurs activités abordant les impacts de la pandémie de COVID-19, notamment une table ronde organisée par le Groupe canadien d'étude en didactique des mathématiques (GCEDM) suivant les mots de bienvenue. On continue la tradition de diversité et excellence scientifique des Réunions de la SMC avec un programme varié des conférences plénières, des discours

While we will miss the opportunity to connect with each other in person, we hope that the scheduled social time (including virtual coffee breaks and a student social Friday night) will help to bring us closer together. To this end, the CMS has chosen the Whova app as a virtual venue for the meeting; in addition to managing the scheduling and delivery of talks, panels, etc., it provides a space for the more informal interactions that form a key component of any scientific meeting. We look forward to bumping into old friends and forging new connections in this virtual arena.

Transforming a meeting of this size to a purely virtual format is a daunting task, and we are grateful to everyone involved for making it possible. We thank the staff and leadership of the CMS—particularly the Meetings Director, Sarah Watson—for the commitment, effort and sacrifice they have made to keep this meeting running in a manner that is safe for both the participants of the Meeting and the broader community. We thank the Department of Mathematics and Statistics at our host institution, McGill University, for financial support. We thank the Scientific Organizing Committee and the organizers of the sessions, mini-courses and panels both for their scientific contributions and for their dedication, patience and flexibility during the transition to a virtual meeting. Finally, we thank you all for your many and varied scientific, pedagogical and social contributions.

We wish you all an excellent meeting!

Sincerely,

Mike Lipnowski and Brent Pym

Your 2020 CMS Winter Meeting Scientific Directors

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d'acceptations de prix, des mini-cours et des sessions spéciales. En effet, le riche programme de la Réunion témoigne de l'engagement de la communauté d'évoluer.

Certes, la rencontre en personne nous manque à tou.te.s, mais nous espérons que les évènements sociaux planifiés (dont les pauses café virtuelles et le cocktail étudiant de vendredi soir) aident à nous rapprocher davantage. À cette fin, la SMC a choisi l'application Whova comme lieu virtuel de la Réunion : en plus de fournir la possibilité de gérer l'horaire de la réunion, cette application offre un espace pour les rencontres informelles qui constituent un élément important des réunions scientifiques. Nous comptons rencontrer des vieux et vieilles ami.e.s et former de nouveaux liens d'amitié dans cet espace virtuel.

Transformer une réunion de cette ampleur en format virtuel est un défi colossal et nous tenons à remercier toutes les personnes impliquées pour rendre cette entreprise possible. Nous remercions le personnel de la SMC — surtout la directrice de réunions, Sarah Watson — pour leur détermination et leurs efforts pour s'assurer que la réunion se déroule d'une manière qui est convenable autant pour les participant.e.s que pour les membres de la communauté. Nous remercions également le Département de mathématiques et de statistiques de notre institution hôte, l'Université McGill, pour leur soutien financier. Gros merci au Comité scientifique et aux organisatrices et organisateurs des sessions, des mini-cours et des tables rondes pour leurs contributions scientifiques, leur dévouement, leur patience et leur flexibilité au cours de la transition en format virtuel. Enfin de compte, nous vous remercions pour vos contributions scientifiques, pédagogiques et sociales.

Bonne réunion!

Cordialement

Mike Lipnowski et Brent Pym Directeurs scientifiques de la Réunion d'hiver 2020 de la SMC

## Doctoral Prize

**Dr. Duncan Dauvergne** (Princeton)

Duncan Dauvergne is an exceptional mathematician whose recently completed PhD thesis comprises several outstanding results unexpected at this stage of one's career. Duncan solved, or significantly contributed to solving, three open problems in probability explaining, among other things, a phenomenon that tantalized researchers in probability, combinatorics and statistical physics. This phenomenon is, in essence, that random systems behave in surprisingly non-random ways.

## Prix de doctorat

**Dr. Duncan Dauvergne** (Princeton)

Duncan Dauvergne est un mathématicien exceptionnel. Sa thèse de doctorat contient des résultats remarquables et impressionnants pour un jeune mathématicien à cette étape de sa carrière. Dauvergne a contribué de façon significative à la résolution de trois problèmes en probabilité qui explique, entre autres, un phénomène qui préoccupent les chercheur.e.s en probabilité, en combinatoire et en physique statistique. Le phénomène est ceci : les systèmes aléatoires montrent des traits curieusement non aléatoires.

In 2007, examples and empirical results for such a phenomenon that appears in random sorting networks led to a number of conjectures. Among them, there was a strong conjecture that Duncan Dauvergne has solved implying thus the validity of all the others. Further work of Dauvergne, joint with Ortmann and Virág, on the scaling limit of last passage percolation toward understanding the geometry of the Robinson-Schensted-Knuth (RSK) bijection was deemed central to the Kardar-Parisi-Zhang (KPZ) universality class and will likely lead to more important results in this area of probability. Equally praised by experts is Duncan's joint work with Thomas Bloom on the global asymptotics of the complex zeros of random polynomials.

Duncan Dauvergne has completed his PhD at University of Toronto under the supervision of Bálint Virág in 2019. He is the author and co-author of several articles published in professional journals such as *The Annals of Probability, Annales de l'Institute Henri Poincaré, and Transactions of the AMS.* Since September 2019, Duncan Dauvergne is instructor and NSERC postdoctoral fellow at Princeton University.

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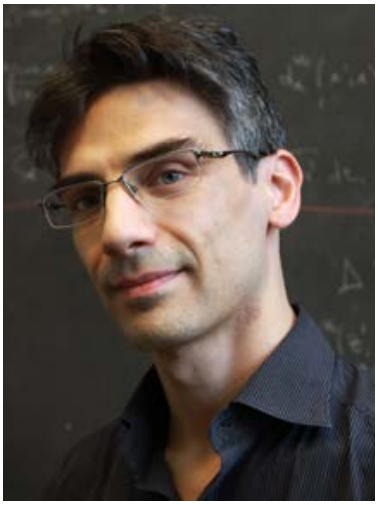
En 2007, des exemples et des résultats empiriques des phénomènes apparaissant en réseaux aléatoires de triage ont mené à de nombreuses conjectures. Parmi elles il y avait la conjecture forte résolue par Duncan Dauvergne qui implique toutes les autres. D'autres travaux de Dauvergne, en collaboration avec Ortmann et Virág, sur la limite hydrodynamique d'un processus de percolation au dernier passage lié à la compréhension de la géométrie de la bijection de Robinson-Schensted-Knuth (RSK) sont considérés comme centraux à la classe d'universalité  Kardar-Parisi-Zhang (KPZ) et mèneront vraisemblement à d'autres résultats importants dans ce domaine des probabilités. Ses recherches collaboratives avec Thomas Bloom sur les zéros complexes asymptotiques de polynômes aléatoires sont également appréciées par les mathématicien.ne.s.

Duncan Dauvergne a obtenu son doctorat à l'Université de Toronto en 2019 sous la direction de Bálint Virág. Il est l'auteur et le collaborateur de plusieurs articles publiés dans les journaux prestigieux tels que *The Annals of Probability, Annales de l'Institute Henri Poincaré, et Transaction of the AMS.* Depuis septembre 2019, Duncan Dauvergne est chargé de cours à Princeton University où il mène ses recherches postdoctorales grâce à la bourse postdoctorale du CRSNG.

## Coxeter-James Prize

**Jacopo De Simoi** (Toronto)

Jacopo De Simoi is awarded the Coxter-James Prize for his work in the area of dynamical systems. He works on some of the most challenging problems in dynamics and has made profound contributions to Hamiltonian systems, Fermi acceleration, hyperbolic billiards, slow-fast systems and nearly integrable systems.



De Simoi works mainly in the field of dynamical systems but he has very wide interests spanning from the study of near integrable systems to strongly chaotic ones. He has worked on some of the most prominent outstanding problems in the field, from the study of the standard map to the statistical properties of partially hyperbolic systems.

## Prix de Coxeter-James

**Jacopo De Simoi** (Toronto)

Jacopo De Simoi a reçu le prix Coxeter-James pour son oeuvre dans le domaine des systèmes dynamiques. Il travaille sur certains des problèmes les plus compliqués en dynamique et a fait de profondes contributions à l'étude des systèmes Hamiltoniens, de l'accélération de Fermi, des billards hyperboliques, des systèmes lent-rapides et des systèmes presque intégrable.

De Simoi travaille principalement dans le domaine des systèmes dynamiques, mais il a des intérêts très variés, allant des systèmes presque intégrables à ceux fortement chaotiques. Il a travaillé sur certaines des questions les plus significatives et exceptionnelle du domaine, de l'étude de l'application standard jusqu'aux propriétés statistiques des systèmes partiellement hyperbolique.

After obtaining Bachelor's and Masters' degrees in Physics from the University of Pisa in Italy, Jacopo De Simoi received his PhD in mathematics from the University of Maryland in 2009. He has held postdoctoral positions in Paris, Toronto and Rome, before moving to the University of Toronto in Mississauga, where he has been assistant professor since 2016.

De Simoi, together with C. Liverani, has published two papers in Inventiones Mathematicae which dramatically impact the theory of chaos in slow-fast dynamical systems. Such systems arise naturally in classical problems of Hamiltonian dynamics and should be thought of as having two characteristic time scales. The rough picture of the dynamics can be captured by a suitable averaging of the behaviour of the orbits. By understanding the combination of slow-fast dynamics as a small random perturbation of the averaged dynamical system, De Simoi and Liverani proved that it exhibits a strong form of chaos for a new class of dynamical systems which forms an open set in a parameter space.

In a paper which appeared in Annals of Mathematics, together with A. Avila and V. Kaloshin, De Simoi has proved a local version of the century old conjecture of Birkhoff, which states that the only integrable billiards are the ones whose shape is elliptical.

In another paper in the Annals, De Simoi and his collaborators proved that the lengths of the periodic orbits of a billiard flow (the length spectrum) locally determine the shape of the billiard. Specifically, smooth axially symmetric planar domains which are close to the circle are spectrally rigid, that is, determined by their length spectrum up to an isometry.

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Après avoir obtenu un baccalauréat et une maîtrise en Physique de l'Université de Pise, en Italie, Jacopo De Simoi a reçu son doctorat en mathématiques à l'Université du Maryland, en 2009. Il a tenu des positions postdoctorales à Paris, Toronto et Rome, avant d'aller à l'Université de Toronto à Mississauga, où il tient un poste de professeur adjoint depuis 2016.

De Simoi, en collaboration avec C. Liverani, a publié 2 articles dans Inventiones Mathematicae qui ont drastiquement influencé la théorie de chaos dans les systèmes dynamiques lent-rapides. Ces systèmes apparaissent naturellement dans des problèmes classiques de dynamiques Hamiltonienne et devraient être perçus comme ayant deux échelles de temps caractéristiques. Une image approximative de la dynamique peut-être atteinte en moyennant les comportements des orbites de façon appropriée. En comprenant la combinaison des dynamiques lent-rapides comme une légère perturbation aléatoire du système dynamique moyenné, De Simoi et Liverani ont montré qu'il présentait une puissante forme de chaos pour une nouvelle classe de système dynamique formant un ensemble ouvert dans un espace de paramètres.

Dans un article qui apparaît dans Annals of Mathematics, De Simoi, avec A. Avila et V. Kaloshin, a prouvé une version locale d'une conjecture centenaire de Birkhoff, qui dicte que les seuls billards intégrables sont ceux dont la forme est elliptique.

Dans un autre article dans Annals, De Simoi et ses collaborateurs ont prouvé que le spectre des longueurs, soit l'ensemble des longueurs des orbites périodiques d'un flot billard, détermine localement la forme du billard. Plus précisément, les domaines planaires, lisses, qui ont une symétrie axiale et qui sont proche du cercle sont rigides d'un point de vue spectral, ce qui veut dire qu'ils sont déterminés à isométrie près par le spectre des longueurs.

## Adrien Pouliot Prize

**Veselin Jungic** (Simon Fraser University)

Dr. Jungic receives the Adrien Pouliot Award in recognition of his outstanding contributions to mathematics education. Throughout his career, Dr. Jungic has pushed forward our understanding of mathematics education and implemented practical solutions for teaching.

## Prix Adrien-Pouliot

**Veselin Jungic** (Simon Fraser University)

M. Jungic reçoit ce prix en reconnaissance de ses contributions exceptionnelles à l'enseignement des mathématiques.

He has documented his work in a series of over 40 math education-related publications in order to share his experiences with others. Veselin Jungic, also known lovingly as Veso in the mathematics community, is a Teaching Professor at the Department of Mathematics, Simon Fraser University. He has been teaching mathematics at the post-secondary level since 1978. Dr. Jungic is a 3M National Teaching Fellow and a recipient of several teaching awards, including the Canadian Mathematical Society Teaching Award and the Pacific Institute for Mathematical Sciences Educational Award. Most of his research is in Ramsey theory and the field of mathematics education and outreach. He has authored and coauthored papers with numerous educational themes, mostly based on his own teaching practices.

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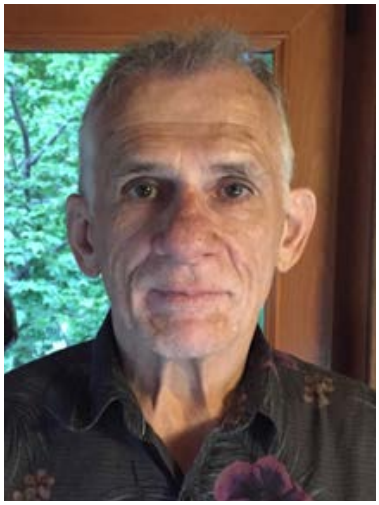
Tout au long de sa carrière, Veselin Jungic a fait avancer notre compréhension de l'enseignement des mathématiques et mis en œuvre des solutions pratiques pour l'enseignement. Il a documenté ses réflexions et ses travaux dans une série de plus de 40 publications liées à l'enseignement des mathématiques afin de partager ses expériences avec les autres.

Veselin Jungic, également connu sous le nom de Veso dans la communauté mathématique, est professeur au Département de mathématiques de Simon . Il enseigne les mathématiques au niveau postsecondaire depuis 1978. M. Jungic est boursier national d'enseignement de 3M et lauréat de plusieurs prix d'enseignement, dont le prix d'excellence en enseignement de la Société mathématique du Canada et le prix d'enseignement du Pacific Institute for Mathematical Sciences. La plupart de ses recherches portent sur la théorie de Ramsey, l'enseignement et de la diffusion des mathématiques. Il a écrit et co-écrit des articles touchant à de nombreux thèmes éducatifs, principalement basés sur ses propres pratiques d'enseignement.

## Graham Wright Award for Distinguished Service

**Claude Levesque** (Laval)

Claude Levesque has made sustained and distinguished contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society (CMS) in numerous ways. He organized three influential CMS conferences at his home university, Laval. As an organizer, he had a strategy of developing conferences with many special sessions. While the diversity of sessions at these meetings served the broader mathematical community, the meetings also broke attendance records.



Claude Levesque was devoted to fostering and developing publications to serve the Canadian mathematical community. He served for many years as Editor and Editor in Chief of *Annales des sciences mathématiques du Québec*, a joint publication with the Institut des sciences mathématiques du Québec (ISM) and the Centre de recherché mathématique

## Prix Graham-Wright pour service méritoire

**Claude Levesque** (Laval)

Claude Levesque s'est distingué par ses contributions importantes à la communauté mathématique canadienne et, plus particulièrement, à la Société mathématique du Canada (SMC). Il a notamment organisé trois réunions de la SMC à l'Université Laval, où il enseigne. En tant qu'organisateur, il s'est donné la mission de développer des sessions qui portent sur une grande diversité de sujets. Cela a augmenté l'engagement de la communauté mathématique et a fait en sorte que ces évènements ont battu des records de participation.

Claude Levesque a aussi consacré une partie de sa carrière mathématique à favoriser et à développer des publications qui servent la communauté mathématique du Canada. Pendant de nombreuses années, il a été rédacteur et rédacteur en chef d'*Annales des sciences mathématiques du Québec,*

(CRM). When conditions changed, and the journal needed a new home, he helped transition this journal to a new Springer journal, Annales mathématiques du Québec (AMQ), where it enjoyed great success, with papers from top mathematicians.

He helped build community at very many levels in Canada, based on sharing his love of mathematics with others. Claude Levesque helped found the *Centre interuniversitaire en calcul mathématique algébrique (CICMA)*, which provides a critical mass in number theory and computational algebra, with researchers at Concordia, Laval and McGill, and established in 1990. The main goals of CICMA is to support of research in these areas, and to promote research interactions between the subjects. With colleagues, Claude Levesque was also foundational in establishing the *Canadian Number Theory Association (CNTA)*. This association contributes to the excellent health of the Canadian mathematical community by organizing meetings across the country. In a similar vein, Claude Levesque, with colleague Chip Snyder, created the annual *Quebec-Maine Number Theory Conference.* Again, this has had an enduring positive impact on the mathematics in Canada.

Claude Levesque's contributions have extended beyond Canada's borders He has been very generous with his time lecturing in developing countries, and he has lectured very widely (in almost 45 countries).

Quote from Mark: "Claude Levesque has served the Canadian mathematical community over an entire career in many different ways: leading publication ventures, organizing meetings and developing new centres and associations. The impact of his work is impressive and wide ranging and we are very pleased to be able to present him with the Graham Wright Award for Distinguished Service."

Claude Leveque finished his undergraduate studies at Université Laval in 1970 where he then continues his studies and received his Master's degree in mathematicsin 1973. In the following years, Dr. Levesque completed his Ph.D. at the Illinois Institute of Technology. He has been teaching at Laval University since 1986, but has served as invited professors in many different universities such as University of Hawa'i, Concordia University and University of Saga.

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un journal publié conjointement avec l'Institut des sciences mathématiques du Québec (ISM) et le Centre de recherche mathématique (CRM). Quand le journal a eu besoin d'un nouvel éditeur il a aidé à sa transition vers un journal Springer *Annales mathématiques du Québec (AMQ)*, qui a connu un plein succès et a publié des articles des grand.e.s mathématicien.ne.s.

M. Levesque a aussi joué un rôle important dans la création d'une communauté au Canada en partageant son amour pour les mathématiques avec ses pairs. En collaboration avec des chercheur.e.s des Universités Concordia, Laval et McGill, il a créé le *Centre interuniversitaire en calcul mathématique algébrique (CICMA)* établi en 1990. Ce centre a atteint une masse critique dans les domaines de théorie des nombres et de calcul formel. Les objectifs principaux du CICMA sont, entre autres, le soutien à la recherche dans les domaines sous-mentionnés et la promotion de l'interaction entre différents sujets. Claude Levesque et ses collègues ont aussi joué un rôle fondamental dans l'établissement de l'*Association pancanadienne en théorie des nombres.* Celle-ci contribue au bien général de la communauté mathématique du Canada au moyen d'organiser des conférences à travers le pays. De surcroît, Claude Levesque et son collègue Chip Snyder ont créé la *Conférence de théorie des nombres Main-Québec.* Cette dernière a eu un impact positif sur les mathématiques au Canada.

Le Président de la Société mathématique Mark Lewis apprécie les contributions de M. Levesque qui, selon lui, « dépassent les frontières du Canada. » M. Lewis affirme : « [M. Levesque] a un éducateur généreux qui a consacré son temps à enseigner dans les pays en développement. Il a enseigné dans près de 45 pays. »

Claude Levesque a terminé ses études de premier cycle à l'Université Laval en 1970, il a ensuite obtenu une maîtrise en mathématiques en 1973 de la même université. Il a continué ses études à l'Illinois Institute of Technology, où il a obtenu son doctorat. M. Levesque enseigne à l'Université Laval depuis 1986, mais il a aussi été professeur invité dans d'autres universités telles que University of Hawa'i, Concordia University et University of Saga.

## G. de B. Robinson Award

**Chao Zhang**
(Shing-Tung Yau Center of Southeast University, China)

Professor Chao Zhang is being recognized for his paper "Ekedahl-Oort Strata for Good Reductions of Shimura Varieties of Hodge Type" (*Canad. J. Math.* 70 (2018), no. 1, 451-480).

The work of Zhang is devoted to the study of Shimura varieties. These varieties have become a valuable tool in modern Number Theory. Their étale cohomology constitutes one of the ways to construct Galois representations. They also provide concrete incarnations of automorphic forms realized as modular forms. Zhang introduces stratifications

## Prix G. de B. Robinson

**Chao Zhang**
(Shing-Tung Yau Center of Southeast University, China)

Le professeur Chao Zhang est primé pour son article intitulé « Ekedahl-Oort Strata for Good Reductions of Shimura Varieties of Hodge Type » (*Canad. J. Math.* 70 (2018), no. 2, 451-480).

Les travaux du professeur Zhang sont consacrés à l'étude des variétés de Shimura. Ces variétés se révèlent être d'une utilité primordiale en théorie des nombres moderne. Leur cohomologie étale constitue une façon de réaliser la construction de représentations galoisiennes. Elles constituent également des exemples tangibles de formes automorphes

of the special fibers of Shimura varieties of Hodge type in odd characteristics into spaces that are easier to understand, e.g., they are quasi-affine and smooth.

His work vastly generalizes previous work of Frans Oort for moduli spaces of principally polarized abelian varieties and of Ben Moonen, Torsten Wedhorn and Eva Viehmann for special classes of Shimura varieties (those of PEL type). Zhang's result has been instrumental in recent important developments in the construction of torsion Galois representations, e.g., in the work of Wushi Goldring and Jean-Stefan Koskivirta, and in the study of the tautological ring of Shimura varieties, such as in the work of Torsten Wedhorn and Paul Ziegler.

Dr. Zhang is currently an *Associate Professor* of *Shing-Tung Yau Center of Southeast University* in Nanjing, China. After finishing his graduate study in China, he received a scholarship from the Erasmus Mundus ALGANT-DOC doctoral program, and became a Ph.D. student in *Leiden University* and the *University of Milan*, with advisors Prof. Bas Edixhoven and Prof. Fabrizio Andreatta. Upon obtaining his Ph.D. in 2013, he started a postdoc in the *Yau Mathematical Sciences Center* (Tsinghua University, Beijing) and the *Institute of Mathematics of Academia Sinica* (Taipei). He joined Southeast University in December 2019.

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se concrétisant comme formes modulaires. Le professeur Zhang introduit des stratifications des fibres spéciales de variétés de Shimura de type de Hodge dont la caractéristique est impaire dans des espaces qui sont plus aisément compréhensibles, p. ex. ils sont quasi-affines et lisses.

Ses travaux généralisent considérablement ceux menés antérieurement par Frans Oort sur l'espace des modules des variétés abéliennes principalement polarisées, de même que ceux menés par Ben Moonen, Torsten Wedhorn et Eva Viehmann sur certaines classes particulières de variétés de Shimura (celles de type PEL). Les résultats obtenus par le professeur Zhang ont joué un rôle déterminant dans des développements récents fort importants en lien avec la construction de représentations galoisiennes de torsion, p. ex. dans les travaux de Wushi Goldring et Jean-Stefan Koskivirta ainsi que dans l'étude des anneaux tautologiques sur les variétés de Shimura menée notamment par Torsten Wedhorn et Paul Ziegler.

M. Zhang est professeur associé au Centre Shing-Tun Yau de l'Université du Sud-Est à Nanjing, en Chine. Après avoir fait ses études de deuxième cycle en Chine, il a reçu une bourse du programme doctoral ALGANT-DOC d'Erasmus Mundus et a commencé ses études doctorales à l'Université de Leiden et à l'Université de Milan, sous la direction des professeurs Bas Edixhoven et Fabrizio Andreatta. Il a obtenu son doctorat en 2013 et a commencé ses recherches postdoctorales au Yau Mathematical Sciences Center (à Tsinghua University, à Beijing) et à l'Institut des mathématiques de l'Academia Sinica (à Taipei). Il s'est joint à l'Université du Sud-Est en decembre 2019.

# Call for Nominations / Appel de candidatures

## 2021 Adrien Pouliot Award

Nominations of individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada are solicited. Such contributions are to be interpreted in the broadest possible sense and might include: community outreach programs, the development of a new program in either an academic or industrial setting, publicizing mathematics so as to make mathematics accessible to the general public, developing mathematics displays, establishing and supporting mathematics Conférences and competitions for students, etc.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation.

Nominations must be received by the CMS Office **no later than April 30, 2021.**

**Please submit your nomination electronically, preferably in PDF format, to** apaward@cms.math.ca.

### Nomination requirements

- Include contact information for both nominee and nominator.
- Describe the nominated individual's or team's sustained contributions to mathematics education. This description should provide some indication of the time period over which these activities have been undertaken and some evidence of the success of these contributions. This information must not exceed four pages.
- Two letters of support from individuals other than the nominator should be included with the nomination.
- Curricula vitae should not be submitted since the information from them relevant to contributions to mathematics education should be included in the nomination form and the other documents mentioned above.
- If nomination was made in the previous year, please indicate this.
- Members of the CMS Education Committee will not be considered for the award during their tenure on the committee.

### Renewals

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. In this case, only updating materials need be provided as the original has been retained.

## Prix Adrien-Pouliot 2021

Nous sollicitons la candidature de personne ou de groupe de personnes ayant contribué d'une façon importante et soutenue à des activités mathématiques éducatives au Canada. Le terme « contributions » s'emploie ici au sens large; les candidat.e.s pourront être associé.e.s à une activité de sensibilisation, un nouveau programme adapté au milieu scolaire ou à l'industrie, des activités promotionnelles de vulgarisation des mathématiques, des initiatives spéciales, des conférences ou des concours à l'intention des étudiant.e.s, etc.

La SMC a pour but de promouvoir et de célébrer la diversité au sens le plus large. Nous encourageons fortement les directeurs et les directrices de département et les comités de mise en candidature à proposer des collègues exceptionnel.le.s sans distinction de race, de genre, d'appartenance ethnique ou d'orientation sexuelle.

Les mises en candidature doivent parvenir au bureau de la SMC **avant le 30 avril 2021**.

Veuillez faire parvenir votre mise en candidature par voie électronique, de préférence en format PDF, à prixap@smc.math.ca.

### Conditions de candidature

- Inclure les coordonnées des candidat.e.s ainsi que des présentateurs et des présentatrices.
- Décrire en quoi le et la candidat.e a contribué de façon soutenue à des activités mathématiques. Donner un aperçu de la période couverte par les activités visées et du succès obtenu. La description ne doit pas dépasser quatre pages.
- Le dossier de candidature comportera deux lettres d'appui signées par des personnes autres que le présentateur ou la présentatrice.
- Il n'est pas nécessaire d'inclure des curriculums vitae, car les renseignements qui s'y trouvent et qui se rapportent aux activités éducatives visées devraient figurer sur le formulaire de mise en candidature et dans les autres documents énumérés ci- dessus.
- Veuillez indiquer si la candidature a été soumise l'année précédente.
- Les membres du Comité d'éducation de la SMC ne pourront être candidat.e.s pour l'obtention d'un prix pendant la durée de leur mandat au Comité.

### Renouveler une mise en candidature

Il est possible de renouveler une mise en candidature présentée l'année précédente, pourvu que l'on en manifeste le désir avant la date limite. Dans ce cas, le présentateur ou la présentatrice n'a qu'à soumettre des documents de mise à jour puisque le dossier original a été conservé.

# Call for Nominations 2021 CMS Blair Spearman Doctoral Prize

The CMS Blair Spearman Doctoral Prize recognizes outstanding performance by a doctoral student. The prize is awarded to one recipient of a Ph.D. from a Canadian university whose overall performance in graduate school is judged to be the most outstanding. Although the dissertation will be the most important criterion (the impact of the results, the creativity of the work, the quality of exposition, etc.) it will not be the only one. Other publications, activities in support of students and other accomplishments will also be considered.

Nominees must have their Ph.D. conferred by a Canadian university in the year (January 1st to December 31st) preceding the nomination deadline. Nominations that were not successful in the first competition will be kept active for a further year (with no possibility of updating the file) and will be considered by the Doctoral Prize Selection Committee in the following year's competition.

The CMS Blair Spearman Doctoral Prize will consist of an award of $2,000, a two-year complimentary membership in the CMS, a framed certificate and a stipend for travel expenses to attend the CMS meeting to receive the award and present a plenary lecture.

## Nominations

Candidates must be nominated by their university and the nominator is responsible for preparing the documentation described below, and submitting the nomination to the email address below.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation. The deadline for the receipt of nominations is **January 31, 2021**.

## The documentation shall consist of:

- A curriculum vitae prepared by the student.
- A resumé of the student's work written by the student and which must not exceed ten pages. The resumé should include a brief description of the thesis and why it is important, as well as of any other contributions made by the student while a doctoral student.
- Three letters of recommendation of which one should be from the thesis advisor and one from an external reviewer. A copy of the external examiner's report may be substituted for the latter. More than three letters of recommendation are not accepted.

All documentation, including letters of recommendation, should be submitted electronically, preferably in PDF format, no later than **January 31, 2021**, to docprize@cms.math.ca.

# Appel de mises en candidature Prix de doctorat Blair-Spearman de la SMC 2021

Le Prix de doctorat Blair-Spearman de la SMC récompense le travail exceptionnel d'un.e doctorant.e en mathématiques. Le prix sera décerné à une personne qui aura reçu son diplôme de troisième cycle d'une université canadienne l'année précédente (entre le 1er janvier et le 31 décembre) et dont les résultats pour l'ensemble des études supérieures seront jugés les meilleurs. La dissertation constituera le principal critère de sélection (impact des résultats, créativité, qualité de l'exposition, etc.), mais ne sera pas le seul aspect évalué. On tiendra également compte des publications de l'étudiant.e, de son engagement dans la vie étudiante et de ses autres réalisations.

Les mises en candidature qui ne seront pas choisies dans leur première compétition seront considérées pour une année additionelle (sans possibilité de mise à jour du dossier), et seront révisées par le comité de sélection du Prix de doctorat l'an prochain.

Le lauréat du Prix de doctorat Blair-Spearman de la SMC aura droit à une bourse de 2 000 $. De plus, la SMC lui offrira l'adhésion gratuite à la Société pendant deux ans et lui remettra un certificat encadré et une subvention pour frais de déplacements lui permettant d'assister à la réunion de la SMC où il recevra son prix et présentera une conférence.

## Candidatures

Les candidat.e.s doivent être nommés par leur université; la personne qui propose un candidat.e doit se charger de regrouper les documents décrits aux paragraphes suivants et de faire parvenir la candidature à l'adresse courriel ci-dessous.

La SMC a pour but de promouvoir et de célébrer la diversité au sens le plus large. Nous encourageons fortement les directeurs ou directrices de département et les comités de mise en candidature à proposer des collègues exceptionnel.le.s sans distinction de race, de genre, d'appartenance ethnique ou d'orientation sexuelle. Les candidatures doivent parvenir à la SMC au plus tard le **31 janvier 2021**.

## Le dossier sera constitué des documents suivants :

- Un curriculum vitae rédigé par l'étudiant.e.
- Un résumé du travail du candidat.e d'au plus dix pages, rédigé par l'étudiant.e, où celui-ci décrira brièvement sa thèse et en expliquera l'importance, et énumérera toutes ses autres réalisations pendant ses études de doctorat.
- Trois lettres de recommandation, dont une du direct.rice.eur de thèse et une d'un.e examinat.rice.eur de l'extérieur (une copie de son rapport serait aussi acceptable). Le comité n'acceptera pas plus de trois lettres de recommandation.

Veuillez faire parvenir tous les documents par voie électronique, de préférence en format PDF, au plus tard le **31 janvier 2021** à prixdoc@smc.math.ca.

## 2021 Graham Wright Award for Distinguished Service

In 1995, the Society established this award to recognize individuals who have made sustained and significant contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society. The award was renamed in 2008, in recognition of Graham Wright's 30 years of service to the Society as the Executive Director and Secretary.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation.

Nominations should include a reasonably detailed rationale and be submitted by **March 31, 2021**.

All documentation should be submitted electronically, preferably in PDF format, by the appropriate deadline, to gwaward@cms.math.ca.

## Prix Graham-Wright pour service méritoire 2021

En 1995, la Société mathématique du Canada a créé un prix pour récompenser les personnes qui contribuent de façon importante et soutenue à la communauté mathématique canadienne et, notamment, à la SMC. Ce prix était renommé à compter de 2008 en hommage de Graham Wright pour ses 30 ans de service comme Directeur administratif et secrétaire de la SMC.

La SMC a pour but de promouvoir et de célébrer la diversité au sens le plus large. Nous encourageons fortement les directeurs ou les directrices de département et les comités de mise en candidature à proposer des collègues exceptionnel.le.s sans distinction de race, de genre, d'appartenance ethnique ou d'orientation sexuelle.

Pour les mises en candidature prière de présenter des dossiers avec une argumentation convaincante et de les faire parvenir, le **31 mars 2021** au plus tard.

Veuillez faire parvenir tous les documents par voie électronique, de préférence en format PDF, avant la date limite à prixgw@smc.math.ca.

## Canadian Journal of Mathematics (CJM) - Editors-in-Chief (EIC)

The CMS invites expressions of interest for the Editor-In-Chief (EIC) of the *Canadian Journal of Mathematics* (CJM); **a team of two Editors-In-Chief** are being solicited, with a five-year term to commence January 1, 2022. It is preferred that both EICs be located at the same university and some partial funding support from the CMS is available for both EIC positions.

Since 1949, the *Canadian Journal of Mathematics* has been committed to publishing original mathematical research of high standard following rigorous academic peer review. New research papers are published continuously online and are collated into print issues six times each year. CJM and CMB (*Canadian Mathematical Bulletin*) are supported by respective Editors-in-Chief and share a common Editorial Board.

Expressions of interest should include a cover letter, your curriculum vitae, and an expression of views regarding the publication. Since being EIC of CJM is a large responsibility that may require a lessening of responsibilities in both individual's normal work, individuals should review their candidacy with their university department and include a letter of support.

Please submit your expression of interest electronically to: CJM-EIC-2020@cms.math.ca **before April 15, 2021.**

If you have any questions, please contact us at the email address above.

## Journal canadien de mathématiques (JCM) - Rédacteurs ou Rédactrices en chef

La SMC invite les personnes intéressées par deux postes de rédacteur ou rédactrice en chef au *Journal canadien de mathématiques* (JCM) à lui faire part de leur intérêt. **Une équipe de deux rédacteurs ou rédactrices en chef** est sollicitée pour un mandat de cinq ans qui commencera le 1 janvier 2022. Il est préférable que les deux rédacteurs ou rédactrices en chef soient situés dans la même université et un soutien partiel financier de la SMC sera disponible pour ces deux postes.

Depuis 1949, le *Journal canadien de mathématiques* s'engage à publier des recherches en mathématiques, originales et de haut niveau, suivant de rigoureux examens par des pairs. Les articles de recherches sont disponibles en tout temps en ligne et sont rassemblés en six éditions imprimées par année. Le JCM et le BCM ont chacun leur rédacteur ou rédactrice en chef et partagent un même conseil de rédaction.

Les propositions de candidature comprendront les éléments suivants : une lettre de présentation, votre curriculum vitae et un texte dans lequel vous exprimez votre opinion et vos idées par rapport à la publication. Puisque devenir rédacteur ou rédactrice en chef de la JCM est une grande responsabilité qui peut nécessiter une réduction dans la charge normale de travail, les deux individu.e.s devraient vérifier leur candidature avec leur département et veuillez ajouter une preuve du soutien.

Veuillez faire parvenir votre candidature par courriel à : CJM-EIC-2020@smc.math.ca **au plus tard le 15 avril 2021.**

Si vous avez des questions, veuillez nous contacter à l'adresse courriel ci-dessus.

# CMS Election Notice / Avis d'élection de la SMC

In 2021, the CMS will be electing eleven (11) officers and directors. Candidates have to agree to the nomination and provide the committee with biographical information.

You are invited to nominate members to be candidates and their nominations will be accepted by the Nominating Committee **prior to March 1, 2021** provided that each person nominated: (i) is supported in writing by at least five (5) other members of the CMS; and (ii) has given written acceptance to stand for office and to supply biographical information.

Nominations with supporting materials should be e-mailed to **nominations-2021@cms.math.ca** or sent to:

Nominating Committee Chair
Canadian Mathematical Society
209–1725 St. Laurent Blvd.
Ottawa, ON
K1G 3V4 Canada

Nominations are being solicited for the following slate of candidates for the Executive Committee *(length of elected term in parentheses)*:

**President-Elect** *(1 year)*/President *(2 years)*/**Past-President** *(1 year)*;

**Vice-President – Atlantic** (N.B., P.E.I., N.S., N.L.) *(4 years)*;

**Vice-President – Pacific** (B.C., Yukon) *(4 years)*.

Nominations are also being solicited for **Board of Directors members** *(length of elected term in parentheses)*:

**Atlantic** – 1 member *(4 years)*;

**Quebec** – 1 member *(4 years)*;

**Ontario** – 2 members *(4 years)*;

**West** – 1 member *(4 years)*;

**Pacific** – 2 members *(4 years)*; and

**Student** – 1 member *(2 years)*.

For 2021, the CMS will hold the election electronically in April and the results formally approved in June at the Annual General Meeting (AGM) in Ottawa, Ontario. Updated information will be periodically e-mailed to members and posted on the CMS website at: **https://cms.math.ca/about-the-cms/governance/elections/**

Alexandre Girouard Chair, CMS Nominating Committee

En 2021, la SMC compte élire onze (11) dirigeant.e.s et administrat.rices.eurs. Les candidat.e.s doivent accepter la nomination et envoyer une notice biographique au Comité.

La SMC vous invite à proposer des candidatures. Le Comité des mises en candidature acceptera les nominations **d'ici le 1er mars 2021,** à condition que la personne nommée : (i) ait reçu l'appui par écrit d'au moins cinq (5) autres membres de la SMC; (ii) ait accepté par écrit sa candidature; et (iii) ait fourni ses renseignements biographiques.

Les nominations et les documents justificatifs doivent être envoyés par courriel à candidatures-2021@smc.math.ca

ou par la poste à :

Président du Comité des mises en candidature Société mathématique du Canada 209 - 1725 boul. Saint-Laurent Ottawa (Ontario) K1G 3V4 Canada

On demande des candidatures aux postes suivants au sein du Comité exécutif *(longueur du mandat entre paranthèses)* :

**Président.e élu.e** *(1 an)*/Président.e *(2 ans)*/ **Président.e sortant** *(1 an)* ;

**Vice-président.e – Atlantique** (N.-B., Î.-P.-É, N.-É., T.-N.-L.) *(4 ans)* ;

**Vice-président.e – Pacifique** (C.-B., Yukon) *(4 ans).*

La SMC est à la recherche des candidatures pour les **postes suivants au sein du Conseil d'administration** *(la durée du mandat entre parenthèses)* :

**Atlantique** – 1 membre *(4 ans)* ;

**Québec** – 1 membre *(4 ans)* ;

**Ontario** – 2 membres *(4 ans)* ;

**Ouest** (Alb., Sask., Man., T.N.-O., Nunavut) – 1 membre *(4 ans)* ;

**Pacifique** – 2 membres *(4 ans)* ; et

**Étudiant.e** – 1 membre *(2 ans)*.

Les membres de la SMC recevront la démarche à suivre pour voter électroniquement par courriel et auront quatre semaines pour se prononcer. Nous enverrons également des mises à jour périodiques aux membres par courriel, dont la liste des candidat.e.s et publierons le tout sur le site Web de la SMC à l'adresse **https://smc.math.ca/apropos-de-la-smc/la-gouvernance/elections/**

Les résultats seront officiellement adoptés à l'assemblée générale annuelle (AGA) de la SMC, en juin, à la Réunion d'été de la SMC qui se tiendra à Ottawa, en Ontario. Tous.tes les membres de la SMC sont invité.e.s à participer à l'AGA.

Alexandre Girouard Président du Comité des mises en candidature

# List of Abbreviations / Liste des abbréviations

| | |
|---|---|
| AddComb | Additive Combinatorics and Discrete Geometry<br>Combinatoire Additive et Géométrie Discrète |
| AlgComb | Algebraic Combinatorixx (Women in Algebraic Combinatorics)<br>Combinatoire AlgébriXX (Les Femmes en Combinatoire Algébrique) |
| AlgGeom | Algebraic Geometry of Integrable Systems<br>Géométrie Algébrique des Systèmes Intégrables |
| APAward | Adrien Pouliot Award<br>Prix Adrien-Pouliot |
| ArithGr | Computations with Arithmetic Groups<br>Approche Calculatoire aux Groupes Arithmétiques |
| ArStat | Arithmetic Statistics<br>Statistique Arithmétique |
| CAssess | Creative Assessments in the COVID-19 times<br>L'Évaluation Créative au Temps de la COVID |
| CJPrize | Coxeter-James Prize<br>Prix Coxeter-James |
| CMESG | Hacking COVID-19: Share your innovative ways to deal with teaching online<br>Passer à travers la COVID-19 : Partage d'expériences d'enseignement à distance. |
| CombDes | Combinatorial Designs<br>Design combinatoire |
| DerCat | Derived Categories and (Non)commutative Algebraic Geometry<br>Catégories Dérivées et Géométrie Algébrique (Non) Commutative |
| DiscAna | Discrete Analysis<br>Analyse Discrète |
| DisDynS | Applications and Recent Developments in Discontinuous Dynamical Systems<br>Applications et Avancées Récentes dans la Théorie des Systèmes Dynamiques Manifestant des Discontinuités |
| DocPriz | Doctoral Prize<br>Prix de doctorat |
| EnComb | Enumerative Combinatorics<br>Combinatoire Énumérative |
| EqArMan | Equidistribution on Arithmetic Manifolds<br>Équidistributions sur les Variétés Arithémtiques |
| FibratD | Fibrations and Degenerations in Algebraic Geometry<br>Fibrations et Dégénérations en Géométrie Algébrique |
| GraphTh | Graph Theory<br>Théorie des graphes |
| HarmAna | Recent Advances in Harmonic and Complex Analysis<br>Développements récents en analyses harmonique et complexe |
| HistMat | History and Philosophy of Mathematics<br>Histoire et philosophie des mathématiques |
| HomotTh | Homotopy Theory<br>Théorie de l'Homotopie |
| LogicAp | Logic and Applications<br>Logique et Applications |
| MathBio | Mathematical biology<br>Biomathématiques |
| Mindst | The legacy of Mindstorms<br>L'héritage de Mindstorms |
| NLinPDE | Nonlinear PDEs and kinetic problems<br>ÉDP non linéaires et problèmes cinétiques |

# List of Abbreviations / Liste des abbréviations

| | |
|---|---|
| OpAlg | Operator algebras, (semi)groups, and dynamics<br>Algèbres d'opérateur, (semi)groupes et dynamiques |
| OptimDS | Optimization and Data Science<br>Optimisation et Science des Données |
| OpTrans | Optimal Transport and Applications<br>Transport Optimal et Applications |
| Plenary | Plenary Lectures<br>Conférences plénières |
| Poster | AARMS-CMS Student Poster Session<br>Présentations par affiches des étudiants - AARMS-SMC |
| ProbNTh | Probability in Number Theory<br>Applications des Probabilités en Théorie des Nombres |
| PubLec | Public Lecture<br>Conférence publique |
| SpectrM | Spectral Methods and Singular Integral Equations<br>Méthodes Spectrales et Équations Intégrales Singulières |
| SpectTh | Geometric and Computational Spectral Theory<br>Théorie Spectrale Géométrique et Computationnelle |
| SympTop | Symplectic Topology<br>Topologie Symplectique |
| VarAna | Variational Analysis: Theory and Applications<br>Analyse Variationnelle : Théorie et Applications |

# Schedule for Business Meetings / Horaire pour Séances de travail

| Tuesday December 1 | mardi 1er décembre |
|---|---|
| 13:00 - 17:00 | CMS Executive Committee / Comité exécutif SMC |

| Thursday December 3 | jeudi 3 décembre |
|---|---|
| 11:00 - 12:00 | CMS Development Group Meeting / Réunion du Groupe de développement SMC |
| 12:30 - 17:30 | CMS Board of Directors Meeting / Réunion du Conseil d'administration SMC |

| Tuesday December 8 | mardi 8 décembre |
|---|---|
| 11:00 - 13:00 | Mathematical Competitions Committee / Comité des concours mathématiques |

# Schedule for Related Activities / Horaire pour Activités sociales

| Friday December 4 | vendredi 4 décembre |
|---|---|
| 11:00 - 11:15 | Opening and Welcome / Ouverture et bienvenue |
| 11:15 - 12:45 | CMS \|CMESG Panel |
| 12:45 - 13:00 | Break / Pause |
| 12:45 - 13:00 | Equity, Diversity and Inclusiveness Committee Breakout - COVID19 Panel Discussion |
| 15:00 - 15:30 | Break / Pause |
| 17:30 - 18:30 | Student Social / Soirée étudiante |

| Saturday December 5 | samedi 5 décembre |
|---|---|
| 12:00 - 12:30 | Break / Pause |
| 13:30 - 14:00 | Break / Pause |

| Sunday December 6 | dimanche 6 décembre |
|---|---|
| 12:00 - 12:30 | Break / Pause |
| 13:30 - 14:00 | Break / Pause |

| Monday December 7 | lundi 7 décembre |
|---|---|
| 12:00 - 12:30 | Break / Pause |
| 12:00 - 12:30 | Equity, Diversity and Inclusiveness Committee Breakout - Challenges Faced by Mathematicians from Underrepresented Groups |
| 12:00 - 12:30 | Equity, Diversity and Inclusiveness Committee Breakout - Challenges Faced by Parents of Young Children |
| 13:30 - 14:00 | Break / Pause |
| 13:30 - 14:00 | Equity, Diversity and Inclusiveness Committee Breakout - Supporting Early Career Researchers |
| 13:30 - 14:00 | Equity, Diversity and Inclusiveness Committee Breakout - Supporting LGBTQ+ Mathematicians |
| 17:00 - 18:00 | Equity, Diversity and Inclusiveness Committee Panel / Social |

| Tuesday December 8 | mardi 8 décembre |
|---|---|
| 12:30 - 13:00 | Break / Pause |
| 14:00 - 14:30 | Break / Pause |

| Thursday December 3 | jeudi 3 décembre |
|---|---|
| 9:30 - 10:00 | Marc Masdeu (Universitat Autònoma de Barcelona), *Quaternionic rigid meromorphic cocycles*, ArithGr (p. 96) |
| 10:00 - 10:30 | Graham Ellis (National University of Ireland, Galway), *An algorithm for computing Hecke operators*, ArithGr (p. 95) |
| 10:45 - 11:15 | Angelica Babei (Centre de recherches mathématiques), *Zeros of period polynomials for Hilbert modular forms*, ArithGr (p. 94) |
| 11:15 - 11:45 | Ben Breen (Clemson University), *A trace formula for Hilbert modular forms*, ArithGr (p. 95) |
| 12:00 - 12:30 | Avner Ash (Boston College), *Cohomology of congruence subgroups of $SL_3(Z)$ and real quadratic fields*, ArithGr (p. 94) |

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|---|---|
| 11:00 - 11:15 | Opening and Welcome / Ouverture et bienvenue |
| 11:15 - 12:45 | CMS \|CMESG Panel |
| 12:45 - 13:00 | Break / Pause |
| 12:45 - 13:00 | Equity, Diversity and Inclusiveness Committee Breakout - COVID19 Panel Discussion |
| 13:00 - 13:20 | Fernando Peruani (CY Cergy Paris Université), *A mathematical approach to bacterial infections: models for bacterial exploration and infection*, MathBio (p. 155) |
| 13:00 - 13:30 | Kristine Bauer (University of Calgary), *Operads of functors with derivatives*, HomotTh (p. 137) |
| 13:00 - 13:30 | Sam Chow (Warwick), *Bohr sets in diophantine approximation*, DiscAna (p. 101) |
| 13:00 - 13:30 | Craig Fraser (IHSPT-Toronto), *Henri Poincaré's Development of Hamilton-Jacobi Theory*, HistMat (p. 133) |
| 13:00 - 13:30 | Stefan Glock (ETH Zurich), *Approximate Steiner triple systems of large girth*, CombDes (p. 90) |
| 13:00 - 13:30 | Jan Hubicka (Charles University), *Big Ramsey degrees of the homogeneous universal partial order*, LogicAp (p. 144) |
| 13:00 - 13:30 | Dimitris Koukoulopoulos (Montréal), *How concentrated can the divisors of a typical integer be ?*, ProbNTh (p. 181) |
| 13:00 - 13:30 | Lucas Mol (University of Winnipeg), *The Threshold Dimension of a Graph*, GraphTh (p. 130) |
| 13:00 - 13:30 | Alexei Oblomkov (UMass Amherst), *3D sigma models with defects and knot homology*, AlgGeom (p. 76) |
| 13:00 - 13:30 | Romain Petrides (Université Paris Diderot), *Free boundary minimal surfaces of any topological type in euclidean balls via shape optimization (Part 1)*, SpectTh (p. 125) |
| 13:00 - 13:30 | Neha Prabhu (Chennai Mathematical Instittue), *A joint distribution theorem with applications to extremal primes for elliptic curves*, ArStat (p. 85) |
| 13:00 - 13:40 | Zhang Jun (Montreal), *Quantitative Lagrangian embeddings*, SympTop (p. 196) |
| 13:00 - 14:00 | Jordon Kostiuk (Brown University), *Geometric Variations of Local Systems*, FibratD (p. 116) |
| 13:20 - 13:40 | Grant Lythe (University of Leeds), *How many TCR clonotypes does a body maintain ?*, MathBio (p. 153) |
| 13:30 - 14:00 | Ricardo Alonso (Texas A&M University at Qatar, Qatar), *Brief Intro to Dissipative Particle Systems and the role of self-similarity*, NLinPDE (p. 159) |
| 13:30 - 14:00 | Emma Bailey (CUNY), *Random matrices and $L$-functions: moments of moments, branching, and log-correlation*, ProbNTh (p. 179) |
| 13:30 - 14:00 | Curtis Bright (Waterloo), *A Resolution of Lam's Problem via Satisfiability Solvers*, CombDes (p. 88) |
| 13:30 - 14:00 | Ben Cameron (Guelph), *The mean subtree order of a graph under edge addition*, GraphTh (p. 128) |
| 13:30 - 14:00 | Anup Dixit (Chennai Mathematical Institute), *On the classification problem for general Dirichlet series*, ArStat (p. 84) |
| 13:30 - 14:00 | Colin Jahel (Lyon), *Actions of automorphism groups of Fraïssé limits on the space of linear orderings.*, LogicAp (p. 144) |
| 13:30 - 14:00 | Henrik Mathiesen (Chicago), *Free boundary minimal surfaces of any topological type in Euclidean balls via shape optimization (Part 2)*, SpectTh (p. 124) |
| 13:30 - 14:00 | Ruxandra Moraru (University of Waterloo), *Moduli spaces of stable bundles on complex nilmanifolds*, AlgGeom (p. 76) |
| 13:30 - 14:00 | Apurva Nakade (University of Western Ontario), *Discrete Chern-Simons via 2-group bundles on elliptic curves*, HomotTh (p. 139) |
| 13:30 - 14:00 | Yelda Nasifoglu (Oxford), *The changing nature of mathematical diagrams in the seventeenth century*, HistMat (p. 134) |
| 13:36 - 14:06 | Marina Iliopoulou (Kent), *A discrete Kakeya-type inequality*, DiscAna (p. 102) |
| 13:40 - 14:00 | Bard Ermentrout (University of Pittsburgh), *A model for the the inflammatory response to SARS-CoV-2 in the upper- and lower-respiratory tracts.*, MathBio (p. 151) |
| 14:00 - 14:20 | Sam Jamaleddine (McGill University), *Investigating the effects of T cell avidity distributions on acute vs. chronic viral infection dynamics*, MathBio (p. 153) |
| 14:00 - 14:30 | Iain Beaton (Dalhousie University), *The Average Order of Dominating Sets of a Graph*, GraphTh (p. 128) |
| 14:00 - 14:30 | Gong Chen (Fields Institute and University of Toronto, Canada), NLinPDE (p. 160) |
| 14:00 - 14:30 | Iren Darijani (Memorial), *Colourings of star systems*, CombDes (p. 89) |
| 14:00 - 14:30 | Lucile Devin (Chalmers University of Technology and University of Gothenburg), *Chebyshev's bias and sums of two squares*, ArStat (p. 83) |

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| 14:00 - 14:30 | Jack Ding (University of Toronto), *Equivariant multiplicities of Schubert Varieties in the Based Loop Group*, AlgGeom (p. 75) |
| 14:00 - 14:30 | Suresh Eswarathasan (Dalhousie), *Counting tangencies of nodal domains*, ProbNTh (p. 181) |
| 14:00 - 14:30 | Juan Fernández González and Dirk Schlimm (McGill), *From a doodle to a theorem: a case study in mathematical discovery*, HistMat (p. 133) |
| 14:00 - 14:30 | Dakota Ihli (UIUC), *What generic automorphisms of the random poset look like*, LogicAp (p. 144) |
| 14:00 - 14:30 | Sacha Ikonicoff (University of Calgary), *Unstable algebras over an operad*, HomotTh (p. 138) |
| 14:00 - 14:30 | Rosa Orellana (Dartmouth College), AlgComb (p. 72) |
| 14:00 - 14:30 | Jeffrey Ovall (Portland State U.), *Exploring Eigenvector Localization Using Filtered Subspace Iteration (FEAST)*, SpectTh (p. 124) |
| 14:00 - 15:00 | Elana Kalashnikov (Harvard University), FibratD (p. 116) |
| 14:10 - 14:50 | Marcelo Atallah (Montreal), *Hamiltonian no-torsion*, SympTop (p. 195) |
| 14:12 - 14:42 | Aled Walker (CRM Montreal), *Effective results on the structure of sumsets*, DiscAna (p. 104) |
| 14:20 - 14:40 | Jürgen Reingruber (Institut de Biologie École Normale Supérieure), *Monitoring and predicting the Covid-19 epidemic and its implications for hospitals*, MathBio (p. 156) |
| 14:30 - 15:00 | Katharine Adamyk (University of Western Ontario), *Lifting A(1)-Modules*, HomotTh (p. 136) |
| 14:30 - 15:00 | Zheng Chen (University of Massachusetts Dartmouth, US), *Multiscale Convergence Properties for Spectral Approximation of a Model Kinetic Equation*, NLinPDE (p. 160) |
| 14:30 - 15:00 | Graham Cox (Memorial), *Defining the spectral position of a Neumann domain*, SpectTh (p. 120) |
| 14:30 - 15:00 | Alexandra Florea (Columbia University), *Non-vanishing for cubic $L$-functions*, ArStat (p. 84) |
| 14:30 - 15:00 | Jeannette Janssen (Dalhousie University), *Simultaneous embeddings of nested interval graphs*, GraphTh (p. 129) |
| 14:30 - 15:00 | Sacha Mangerel (CRM), *Arrangements of Consecutive Values of Real Multiplicative Functions*, ProbNTh (p. 182) |
| 14:30 - 15:00 | Davesh Maulik (MIT), *Cohomology of the moduli of Higgs bundles and the Hausel-Thaddeus conjecture*, AlgGeom (p. 76) |
| 14:30 - 15:00 | Margaret E. Schotte (York), *'Demonstrate all this with diagrams': Recovering mathematical practice from early modern navigation exams*, HistMat (p. 134) |
| 14:30 - 15:00 | Sophie Spirkl (University of Waterloo), *A complete multipartite basis for the chromatic symmetric function*, AlgComb (p. 73) |
| 14:30 - 15:00 | Andy Zucker (UCSD), *Big Ramsey degrees via coding trees*, LogicAp (p. 148) |
| 14:40 - 15:00 | Becca Asquith (Imperial College London), MathBio (p. 150) |
| 14:48 - 15:18 | Sarah Peluse (IAS), *Modular zeros in the character table of the symmetric group*, DiscAna (p. 103) |
| 15:00 - 15:30 | Break / Pause |
| 15:24 - 15:54 | Fernando Shao (University of Kentucky), *Gowers uniformity of primes in arithmetic progressions*, DiscAna (p. 104) |
| 15:30 - 16:00 | Matt Bowen (McGill), *Monochromatic products and sums in $\mathbb{N}$*, LogicAp (p. 142) |
| 15:30 - 16:00 | Francesco Cellarosi (Queens), *Rational Horocycle lifts and the tails of Quadratic Weyl sums*, ProbNTh (p. 180) |
| 15:30 - 16:00 | Samantha Dahlberg (Arizona State University), *Diameters of Graphs of Reduced Words of Permutations*, AlgComb (p. 71) |
| 15:30 - 16:00 | Daniel Horsley (Monash), *An Evans-style result for block designs*, CombDes (p. 90) |
| 15:30 - 16:00 | Margaret-Ellen Messinger (Mount Allison), *Reconfiguration for Dominating Sets*, GraphTh (p. 129) |
| 15:30 - 16:00 | Boris Mordukhovich (Wayne State), *A Generalized Newton Method for Subgradient Systems*, VarAna (p. 204) |
| 15:30 - 16:00 | Iosif Polterovich (Montréal), *The Dirichlet-to-Neumann map, the boundary Laplacian and an unpublished paper of Hörmander*, SpectTh (p. 125) |
| 15:30 - 16:00 | Dayton Preissl (University of Victoria, Canada), *The Hot, Magnetized Relativistic Maxwell Vlasov System*, NLinPDE (p. 161) |
| 15:30 - 16:00 | Junliang Shen (MIT), *Cohomological $\chi$-independence for moduli of 1-dimensional sheaves and moduli of Higgs bundles*, AlgGeom (p. 77) |

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| 15:30 - 16:00 | Quanli Shen (University of Lethbridge), *The fourth moment of quadratic Dirichlet $L$-functions*, ArStat (p. 86) |
| 15:30 - 16:00 | David Waszek (McGill), *From notational change to substantial discovery: Leibniz, Bernoulli, and the exponential notation for differentials*, HistMat (p. 135) |
| 15:30 - 16:30 | Daniel Lopez (IMPA), *Homology supported in Lagrangian submanifolds in mirror quintic threefolds*, FibratD (p. 117) |
| 16:00 - 16:30 | Robert Bailey (Grenfell Campus, MUN), *On the 486-vertex distance-regular graphs of Koolen–Riebeek and Soicher*, GraphTh (p. 127) |
| 16:00 - 16:30 | William Dou (University of Hawaii-Manoa), *What Does "Aligning" Mean ? Practices of Justification across Chinese Logic and Mathematics*, HistMat (p. 133) |
| 16:00 - 16:30 | Tao Feng (BJTU), *Novák's conjecture on cyclic Steiner triple systems and its generalization*, CombDes (p. 90) |
| 16:00 - 16:30 | Iva Halacheva (Northeastern University), *Lagrangian correspondences in Schubert calculus*, AlgGeom (p. 75) |
| 16:00 - 16:30 | Alia Hamieh (University of Northern British Columbia), *Mean squares of long Dirichlet polynomials with the divisor function $\tau_2(n)$*, ArStat (p. 84) |
| 16:00 - 16:30 | Megumi Harada (McMaster University), AlgComb (p. 71) |
| 16:00 - 16:30 | Jamal Kawach (Toronto), *Fraïssé and Ramsey properties of Fréchet spaces*, LogicAp (p. 145) |
| 16:00 - 16:30 | Walaa Moursi (Waterloo), VarAna (p. 204) |
| 16:00 - 16:30 | Aled Walker (CRM & Cambridge), *Triple correlations of dilates squares modulo 1*, ProbNTh (p. 183) |
| 16:30 - 17:30 | Alicia Carriquiry (Iowa State University), *Statistics, Mathematics, and the Fair Evaluation of Evidence*, PubLec (p. 63) |
| 16:30 - 17:30 | Tokio Sasaki (University of Miami), *Limits of geometric higher normal functions and Apéry constants*, FibratD (p. 117) |
| 17:00 - 18:00 | Women in Algebraic Combinatorics Social, AlgComb |
| 17:30 - 18:30 | Student Social / Soirée étudiante |
| 19:00 - 19:30 | Hiroaki Kikuchi (Tsuda University, Japan), *Existence of a ground state and blowup problem for a class of nonlinear Schrödinger equations*, NLinPDE (p. 161) |
| 19:30 - 20:00 | Takafumi Akahori (Shizuoka University, Japan), *Uniqueness of ground states for combined power-type nonlinear scalar field equations*, NLinPDE (p. 159) |
| 20:00 - 20:30 | Kai Koike (Kyoto University, Japan), *Refined pointwise estimates for the solutions to a system of a 1D viscous compressible fluid and a moving point mass*, NLinPDE (p. 161) |
| 20:30 - 21:00 | Tong Yang (City University of Hong Kong, Hong Kong), *Some recent progress on the Boltzmann equation without angular cutoff*, NLinPDE (p. 162) |
| 21:00 - 21:30 | I-Kun Chen (National Taiwan University, Taiwan), NLinPDE (p. 160) |

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| 9:00 - 9:30 | Karen Strung (Czech Academy of Sciences), *Constructions in minimal amenable dynamics and applications to classification of C*-algerbas.*, OpAlg (p. 166) |
| 9:30 - 10:00 | Kristin Courtney (University of Münster), *C*-structure on images of completely positive order zero maps*, OpAlg (p. 164) |
| 10:00 - 10:30 | Jamie Gabe (University of Southern Denmark), *Classification of embeddings*, OpAlg (p. 165) |
| 10:00 - 10:30 | Eloise Hamilton (IMJ-PRG, University of Paris), *Moduli spaces for unstable Higgs bundles of rank 2 and their geometry*, AlgGeom (p. 75) |
| 10:30 - 11:00 | Peter Crooks (Northeastern University), *Hessenberg varieties and Poisson slices*, AlgGeom (p. 74) |
| 10:30 - 11:00 | Aaron Tikuisis (University of Ottawa), *Classification of embeddings II*, OpAlg (p. 167) |
| 11:00 - 12:00 | Yvan Saint Aubin (Université de Montréal), *Teaching modeling in first year - Un cours de modélisation en première année*, Plenary (p. 64) |
| 12:00 - 12:30 | Break / Pause |
| 12:30 - 13:30 | Veselin Jungic (Simon Fraser University), *Teaching and Preaching Mathematics: Reflections on the Past and Thoughts on the Future*, APAward (p. 66) |
| 13:30 - 14:00 | Break / Pause |
| 13:30 - 14:00 | Oleksiy Klurman (Bristol), *Zeros of Fekete polynomials*, DiscAna (p. 102) |
| 14:00 - 14:20 | Simon Girel (Université Côte d'Azur), *Mathematical modeling of the CD8 T-cells immune response*, MathBio (p. 152) |
| 14:00 - 14:30 | Montaz Ali (University of the Witwatersrand), *Convex Formulation for Planted Quasi-Clique Recovery*, OptimDS (p. 173) |
| 14:00 - 14:30 | Mariya Boyko (Independent scholar), *Socialist competition and its role in Soviet mathematics education*, HistMat (p. 132) |
| 14:00 - 14:30 | Matthew Colbrook (Cambridge University), *A Mathieu function boundary spectral method for acoustic scattering*, SpectrM (p. 191) |
| 14:00 - 14:30 | Patrick Combettes (NCSU), *Proximal Analysis of Deep Neural Networks*, VarAna (p. 203) |
| 14:00 - 14:30 | Brandon Doherty (University of Western Ontario), *Cubical models of (infinity,1)-categories*, HomotTh (p. 137) |
| 14:00 - 14:30 | Olivia Dumitrescu (UNC Chapel Hill), AlgGeom (p. 75) |
| 14:00 - 14:30 | Ahmet Guloglu (Bilkent University), *Non-vanishing of Cubic Twists of L-functions*, ArStat (p. 84) |
| 14:00 - 14:30 | Adam Harper (Warwick), *Large fluctuations of random multiplicative functions*, ProbNTh (p. 181) |
| 14:00 - 14:30 | Pamela Harris (Williams College), *Kostant's partition function and magic multiplex juggling sequences*, AlgComb (p. 72) |
| 14:00 - 14:30 | Deirdre Haskell (McMaster), LogicAp (p. 144) |
| 14:00 - 14:30 | Melissa Huggan (Ryerson), *The Orthogonal Colouring Game*, GraphTh (p. 129) |
| 14:00 - 14:30 | Matjaž Konvalinka (University of Ljubljana), *Some natural extensions of the parking space*, EnComb (p. 108) |
| 14:00 - 14:30 | Robert McCann (University of Toronto), *Inscribed radius bounds for lower Ricci bounded metric measure spaces with mean convex boundary*, OpTrans (p. 171) |
| 14:00 - 14:30 | Joanna Niezen (Victoria), *Sarvate-Beam Group Divisible Designs*, CombDes (p. 92) |
| 14:00 - 14:30 | David Sher (DePaul U.), *Inverse Steklov spectral problem for curvilinear polygons*, SpectTh (p. 125) |
| 14:00 - 14:30 | Stacey Smith ? (Ottawa), *Using non-smooth models to determine thresholds for microbial pest management*, DisDynS (p. 80) |
| 14:00 - 14:40 | Ilia Kirillov (Toronto), *Classification of coadjoint orbits for symplectomorphism groups of surfaces with boundary*, SympTop (p. 196) |
| 14:00 - 15:00 | Matt Kerr (Washington University at St. Louis), *Frobenius constants and limiting mixed Hodge structures*, FibratD (p. 116) |
| 14:06 - 14:36 | Zane Li (Indiana University), *Connections between decoupling and efficient congruencing*, DiscAna (p. 102) |
| 14:20 - 14:40 | Jacques Bélair (Université de Montréal), *Waning immunity in a two-strain disease model*, MathBio (p. 150) |
| 14:30 - 15:00 | Travis Askham (NJIT), *Fast multipole methods for continuous charge distributions*, SpectrM (p. 191) |
| 14:30 - 15:00 | Ana Balibanu (Harvard University), *Steinberg slices in quasi-Poisson varieties*, AlgGeom (p. 74) |
| 14:30 - 15:00 | Everaldo de Mello Bonotto (Universidade de Sau Paulo), *Impulsive semidynamical systems*, DisDynS (p. 78) |

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| 9:00 - 9:30 | Takuya Takeishi (Kyoto Institute of Technology), *Partition functions as C*-dynamical invariants and actions of congruence monoids*, OpAlg (p. 167) |
| 9:30 - 10:00 | Xin Li (University of Glasgow), *K-theory for semigroup C*-algebras and partial crossed products*, OpAlg (p. 166) |
| 10:00 - 10:30 | Nadia Larsen (University of Oslo), *Equilibrium states on C*-algebras of right lcm monoids*, OpAlg (p. 165) |
| 10:30 - 11:00 | Camila Fabre Sehnem (Victoria University of Wellington), *Nuclearity for partial crossed products by exact discrete groups*, OpAlg (p. 166) |
| 11:00 - 12:00 | Nicolas Bergeron (École normale supérieure), *Linking in torus bundles and Hecke L functions*, Plenary (p. 64) |
| 12:00 - 12:30 | Break / Pause |
| 12:00 - 12:30 | Equity, Diversity and Inclusiveness Committee Breakout - Challenges Faced by Mathematicians from Underrepresented Groups |
| 12:00 - 12:30 | Equity, Diversity and Inclusiveness Committee Breakout - Challenges Faced by Parents of Young Children |
| 12:30 - 13:30 | Duncan Dauvergne (Princeton), *The Archimedean limit of random sorting networks*, DocPriz (p. 67) |
| 13:30 - 14:00 | Break / Pause |
| 13:30 - 14:00 | Equity, Diversity and Inclusiveness Committee Breakout - Supporting Early Career Researchers |
| 13:30 - 14:00 | Equity, Diversity and Inclusiveness Committee Breakout - Supporting LGBTQ+ Mathematicians |
| 14:00 - 14:20 | Laurent Mackay (McGill University), *Feedback onto cellular polarization from paxillin, implications for migrating cells.*, MathBio (p. 154) |
| 14:00 - 14:30 | Amenda Chow and Iain Moyles (York), *Choose your own adventure in a multi-variable calculus course for engineering students*, CAssess (p. 97) |
| 14:00 - 14:30 | Tomasz Ciesla (Lancaster), *On lifting invariant probability measures*, LogicAp (p. 143) |
| 14:00 - 14:30 | Asma Hassanezhad (Bristol), *Eigenvalue and multiplicity bounds for the mixed Steklov problem*, SpectTh (p. 122) |
| 14:00 - 14:30 | Winston Heap (Max Planck), *Random multiplicative functions and a model for the Riemann zeta function*, ProbNTh (p. 181) |
| 14:00 - 14:30 | Abdelmonem Ibrhaim (Alzahr University), *Binary whale optimization algorithm for feature selection*, OptimDS (p. 176) |
| 14:00 - 14:30 | Matthew Kennedy (University of Waterloo), *Amenability, proximality and higher order syndeticity*, OpAlg (p. 165) |
| 14:00 - 14:30 | Amir Mohammadi (University of California, San Diego), *Effective results in homogeneous dynamics*, EqArMan (p. 114) |
| 14:00 - 14:30 | Thomas Ransford (Université Laval), *A Gleason-Kahane-Żelazko theorem for reproducing kernel Hilbert spaces.*, HarmAna (p. 188) |
| 14:00 - 14:30 | Gail Wolkowicz (McMaster), *Bifurcation analysis of an impulsive system describing Partial Nitritation and Anammox in a hybrid reactor*, DisDynS (p. 81) |
| 14:00 - 15:00 | Tony Pantev (Penn), DerCat (p. 100) |
| 14:20 - 14:40 | Marc Roussel (University of Lethbridge), *Dynamics-preserving model reduction using bipartite-graph representations of biochemical systems*, MathBio (p. 157) |
| 14:30 - 15:00 | Aleksandr Aravkin (University of Washington), *A Robust Risk Score for Evaluating Evidence in Global Health*, OptimDS (p. 174) |
| 14:30 - 15:00 | Almaz Butaev (University of Calgary), *On geometric preduals of jet spaces on subsets of* $\mathbb{R}^n$, HarmAna (p. 186) |
| 14:30 - 15:00 | Carolyn Gordon (Dartmouth), *Comparing Hodge spectra of manifolds and orbifolds: Part 1*, SpectTh (p. 122) |
| 14:30 - 15:00 | Asaf Katz (University of Michigan), *An application of Margulis' inequality to effective equidistribution*, EqArMan (p. 113) |
| 14:30 - 15:00 | Frithjof Lutscher (Ottawa), *Population dynamics of discrete breeders*, DisDynS (p. 79) |
| 14:30 - 15:00 | Frédéric Ouimet (Caltech), ProbNTh (p. 183) |
| 14:30 - 15:00 | Forte Shinko (Caltech), *Lifts of Borel actions on quotient spaces*, LogicAp (p. 146) |

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| 14:30 - 15:00 | Dan Wolczuk and Paul McGrath (Waterloo), *Using Virtual Escape Rooms to Promote Student-Student Interactions*, CAssess (p. 98) |
| 14:30 - 15:00 | Dilian Yang (University of Windsor), *Zappa-Szép Actions of Groups on Product Systems*, OpAlg (p. 168) |
| 14:40 - 15:00 | Khanh Dao Duc (University of British Columbia), *A study of stochastic dynamics of mRNA translation and their impact across biological scales*, MathBio (p. 151) |
| 15:00 - 15:20 | Brian Merchant (University of British Columbia), *Using a Rho GTPase based model of cell polarization to explain group advantage in chemotaxis*, MathBio (p. 154) |
| 15:00 - 15:30 | Shai Evra (Princeton University), *Ramanujan Conjecture and the Density Hypothesis*, EqArMan (p. 111) |
| 15:00 - 15:30 | Sean Fitzpatrick (Lethbridge), *Deconstructing Exams for Remote Learning*, CAssess (p. 97) |
| 15:00 - 15:30 | Elizabeth Gillaspy (University of Montana), *Homotopy of product systems, and K-theory for higher-rank graphs*, OpAlg (p. 165) |
| 15:00 - 15:30 | Katie Gittins (Durham), *Comparing Hodge spectra of manifolds and orbifolds: Part 2.*, SpectTh (p. 122) |
| 15:00 - 15:30 | Warren Hare (UBC), *Imaginary Derivative Free Optimization*, OptimDS (p. 175) |
| 15:00 - 15:30 | Iain Moyles (York), *A model of phosphorus recycling at the plant scale*, DisDynS (p. 80) |
| 15:00 - 15:30 | Pierre-Olivier Parisé (Université Laval), *Cesàro summability of Taylor series in weighted Dirichlet spaces*, HarmAna (p. 188) |
| 15:00 - 15:30 | Cameron Stewart (Waterloo), *Counting solvable S-unit equations*, ProbNTh (p. 183) |
| 15:00 - 15:30 | Jenna Zomback (UIUC), *A backward ergodic theorem and its forward implications*, LogicAp (p. 148) |
| 15:00 - 16:00 | Katrina Honigs (Oregon), *An obstruction to weak approximation on some Calabi-Yau threefolds*, DerCat (p. 99) |
| 15:20 - 15:40 | Justin Tzou (Macquarie University), *Localized patterns and narrow escape problems in more general geometries*, MathBio (p. 158) |
| 15:30 - 16:00 | Samantha-Jo Caetano (Toronto), *Trump vs. Biden - who will win ?*, CAssess (p. 97) |
| 15:30 - 16:00 | Sebastian Dominguez (Simon Fraser), *Steklov eigenvalues in linear elasticity*, SpectTh (p. 121) |
| 15:30 - 16:00 | Anna Duwenig (University of Wollongong), *Cartan subalgebras for non-principal twisted groupoid C*-algebras*, OpAlg (p. 164) |
| 15:30 - 16:00 | Mikolaj Fraczyk (The University of Chicago), *Density hypothesis in horizontal families*, EqArMan (p. 112) |
| 15:30 - 16:00 | Richard Gottesman (Queens), ProbNTh (p. 181) |
| 15:30 - 16:00 | Larissa Richards (University of Toronto), *On the rate of convergence of discrete interfaces to SLE.*, HarmAna (p. 188) |
| 15:30 - 16:00 | Xiaoping Shi (Thompson River University), *Graph-based change-point test*, OptimDS (p. 177) |
| 15:30 - 16:00 | Marco Tosato (York), *Multi-cycle Periodic Solutions of a Differential Equation with Delay that Switches Periodically*, DisDynS (p. 80) |
| 15:30 - 16:00 | Spencer Unger (Toronto), *Embeddings and factor maps between $\mathbb{Z}^d$ actions*, LogicAp (p. 147) |
| 16:00 - 16:30 | Jean-Marie de Koninck (Laval), *Consecutive integers divisible by a power of their largest prime factor*, ProbNTh (p. 180) |
| 16:00 - 16:30 | Ben Hayes (University of Virginia), *A random matrix approach to the Peterson-Thom conjecture*, OpAlg (p. 165) |
| 16:00 - 16:30 | Thomas Humphries (University of Washington Bothell), *Unrolled iterative algorithm for CT image reconstruction with learned penalty term*, OptimDS (p. 175) |
| 16:00 - 16:30 | Antoine Metras (Montréal), *Steklov extremal metrics in higher dimension*, SpectTh (p. 124) |
| 16:00 - 16:30 | Nicholas Miller (University of California, Berkeley), *Geodesic submanifolds of hyperbolic manifolds*, EqArMan (p. 114) |
| 16:00 - 16:30 | Gergely Rost (Szeged University), DisDynS (p. 80) |
| 16:00 - 16:30 | Jerrod Smith (Calgary), *Peer and Open-ended Assessment in Linear Algebra and Intro Proof Courses*, CAssess (p. 98) |
| 16:00 - 16:30 | Riley Thornton (UCLA), *Factor of i.i.d. processes and Cayley diagrams*, LogicAp (p. 147) |
| 16:00 - 16:30 | Ignacio Uriarte-Tuero (Michigan State University), *Two weight norm inequalities for singular integrals in $\mathbb{R}^n$*, HarmAna (p. 189) |
| 16:00 - 17:00 | Sabin Cautis (UBC), *Categorical structure of Coulomb branches of 4D N=2 gauge theories*, DerCat (p. 99) |
| 16:30 - 17:00 | Monica Gabriela Cojocaru (University of Guelph), OptimDS (p. 174) |
| 16:30 - 17:00 | Tyrone Crisp (University of Maine), *An imprimitivity theorem for Hilbert modules*, OpAlg (p. 164) |

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| 16:30 - 17:00 | Alex Kontorovich (Rutgers University), *Applications of Thin Orbits*, EqArMan (p. 113) |
| 16:30 - 17:00 | Anton Mosunov (Waterloo), *Let's Think Together: Using Oral Assessments to Develop Students' Thought Process*, CAssess (p. 98) |
| 16:30 - 17:00 | Ram Murty (Queens), *An "all-purpose" Erdos-Kac theorem*, ProbNTh (p. 182) |
| 16:30 - 17:00 | William Verreault (Université Laval), *Nonlinear Oscillatory Expansions of holomorphic functions*, HarmAna (p. 189) |
| 16:30 - 17:00 | Konrad Wrobel (Texas A&M), *Cost of inner amenable equivalence relations*, LogicAp (p. 148) |
| 17:00 - 18:00 | Equity, Diversity and Inclusiveness Committee Panel / Social |
| 17:00 - 17:30 | James Wilson (University of Vermont), *Discretization of adapted functions*, HarmAna (p. 189) |
| 17:30 - 18:00 | Scott Rodney (Cape Breton University), *Bounded Weak Solutions of Second Order Linear PDEs with Data in Orlicz Spaces*, HarmAna (p. 188) |
| 18:00 - 18:30 | Jie Xiao (Memorial University), HarmAna (p. 190) |
| 18:30 - 19:00 | Javad Mashreghi (Université Laval), *Outer Functions and the Schur Class*, HarmAna (p. 187) |

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| 9:00 - 9:30 | Dan Ursu (University of Waterloo), *Characterizing traces on crossed products of noncommutative C*-algebras*, OpAlg (p. 167) |
| 9:30 - 10:00 | Cecile Armana (Université de Franche-Comté), *Sturm bounds for Drinfeld-type automorphic forms over function fields*, ArithGr (p. 94) |
| 9:30 - 10:00 | Hung-Chang Liao (University of Ottawa), *Almost finiteness, comparison, and tracial Z-stability*, OpAlg (p. 166) |
| 10:00 - 10:30 | Neil Dummigan (University of Sheffield), *Congruences involving non-parallel weight Hilbert modular forms*, ArithGr (p. 95) |
| 10:00 - 10:30 | Maria Grazia Viola (Lakehead University), *Regularities properties of Cuntz-Pimsner algebras associated to C*-correspondences over commutative C*-algebras*, OpAlg (p. 167) |
| 10:30 - 11:00 | Johannes Christensen (KU Leuven), *A new approach to describing KMS states on $C^*$-algebras.*, OpAlg (p. 163) |
| 10:45 - 11:15 | Fang-Ting Tu (Louisiana State University), *A Geometric Interpretation of a Whipple's ${}_7F_6$ Formula*, ArithGr (p. 96) |
| 11:00 - 11:30 | Arvind Ayyer (Indian Institute of Science), *Toppleable permutations and excedances*, EnComb (p. 106) |
| 11:00 - 11:30 | Noe de Rancourt (Vienna), *Intersection-smooth equivalence relations*, LogicAp (p. 143) |
| 11:00 - 11:30 | Kari Eifler (Texas A&M University), *Non-local games and quantum metric spaces*, OpAlg (p. 164) |
| 11:00 - 11:30 | Lam Pham (Hebrew University), *Arithmetic Groups and the Lehmer conjecture*, EqArMan (p. 114) |
| 11:00 - 11:30 | Orit Raz (The Hebrew University of Jerusalem), *Dimension-expanding polynomials and the discretized Elekes-Rónyai theorem*, AddComb (p. 69) |
| 11:00 - 11:30 | Mario Schulz (Quenn Mary U. of London), *Free boundary minimal surfaces in the unit ball*, SpectTh (p. 125) |
| 11:00 - 11:40 | Xiudi Tang (Toronto), *Symplectic ray removal*, SympTop (p. 198) |
| 11:00 - 12:00 | Ellen Kirkman (Wake Forest), *Degree bounds for Hopf actions on Artin-Schelter regular algebras*, DerCat (p. 100) |
| 11:15 - 11:45 | Mark McConnell (Princeton University), ArithGr (p. 96) |
| 11:30 - 12:00 | Benjamin Bogosel (Polytechnique Paris), *Shape optimization of the Steklov eigenvalues under various constraints*, SpectTh (p. 120) |
| 11:30 - 12:00 | Ilse Fischer (University of Vienna), *Bijective proofs of (skew) Schur polynomial factorizations*, EnComb (p. 107) |
| 11:30 - 12:00 | Arie Levit (Yale University), *Quantitative weak uniform discreteness*, EqArMan (p. 113) |
| 11:30 - 12:00 | Boyu Li (University of Victoria), *The Zappa-Szép product of a Fell bundle by a groupoid*, OpAlg (p. 166) |
| 11:30 - 12:00 | Zoltán Vidnyánszky (Caltech), *Bases for Borel graphs of large chromatic number: injective case*, LogicAp (p. 147) |
| 11:30 - 12:00 | Alexia Yavicoli (University of St Andrews), *Patterns in thick compact sets*, AddComb (p. 70) |
| 11:50 - 12:30 | Lara Suarez Lopez (Bochum), *On the rigidity of Legendrian cobordisms*, SympTop (p. 197) |
| 12:00 - 12:30 | Jeffrey Galkowski (UCL), *Geodesic beams and Weyl remainders*, SpectTh (p. 121) |
| 12:00 - 12:30 | Mathilde Gerbelli-Gauthier (McGill University), *Limit multiplicity of non-tempered representations and endoscopy.*, ArithGr (p. 95) |
| 12:00 - 12:30 | Mathilde Gerbelli-Gauthier (McGill University), *Limit multiplicity of non-tempered representations and endoscopy.*, EqArMan (p. 112) |
| 12:00 - 12:30 | Helen Jenne (Université de Tours), *Double-dimer condensation and the dP3 Quiver*, EnComb (p. 108) |
| 12:00 - 12:30 | Aristotelis Panagiotopoulos (Munster), *Dynamical obstructions to classification by (co)homology and other TSI-group invariants.*, LogicAp (p. 146) |
| 12:00 - 12:30 | Sophie Stevens (Johann Radon Institute for Computational and Applied Mathematics), *The Elekes-Szabó Problem and the Uniformity Conjecture*, AddComb (p. 69) |
| 12:30 - 13:00 | Break / Pause |
| 13:00 - 13:20 | John Rinzel (New York University), *A neuronal model for learning to keep a rhythmic beat.*, MathBio (p. 156) |
| 13:00 - 13:20 | Peter Taylor (peter.taylor@queensu.ca), *Let's invite Seymour into our calculus classroom.*, Mindst (p. 201) |
| 13:00 - 13:30 | Daniel Di Benedetto (University of British Columbia), *Discretised point-line incidences and the dimension of Besicovitch sets*, AddComb (p. 68) |

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| 13:00 - 13:30 | Dave Hewett (UCL), *Acoustic scattering by fractal screens*, SpectTh (p. 122) |
| 13:00 - 13:30 | Marni Mishna (Simon Fraser University), *Enumerating excursions on Cayley graphs*, EnComb (p. 109) |
| 13:00 - 13:30 | Will Sawin (Columbia University), *The mixing conjecture over function fields*, EqArMan (p. 114) |
| 13:00 - 13:30 | Felix Weilacher (CMU), *Descriptive Chromatic Numbers of Locally Finite and Everywhere Two Ended Graphs*, LogicAp (p. 147) |
| 13:00 - 14:00 | Colin Ingalls (Carleton), *Explicit coverings of families of elliptic surfaces by squares of curves*, DerCat (p. 99) |
| 13:10 - 13:50 | Qun Wang (Toronto), *Choreographies in the N-Vortex Problem*, SympTop (p. 198) |
| 13:20 - 13:40 | Alfonso Gracia-Saz (alfonso@math.toronto.edu), *Playing with Desmos in the classroom*, Mindst (p. 200) |
| 13:20 - 13:40 | David Holcman (Institut de Biologie École Normale Supérieure), MathBio (p. 152) |
| 13:30 - 14:00 | Shaun Allison (CMU), *Polish groups with the pinned property*, LogicAp (p. 142) |
| 13:30 - 14:00 | Brandon Hanson (University of Georgia), *A better-than-Plunnecke bound for* $A + 2A$, AddComb (p. 68) |
| 13:30 - 14:00 | Junehyuk Jung (Brown University), *Intersections of geodesics on the modular surface*, EqArMan (p. 113) |
| 13:30 - 14:00 | Chiu-Yen Kao (Claremont Mckenna College), *Computation of free boundary minimal surfaces via extremal Steklov eigenvalue problems*, SpectTh (p. 123) |
| 13:30 - 14:00 | Joel Lewis (George Washington University), *Hurwitz numbers for reflection groups*, EnComb (p. 108) |
| 13:40 - 14:00 | Andrew McEachern (andrewm6@yorku.ca), *Tournaments in a Proofs Class*, Mindst (p. 200) |
| 13:40 - 14:00 | Lawrence Oprea (McGill University), *Simulation and analysis of white matter in a variably hypomyelinated transgenic mouse model*, MathBio (p. 154) |
| 14:00 - 14:30 | Break / Pause |
| 14:00 - 14:20 | Bernardo Galvao-Sousa (beni@math.toronto.edu), *Open ended modelling problems*, Mindst (p. 200) |
| 14:00 - 14:20 | Charles S. Peskin (New York University – Courant), *Interaction of Facilitation and Depression in Synaptic Transmission*, MathBio (p. 155) |
| 14:00 - 14:30 | Lindsay Dever (Bryn Mawr College), *Ambient prime geodesic theorems on compact hyperbolic 3-manifolds*, EqArMan (p. 111) |
| 14:00 - 14:30 | Alexandre Girouard (Laval), *Planar domains with prescribed perimeter and large Steklov spectral gap must collapse to a point*, SpectTh (p. 121) |
| 14:00 - 14:30 | Jongchon Kim (University of British Columbia), *Estimates for some geometric maximal functions associated with a set of directions*, AddComb (p. 69) |
| 14:00 - 14:30 | Assaf Shani (Harvard), *Classification by sequences of countable sets of reals*, LogicAp (p. 146) |
| 14:00 - 15:00 | Alicia Lamarche (Utah), DerCat (p. 100) |
| 14:10 - 14:50 | Shira Tanny (Tel Aviv), *The Poisson bracket invariant: elementary and hard approaches.*, SympTop (p. 198) |
| 14:20 - 14:40 | Saeed Farjami (Univeristy of Surrey), *Non-sequential Spike Adding in Cerebellar Stellate Cells*, MathBio (p. 151) |
| 14:20 - 14:40 | Sarah Mayes-Tang (smt@math.toronto.edu), *Using Stories to Learn Math in A First-Year Seminar*, Mindst (p. 200) |
| 14:30 - 15:00 | Filippo Calderoni (UIC), *Descriptive set theory: order and classification*, LogicAp (p. 142) |
| 14:30 - 15:00 | Jonathan Tidor (Massachusetts Institute of Technology), *Joints of Varieties*, AddComb (p. 69) |
| 14:30 - 15:00 | Matthew Young (Texas A&M University), *Moments and hybrid subconvexity for symmetric-square L-functions*, EqArMan (p. 115) |
| 14:40 - 15:00 | Igor Belykh (Georgia State University), *When repulsive coupling promotes synchronization of bursting neurons*, MathBio (p. 150) |
| 14:40 - 15:00 | General Discussion, Mindst (p. 200) |
| 15:00 - 15:20 | Romain Veltz (INRIA-Sophia Antipolis), *Mean field study of stochastic spiking neural networks*, MathBio (p. 158) |
| 15:30 - 16:00 | Wenyu Pan (The University of Chicago), *Exponential mixing of geodesic flows for geometrically finite hyperbolic manifolds with cusps*, EqArMan (p. 114) |
| 15:30 - 16:10 | Pranav Chakravarthy (Western Ontario), *Homotopy type of equivariant symplectomorphisms of rational ruled surfaces.*, SympTop (p. 195) |
| 15:30 - 16:30 | Dylan Allegretti (UBC), DerCat (p. 99) |
| 16:00 - 16:30 | Thomas Hille (Northwestern University), *Bounds for the Least Solution of Homogeneous Quadratic Diophantine Inequalities.*, EqArMan (p. 112) |

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| 16:00 - 16:30 | Tongou Yang (University of British Columbia), *Uniform decoupling in l2 for polynomials*, AddComb (p. 70) |
| 16:20 - 17:00 | Cheng Yang (Toronto), *Symplectic reduction and perturbation theory*, SympTop (p. 198) |
| 16:30 - 17:00 | Alireza Salehi Golsefidy (University of California, San Diego), *Two new concepts for compact groups: Spectral independence and local randomness*, EqArMan (p. 112) |
| 16:30 - 17:00 | Caroline Terry (Ohio State University), *A stable arithmetic regularity lemma in finite abelian groups*, AddComb (p. 69) |
| 16:30 - 17:30 | Max Lieblich (Washington), DerCat (p. 100) |
| 17:00 - 17:30 | Weikun He (Korea Institute of Advanced Study), *Sum-product in representations of Lie groups*, AddComb (p. 68) |

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## Talk List

Zhu, Xuwen, *Spectral properties of spherical conical metrics*, SpectTh (p. 126), Saturday December 5, 16:00 - 16:30

Zomback, Jenna, *A backward ergodic theorem and its forward implications*, LogicAp (p. 148), Monday December 7, 15:00 - 15:30

Zucker, Andy, *Big Ramsey degrees via coding trees*, LogicAp (p. 148), Friday December 4, 14:30 - 15:00

## Schedule/Horaire

| Friday December 4 | vendredi 4 décembre |
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| 16:30 - 17:30 | Alicia Carriquiry (Iowa State University), *Statistics, Mathematics, and the Fair Evaluation of Evidence* (p. 63) |

## Abstract/Résumé

**ALICIA CARRIQUIRY**, Iowa State

[Friday December 4 / vendredi 4 décembre, 16:30]

*Statistics, Mathematics, and the Fair Evaluation of Evidence*

In the last two decades, the validity and reliability of many forensic disciplines have come into question. A 2009 landmark report by the National Research Council of the United States was strongly critical of many forensic practices, but specially of what are known as pattern comparison disciplines. These include fingerprint and shoeprint analysis, ballistics, handwriting analysis and others. At present, pattern forensic examiners rely on subjective assessment of the similarity between two pieces of evidence and not at all on more objective, quantitative methods. In the pattern disciplines, evidence typically takes the form of images, and a common forensic question is whether two impressions could have been made by the same object. For example, was the crime scene footwear impression made by the suspect's shoe ? Today, I discuss new methods that have been developed to quantify the similarity between two images and enable forensic practitioners to make probabilistic statements as they analyze and interpret pattern evidence. For illustration I will talk about two specific application areas, firearms and footwear, where novel methods have the potential to change the practice of forensics everywhere.

# Plenary Lectures / Conférences plénières

## Schedule/Horaire

**Saturday December 5** — **samedi 5 décembre**

11:00 - 12:00 YVAN SAINT AUBIN (Université de Montréal), *Teaching modeling in first year - Un cours de modélisation en première année* (p. 64)

**Sunday December 6** — **dimanche 6 décembre**

11:00 - 12:00 IRENE FONSECA (Carnegie Mellon's Center for Nonlinear Analysis (CNA)), *Geometric Flows and Phase Transitions in Heterogeneous Media* (p. 64)

**Monday December 7** — **lundi 7 décembre**

11:00 - 12:00 NICOLAS BERGERON (École normale supérieure), *Linking in torus bundles and Hecke L functions* (p. 64)

## Abstracts/Résumés

**NICOLAS BERGERON**, École normale supérieure
[Monday December 7 / lundi 7 décembre, 11:00]
*Linking in torus bundles and Hecke L functions*

Torus bundles over the circle are among the simplest and cutest examples of 3-dimensional manifolds. After presenting some of these examples, using in particular animations realized by Jos Leys, I will consider periodic orbits in these fiber bundles over the circle. We will see that their linking numbers — that are rational numbers by definition — can be computed as certain special values of Hecke L-functions. Properly generalised this viewpoint makes it possible to give new topological proof of now classical rationality or integrality theorems of Klingen-Siegel and Deligne-Ribet. It also leads to new related results that I will briefly allude to. All this is extracted from joint works with Pierre Charollois, Luis Garcia and Akshay Venkatesh.

**IRENE FONSECA**, Carnegie Mellon University
[Sunday December 6 / dimanche 6 décembre, 11:00]
*Geometric Flows and Phase Transitions in Heterogeneous Media*

We present the first unconditional convergence results for an Allen-Cahn type bi-stable reaction diffusion equation in a periodic medium. Our limiting dynamics are given by an analog for anisotropic mean curvature flow of the formulation due to Ken Brakke. As an essential ingredient in the analysis, we obtain an explicit expression for the effective surface tension, which dictates the limiting anisotropic mean curvature. This allows us to demonstrate the regularity and uniform ellipticity of the limiting surface tension.

This is joint work with Riccardo Cristoferi (Radboud University, NL), Adrian Hagerty (Edge Case Research), Cristina Popovici, and Rustum Choksi (McGill), Jessica Lin (McGill), Raghavendra Venkatraman (CMU).

**YVAN SAINT AUBIN**, Université de Montréal
[Saturday December 5 / samedi 5 décembre, 11:00]
*Teaching modeling in first year - Un cours de modélisation en première année*

A new first-year course in modeling was created at the Département de mathématiques et de statistique at Université de Montréal. It is compulsory for students in the pure and applied stream and in the statistics one. Anne Bourlioux and I created the course in 2018, following the guidelines in GAIMME*. I shall report on the successes and pitfalls of the three first editions

of the course. I'll also reflect on the similarities between this modeling course and the abstract ones given at the beginning of the programme, like the first real analysis course.

* GAIMME stands for the Guidelines for Assessment and Instruction in Mathematical Modeling Education (2016), a report cosponsored by SIAM and COMAP.

Un nouveau cours de première année en modélisation a été créé au Département de mathématiques et de statistique de l'Université de Montréal. Il est obligatoire pour les étudiants des orientations maths pures et appliquées, et statistique. Anne Bourlioux et moi créèrent le cours en 2018, suivant de près les lignes directrices de GAIMME*. Je décrirai les succès et difficultés des trois premières éditions du cours. Je réfléchirai également aux similarités entre ce cours de modélisation et ceux plus abstraits de première année, tel le cours d'analyse réelle. La conférence sera donnée en anglais.

* GAIMME est le rapport « Guidelines for Assessment and Instruction in Mathematical Modeling Education » (2016) publié conjointement par SIAM et COMAP.

# Prize Lectures / Conférence des lauréats

## Schedule/Horaire

**Saturday December 5** — **samedi 5 décembre**

12:30 - 13:30 Veselin Jungic (Simon Fraser University), *Teaching and Preaching Mathematics: Reflections on the Past and Thoughts on the Future* (p. 66)

**Sunday December 6** — **dimanche 6 décembre**

12:30 - 13:30 Jacopo De Simoi (University of Toronto), *Dynamical spectral rigidity and determination* (p. 66)

**Monday December 7** — **lundi 7 décembre**

12:30 - 13:30 Duncan Dauvergne (Princeton), *The Archimedean limit of random sorting networks* (p. 67)

## Abstract/Résumé

**Adrien Pouliot Award**
**Prix Adrien-Pouliot**

**VESELIN JUNGIC**, Simon Fraser University
[Saturday December 5 / samedi 5 décembre, 12:30]
*Teaching and Preaching Mathematics: Reflections on the Past and Thoughts on the Future*

In this presentation, I will reflect on some of my recent and not-so-recent experiences with teaching and promoting mathematics.

In an effort to describe some of the eternally evolving changes to how mathematics is perceived, learned, and taught, I will try to address why I remain concerned about the future of teaching of our beloved subject despite the increasing importance of mathematics in the modern world.

Part of this presentation will be devoted to the memory of four Canadian mathematicians, Leo and William Moser and Jonathan and Peter Borwein.

**Coxeter-James Prize**
**Prix Coxeter-James**

**JACOPO DE SIMOI**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 12:30]
*Dynamical spectral rigidity and determination*

Given a planar domain with sufficiently regular boundary, one can study periodic orbits of the associated billiard problem. Periodic orbits have a rich and quite intricate structure and it is natural to ask how much information about the domain is encoded in the set of lengths of such orbits. The quantum analog of this question is the celebrated Laplace inverse problem, or "Can one hear the shape of a drum ?"

For a class of smooth convex domains we prove dynamical spectral rigidity: in this class it is not possible to deform a domain without perturbing the length of at least one orbit. In a class of analytic dispersing open billiards we show marked spectral

determination: knowing all lengths of all periodic orbit of such systems together with some combinatorial information allows to completely reconstruct the domain.

Such results are part of an ongoing joint project with V. Kaloshin and other collaborators (Q. Wei, M. Leguil and P. Bálint)

## Doctoral Prize
## Prix de doctorat

**DUNCAN DAUVERGNE**, Princeton
[Monday December 7 / lundi 7 décembre, 12:30]
*The Archimedean limit of random sorting networks*

Consider a list of n particles labelled in increasing order. A sorting network is a way of sorting this list into decreasing order by swapping adjacent particles, using as few swaps as possible. Simulations of large-n uniform random sorting networks reveal a surprising and beautiful global structure involving sinusoidal particle trajectories, a semicircle law, connections to fluid dynamics, and a theorem of Archimedes.

Based on these simulations, Angel, Holroyd, Romik, and Virag made a series of conjectures about the limiting behaviour of sorting networks. In this talk, I will discuss how to use the local structure and combinatorics of random sorting networks to prove these conjectures.

# Additive Combinatorics and Discrete Geometry / Cominatoire Additive et Géométrie Discrète

**Org: Malabika Pramanik** and/et **Josh Zahl** (UBC)

## Schedule/Horaire

| **Tuesday December 8** | **mardi 8 décembre** |
|---|---|
| 11:00 - 11:30 | Orit Raz (The Hebrew University of Jerusalem), *Dimension-expanding polynomials and the discretized Elekes-Rónyai theorem* (p. 69) |
| 11:30 - 12:00 | Alexia Yavicoli (University of St Andrews), *Patterns in thick compact sets* (p. 70) |
| 12:00 - 12:30 | Sophie Stevens (Johann Radon Institute for Computational and Applied Mathematics), *The Elekes-Szabó Problem and the Uniformity Conjecture* (p. 69) |
| 13:00 - 13:30 | Daniel Di Benedetto (University of British Columbia), *Discretised point-line incidences and the dimension of Besicovitch sets* (p. 68) |
| 13:30 - 14:00 | Brandon Hanson (University of Georgia), *A better-than-Plunnecke bound for $A+2A$* (p. 68) |
| 14:00 - 14:30 | Jongchon Kim (University of British Columbia), *Estimates for some geometric maximal functions associated with a set of directions* (p. 69) |
| 14:30 - 15:00 | Jonathan Tidor (Massachusetts Institute of Technology), *Joints of Varieties* (p. 69) |
| 16:00 - 16:30 | Tongou Yang (University of British Columbia), *Uniform decoupling in l2 for polynomials* (p. 70) |
| 16:30 - 17:00 | Caroline Terry (Ohio State University), *A stable arithmetic regularity lemma in finite abelian groups* (p. 69) |
| 17:00 - 17:30 | Weikun He (Korea Institute of Advanced Study), *Sum-product in representations of Lie groups* (p. 68) |

## Abstracts/Résumés

**DANIEL DI BENEDETTO**, The University of British Columbia
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Discretised point-line incidences and the dimension of Besicovitch sets*

We discuss a discretised version of the Szemerédi—Trotter theorem and its application to upper Minkowski dimension estimates for Besicovitch sets in $\mathbb{R}^3$. This talk is based on ongoing joint work with Joshua Zahl.

**BRANDON HANSON**, UGA
[Tuesday December 8 / mardi 8 décembre, 13:30]
*A better-than-Plunnecke bound for $A+2A$*

If $A$ is a finite set in an abelian group, we can measure the additive structure of $A$ by the size of its doubling constant, $K = |A+A|/|A|$. Plunnecke's inequality lets us measure the size of iterated sumsets in terms of $K$, and in particular it tells us that $|A+A+A| \leq K^3|A|$. The set $A+2A = \{a+b+b : a,b \in A\}$ is a subset of $A+A+A$ and so the upper bound $K^3|A|$ applies. In this talk, I will describe recent work with G. Petridis where we prove that in fact $|A+2A| \leq K^{2.95}|A|$, answering a question of B. Bukh.

**WEIKUN HE**, Korea Institute for Advanced Study
[Tuesday December 8 / mardi 8 décembre, 17:00]
*Sum-product in representations of Lie groups*

I will present some results in the spirit of Bourgain's discretized sum-product theorem, but in the context of Lie groups and their linear representations.

Based on a joint work with Nicolas de Saxcé.

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**JONGCHON KIM**, University of British Columbia
[Tuesday December 8 / mardi 8 décembre, 14:00]
*Estimates for some geometric maximal functions associated with a set of directions*

We will discuss geometric maximal functions associated with averages over line segments oriented in a set of directions and their singular integral analogues. The maximal functions can be regarded as "singular" variants of the Nikodym maximal function associated with thin tubes. The main problem is to quantify the dependence of the operator norm on the number and the distribution of directions. We will discuss a divide-and-conquer type approach to this problem for $L^2$ estimates.

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**ORIT RAZ**, The Hebrew University of Jerusalem
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Dimension-expanding polynomials and the discretized Elekes-Rónyai theorem*

I will present a recent result, joint with Josh Zahl, asserting that most real bivariate polynomials are "dimension expanding" when applied to a Cartesian product. More concretely, if $P$ is a polynomial that is not of the form $P(x,y) = h(a(x) + b(y))$ or $P(x,y) = h(a(x)b(y))$, then whenever $A$ and $B$ are Borel subsets of $\mathbb{R}$ with Hausdorff dimension $0 < \alpha < 1$, we have that $P(A,B)$ has Hausdorff dimension at least $\alpha + \varepsilon$ for some $\varepsilon(\alpha) > 0$ that is independent of $P$. This is an analogue of Elekes-Rónyai theorem, which is concerned with the cardinality of $P(A \times B)$ for finite sets $A, B$.

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**SOPHIE STEVENS**, Radon Institute for Computational and Applied Mathematics (RICAM), Linz
[Tuesday December 8 / mardi 8 décembre, 12:00]
*The Elekes-Szabó Problem and the Uniformity Conjecture*

The Elekes-Szabó problem is to find an upper bound for $|Z(F) \cap (A \times B \times C)|$ for a 'non-degenerate' trivariate polynomial $F \in \mathbb{R}[x,y,z]$. Here, $Z(F)$ is the zero set of $F$. If we assume the Uniformity Conjecture, then we show how to obtain stronger bounds for a special family of polynomials in $\mathbb{Q}[x,y,z]$. Our conditional results are quantitatively stronger than the unconditional results of Raz, Sharir and de Zeeuw. In this talk, I will give several applications to additive combinatorics and discrete geometry. For example, to expanders, additive energy bounds, and pinned distances. This is joint work with M. Makhul, O. Roche-Newton and A. Warren.

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**CAROLINE TERRY**, The Ohio State University
[Tuesday December 8 / mardi 8 décembre, 16:30]
*A stable arithmetic regularity lemma in finite abelian groups*

The arithmetic regularity lemma for $\mathbb{F}_p^n$ (first proved by Green in 2005) states that given $A \subseteq \mathbb{F}_p^n$, there exists $H \leq \mathbb{F}_p^n$ of bounded index such that $A$ is Fourier-uniform with respect to almost all cosets of $H$. In general, the growth of the index of $H$ is required to be of tower type depending on the degree of uniformity, and must also allow for a small number of non-uniform elements. Previously, in joint work with Wolf, we showed that under a natural model theoretic assumption, called stability, the bad bounds and non-uniform elements are not necessary. In this talk, we present results extending this work to stable subsets of arbitrary finite abelian groups. This is joint work with Julia Wolf.

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**JONATHAN TIDOR**, Massachusetts Institute of Technology
[Tuesday December 8 / mardi 8 décembre, 14:30]
*Joints of Varieties*

The joints theorem of Guth and Katz states that $n$ lines in $\mathbb{R}^3$ form at most $O(n^{3/2})$ joints, where a joint is the intersection point of 3 non-coplanar lines. The proof of this result introduced a number of techniques that are now part of the standard toolkit of the polynomial method. We generalize this result from lines to varieties. One special case of our result states that $n$ planes (2-flats) in $\mathbb{F}^6$ form at most $O(n^{3/2})$ joints, where a joint is the intersection point of 3 planes that do not all lie in a single hyperplane. Our results introduce new techniques for applying the polynomial method to higher-dimensional objects.

Joint work with Hung-Hsun Hans Yu and Yufei Zhao.

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**TONGOU YANG**, University of British Columbia
[Tuesday December 8 / mardi 8 décembre, 16:00]
*Uniform decoupling in l2 for polynomials*

For each positive integer d, we prove a uniform l2-decoupling inequality for the collection of all polynomials phases of degree at most d. Our result is intimately related to MR4078083, but we use a different partition that is determined by the geometry of each individual function.

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**ALEXIA YAVICOLI**, University of St Andrews
[Tuesday December 8 / mardi 8 décembre, 11:30]
*Patterns in thick compact sets*

I will discuss the connection between thickness, winning sets and patterns in compact sets.

# Algebraic Cominatorixx (Women in Algebraic Combinatorics) / Combinatoire AlgébriXX (Les Femmes en Combinatoire Algébrique)

Org: **Angele Foley** (Laurier) and/et **Steph van Willigenburg** (UBC)

## Schedule/Horaire

| **Friday December 4** | **vendredi 4 décembre** |
|---|---|
| 14:00 - 14:30 | Rosa Orellana (Dartmouth College) (p. 72) |
| 14:30 - 15:00 | Sophie Spirkl (University of Waterloo), *A complete multipartite basis for the chromatic symmetric function* (p. 73) |
| 15:30 - 16:00 | Samantha Dahlberg (Arizona State University), *Diameters of Graphs of Reduced Words of Permutations* (p. 71) |
| 16:00 - 16:30 | Megumi Harada (McMaster University) (p. 71) |
| 17:00 - 18:00 | Women in Algebraic Combinatorics Social |

| **Saturday December 5** | **samedi 5 décembre** |
|---|---|
| 14:00 - 14:30 | Pamela Harris (Williams College), *Kostant's partition function and magic multiplex juggling sequences* (p. 72) |
| 14:30 - 15:00 | Lucy Martinez (Stockton University), *Minimum Rank of Regular Bipartite Graphs* (p. 72) |
| 15:00 - 15:30 | Sunita Chepuri (University of Michigan), *Kazhdan-Lusztig Immanants for $k$-Positive Matrices* (p. 71) |
| 15:30 - 16:00 | Nancy Wallace (UQAM), *Toward a Schurification of Schröder path formulas.* (p. 73) |
| 16:00 - 16:30 | Anna Pun (University of Virginia), *Distribution properties for t-hooks in partitions* (p. 72) |
| 16:30 - 17:00 | Olya Mandelshtam (Brown University), *The multispecies TAZRP and modified Macdonald polynomials* (p. 72) |

## Abstracts/Résumés

**SUNITA CHEPURI**, University of Michigan
[Saturday December 5 / samedi 5 décembre, 15:00]
*Kazhdan-Lusztig Immanants for $k$-Positive Matrices*

Immanants are matrix functionals that generalize the determinant. One notable family of immanants are the Kazhdan-Lusztig immanants. These immanants are indexed by permutations and are defined as sums involving Kazhdan-Lusztig polynomials specialized at $q = 1$. Kazhdan-Lusztig immanants have several interesting combinatorial properties, including that they are nonnegative on totally positive matrices. We give a condition on permutations that allows us to extend this theorem to the setting of $k$-positive matrices.

**SAMANTHA DAHLBERG**, Arizona State University
[Friday December 4 / vendredi 4 décembre, 15:30]
*Diameters of Graphs of Reduced Words of Permutations*

It is a classical result that any permutation in the symmetric group can be generated by a sequence of adjacent transpositions. The sequences of minimal length are called reduced words. The graphs of these reduced words, with edges determined by relations in the underlying Coxeter group, have been well studied. Recently, the diameter has been calculated for the longest permutation $n \cdots 21$ by Reiner and Roichman as well as Assaf. In this talk we present our results on diameters for certain classes or permutations. We also make progress on conjectured bounds of the diameter by Reiner and Roichman, which are based on the underlying hyperplane arrangement.

**MEGUMI HARADA**, McMaster University
[Friday December 4 / vendredi 4 décembre, 16:00]

**PAMELA HARRIS**, Williams College
[Saturday December 5 / samedi 5 décembre, 14:00]
*Kostant's partition function and magic multiplex juggling sequences*

Kostant's partition function is a vector partition function that counts the number of ways one can express a weight of a Lie algebra g as a nonnegative integral linear combination of the positive roots of g. Multiplex juggling sequences are generalizations of juggling sequences that specify an initial and terminal configuration of balls and allow for multiple balls at any particular discrete height. Magic multiplex juggling sequences generalize further to include magic balls, which cancel with standard balls when they meet at the same height. In this talk, we present a combinatorial equivalence between positive roots of a Lie algebra and throws during a juggling sequence. This provides a juggling framework to calculate Kostant's partition functions, and a partition function framework to compute the number of juggling sequences. This is joint work with Carolina Benedetti, Christopher R. H. Hanusa, Alejandro Morales, and Anthony Simpson.

**OLYA MANDELSHTAM**, Brown University
[Saturday December 5 / samedi 5 décembre, 16:30]
*The multispecies TAZRP and modified Macdonald polynomials*

Recently, a formula for the symmetric Macdonald polynomials $P_\lambda(X;q,t)$ was given in terms of objects called multiline queues, which also compute probabilities of a statistical mechanics model called the multispecies asymmetric simple exclusion process (ASEP) on a ring. It is natural to ask whether the modified Macdonald polynomials $\widetilde{H}_\lambda(X;q,t)$ can be obtained using a combinatorial gadget for some other statistical mechanics model. We answer this question in the affirmative. In this talk, we will give a new formula for $\widetilde{H}_\lambda(X;q,t)$ in terms of fillings of tableaux called polyqueue tableaux. We define a multispecies totally asymmetric zero range process (TAZRP) on a ring with parameter $t$, whose (unnormalized) stationary probabilities are computed by polyqueue tableaux, and whose partition function is equal to $\widetilde{H}_\lambda(X;1,t)$. This talk is based on joint work with Arvind Ayyer and James Martin.

**LUCY MARTINEZ**, Stockton University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Minimum Rank of Regular Bipartite Graphs*

The rank of a graph $G$ is defined as the rank of its adjacency matrix $A$. The smallest rank among all the matrices with the same pattern of non-zeros entries as $A$, over the field $\mathbb{F}$, is called the minimum rank of $A$ over $\mathbb{F}$. The smallest among all the minimum ranks of $A$ (considering all the fields) is called the minimum rank of $G$. In this work, we study regular bipartite graphs. Specifically, we used linear recursions with linear complexity 2 and zero forcing sets to prove that the minimum rank of a $(n-1)$-regular bipartite graph, with $n$ vertices on each side, is 4.

**ROSA ORELLANA**, Dartmouth College
[Friday December 4 / vendredi 4 décembre, 14:00]

**ANNA PUN**, University of Virginia
[Saturday December 5 / samedi 5 décembre, 16:00]
*Distribution properties for t-hooks in partitions*

Partitions, the partition function $p(n)$, and the hook lengths of their Ferrers-Young diagrams are important objects in combinatorics, number theory and representation theory. For positive integers $n$ and $t$, we study $p_t^e(n)$ (resp. $p_t^o(n)$), the number of partitions of $n$ with an even (resp. odd) number of $t$-hooks. Using the Rademacher circle method, we find an exact formula for $p_t^e(n)$ and $p_t^o(n)$.

In this talk, we will discuss how we use this exact formula to show the distribution properties of $p_t^e(n)$ and $p_t^o(n)$ which is far from uniform, and the signs of $p_t^e(n) - p_t^o(n)$ for large $n$.

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**SOPHIE SPIRKL**, University of Waterloo

[Friday December 4 / vendredi 4 décembre, 14:30]

*A complete multipartite basis for the chromatic symmetric function*

The complete multipartite basis $r_\lambda$ for symmetric functions was introduced by Penaguiao. In this talk, I will tell you why this basis is interesting, and give a combinatorial interpretation for the $r_\lambda$-coefficients of the chromatic symmetric function.

Joint work with Logan Crew.

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**NANCY WALLACE**, UQAM

[Saturday December 5 / samedi 5 décembre, 15:30]

*Toward a Schurification of Schröder path formulas.*

The Shuffle theorem of Carlsson and Mellit, states that $\nabla(e_n)$ is given by Parking function formulas. Schröder paths are a particular case of Parking functions. These formulas are symmetric in the variables $q$ and $t$. More preciously, for all $n$, $\nabla(e_n)$ can be seen as a $GL_2 \times \mathbb{S}_n$-module. In this talk we will put forth a partial formula for the irreducible bicharacters of these modules. Namely we will write subsets of the Schröder paths formulas as products of Schur functions in the variables $q$ and $t$ and the usual Schur functions in the variables $X = \{x_1, x_2, \ldots\}$.

# Algebraic Geometry of Integrable Systems / Géométrie Algébrique des Systèmes Intégrables

**Org: Michael Groechenig** (Toronto) and/et **Steven Rayan** (Saskatchewan)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Alexei Oblomkov (UMass Amherst), *3D sigma models with defects and knot homology* (p. 76) |
| 13:30 - 14:00 | Ruxandra Moraru (University of Waterloo), *Moduli spaces of stable bundles on complex nilmanifolds* (p. 76) |
| 14:00 - 14:30 | Jack Ding (University of Toronto), *Equivariant multiplicities of Schubert Varieties in the Based Loop Group* (p. 75) |
| 14:30 - 15:00 | Davesh Maulik (MIT), *Cohomology of the moduli of Higgs bundles and the Hausel-Thaddeus conjecture* (p. 76) |
| 15:30 - 16:00 | Junliang Shen (MIT), *Cohomological $\chi$-independence for moduli of 1-dimensional sheaves and moduli of Higgs bundles* (p. 77) |
| 16:00 - 16:30 | Iva Halacheva (Northeastern University), *Lagrangian correspondences in Schubert calculus* (p. 75) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 10:00 - 10:30 | Eloise Hamilton (IMJ-PRG, University of Paris), *Moduli spaces for unstable Higgs bundles of rank 2 and their geometry* (p. 75) |
| 10:30 - 11:00 | Peter Crooks (Northeastern University), *Hessenberg varieties and Poisson slices* (p. 74) |
| 14:00 - 14:30 | Olivia Dumitrescu (UNC Chapel Hill) (p. 75) |
| 14:30 - 15:00 | Ana Balibanu (Harvard University), *Steinberg slices in quasi-Poisson varieties* (p. 74) |
| 15:00 - 15:30 | Lisa Jeffrey (University of Toronto), *The triple reduced product and Higgs bundles* (p. 76) |
| 15:30 - 16:00 | Brent Pym (McGill University), *Beauville-Bogomolov-Weinstein splitting for Poisson varieties* (p. 76) |
| 16:00 - 16:30 | Shiyu Shen (University of Toronto), *Topological mirror symmetry for parabolic Higgs bundles* (p. 77) |
| 16:30 - 17:00 | Jacques Hurtubise (McGill University), *Moduli of bundles and degenerations of curves.* (p. 75) |

## Abstracts/Résumés

**ANA BALIBANU**, Harvard University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Steinberg slices in quasi-Poisson varieties*

We consider a multiplicative analogue of the universal centralizer of a semisimple group G — a family of centralizers parametrized by the regular conjugacy classes of the simply-connected cover of G. This multiplicative analogue has a natural symplectic structure and sits as a transversal in the quasi-Poisson double D(G). We show that D(G) extends to a smooth groupoid over the wonderful compactification of G, and we use this to construct a log-symplectic partial compactification of the multiplicative universal centralizer.

**PETER CROOKS**, Northeastern University
[Saturday December 5 / samedi 5 décembre, 10:30]
*Hessenberg varieties and Poisson slices*

Hessenberg varieties constitute a natural generalization of Grothendieck–Springer fibres, and their study lies at the interface of algebraic geometry, representation theory, and symplectic geometry. One defines Hessenberg varieties in the presence of Lie-theoretic data, which often include a complex semisimple Lie algebra $\mathfrak{g}$ with adjoint group $G$, the wonderful compactification

$\overline{G}$ of $G$, and the log cotangent bundle $\mu : T^*\overline{G}(\log D) \longrightarrow \mathfrak{g} \oplus \mathfrak{g}$. The family of *standard Hessenberg varieties* is then a log symplectic Hamiltonian $G$-variety $\nu : \mathrm{Hess} \longrightarrow \mathfrak{g}$ bearing a close connection to the Kostant−Toda lattice. Balibanu has constructed a Poisson isomorphism

$$\mu^{-1}(\mathcal{S} \times \mathcal{S}) \cong \nu^{-1}(\mathcal{S}) \quad (*),$$

where $\mathcal{S} \subseteq \mathfrak{g}$ is a principal Slodowy slice. This allows one to embed generic fibres of $\nu$ into $\overline{G}$.
I will explain that $(*)$ extends to a $G$-equivariant Poisson bimeromorphism

$$\mu^{-1}(\mathfrak{g} \times \mathcal{S}) \cong \mathrm{Hess} \quad (**),$$

and that $(**)$ is an isomorphism if $\mathfrak{g} = \mathfrak{sl}_2$. This represents joint work with Markus Röser.

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**JACK DING**, University of Toronto
[Friday December 4 / vendredi 4 décembre, 14:00]
*Equivariant multiplicities of Schubert Varieties in the Based Loop Group*

We compute equivariant multiplicities in the K-homology of Schubert varieties in the based loop group $\Omega G$ for the case of $G = SU(2)$. After taking a limit as the dimension of the Schubert varieties goes to $\infty$, we can interpret our results as an infinite-dimensional version of the well-known Atiyah-Bott-Lefschetz Formula. From this result we also derive an effective formula for computing characters of certain Demazure modules.

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**OLIVIA DUMITRESCU**, UNC Chapel Hill
[Saturday December 5 / samedi 5 décembre, 14:00]

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**IVA HALACHEVA**, Northeastern University
[Friday December 4 / vendredi 4 décembre, 16:00]
*Lagrangian correspondences in Schubert calculus*

Given a reductive algebraic group G, it is a natural question to consider the inclusions of partial flag varieties H/Q into G/P and their pullbacks in equivariant cohomology, in terms of Schubert classes. We look at the case of the symplectic and usual Grassmannian, and describe a generalized construction involving Maulik-Okounkov classes and cotangent bundles of the Grassmannians, with Lagrangian correspondences playing a key role. This is joint work with Allen Knutson and Paul Zinn-Justin.

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**ELOISE HAMILTON**, IMJ-PRG, University of Paris
[Saturday December 5 / samedi 5 décembre, 10:00]
*Moduli spaces for unstable Higgs bundles of rank 2 and their geometry*

The moduli space of semistable Higgs bundles is widely studied thanks to its rich geometric structure, in particular as it is an example of a Completely Integrable Hamiltonian System. In this talk we shift our focus from semistable to unstable Higgs bundles, guided by the questions of whether moduli spaces for unstable Higgs bundles can be constructed, and if so whether they admit a similarly rich geometric structure. We will start by considering the case of unstable (twisted) Higgs bundles of rank 2 on the projective line and by showing how moduli spaces can be constructed explicitly in this setting. We will then consider such Higgs bundles on a curve of arbitrary genus and explain how recent results in a generalisation of Geometric Invariant Theory (GIT), called Non-Reductive GIT, can be used to construct moduli spaces for them. We will finish by briefly describing initial steps towards understanding the geometry of these moduli spaces.

**JACQUES HURTUBISE**, McGill University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Moduli of bundles and degenerations of curves.*

A good picture of the degeneration of moduli of bundles, corresponding to a degeneration of a smooth curve to a nodal curve would involve on one hand a good holomorphic family of moduli, and on the other, and in parallel, a compatible degeneration of the moduli of representations of the fundamental group of the surface, following Narasimhan and Seshadri. We present an approach to this problem. (joint with I. Biswas)

**LISA JEFFREY**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 15:00]
*The triple reduced product and Higgs bundles*

We give an identification of the triple reduced product of three coadjoint orbits in $SU(3)$ with a space of Hitchin pairs $(\mathcal{E}, \Phi)$ over a genus $0$ curve with three punctures, where the residues of $\Phi$ at the punctures are constrained to lie in fixed coadjoint orbits. In the language of Hitchin systems, we identify the moment map for a Hamiltonian circle action on this space of pairs. We make use of the results of Adams, Harnad and Hurtubise to find a description of this system.

**DAVESH MAULIK**, MIT
[Friday December 4 / vendredi 4 décembre, 14:30]
*Cohomology of the moduli of Higgs bundles and the Hausel-Thaddeus conjecture*

I will discuss some results on the structure of the cohomology of the moduli space of stable $SL_n$ Higgs bundles on a curve. As a consequence, we obtain a new proof of the Hausel-Thaddeus conjecture, proven previously by Groechenig-Wyss-Ziegler via p-adic integration. If time allows, I will also mention connections with the P=W conjecture. This is joint work with Junliang Shen.

**RUXANDRA MORARU**, University of Waterloo
[Friday December 4 / vendredi 4 décembre, 13:30]
*Moduli spaces of stable bundles on complex nilmanifolds*

A *nilmanifold* is the quotient $N = \Gamma\backslash G$ of a connected, simply connected nilpotent Lie group $G$ by a discrete, co-compact subgroup $\Gamma \subset G$. If $N$ is equipped with a complex structure $I$ induced by a left-invariant complex structure on $G$, then $(N, I)$ is called a *complex nilmanifold*. Other than complex tori, examples of complex nilmanifolds are given by Kodaira surfaces and Iwasawa manifolds, to name a few. In this talk, I will present some interesting examples of moduli spaces of stable bundles on complex nilmanifolds.

**ALEXEI OBLOMKOV**, University of Massachusetts, Amherst
[Friday December 4 / vendredi 4 décembre, 13:00]
*3D sigma models with defects and knot homology*

Talk is based on the joint work with Lev Rozansky. In our work we construct a mathematical model for the gauged Kapustin-Rozansky-Saulina 3D sigma model with defects. The targets of the sigma model are the cotangent bundles to Lie algebras $\mathfrak{gl}_n$. The source of the sigma models is $\mathbb{R}^2 \times S^1$. In the case when the surface defect is of the form $C \times S^1 \subset \mathbb{R}^2 \times S^1$ the value of the partition function on the surface $\mathbb{R}^2 \times$ point is equal to the Khovanov-Rozansky homology of the knot that projects to $C$. Physics leads us to a geometric realisation of the Ocneanu-Jones trace in terms of sheaves on the Hilbert scheme of points on the plane. We use our constructions to explicitly compute the homology of torus knots. We also prove Poincare duality for the homology of knots, the duality that was conjectured by Dunfield-Gukov-Rasmussen in 2005.

**BRENT PYM**, McGill University
[Saturday December 5 / samedi 5 décembre, 15:30]
*Beauville-Bogomolov-Weinstein splitting for Poisson varieties*

The celebrated Beauville-Bogomolov and Weinstein decomposition theorems explain that certain geometries can be "split" as a product of smaller-dimensional geometries of the same type: the former is a global splitting for compact Kähler manifolds with trivial canonical class, while the latter is a local splitting for Poisson manifolds near a point on a symplectic leaf. I will describe a sort of fibre product of these results, governing the structure of complex projective Poisson manifolds. It shows, for instance, that after passing to an étale cover, a projective Poisson variety with a simply connected compact symplectic leaf splits as a product of said leaf and a projective Poisson variety containing a point where its Poisson bracket vanishes. The proof combines results from Hodge theory and holomorphic foliation theory with a recent notion of "subcalibations" for Poisson manifolds due to Frejlich and Mărcut in the differentiable setting. This talk is based on joint work with Stéphane Druel, Jorge Vitório Pereira and Frédéric Touzet.

**JUNLIANG SHEN**, MIT
[Friday December 4 / vendredi 4 décembre, 15:30]
*Cohomological $\chi$-independence for moduli of 1-dimensional sheaves and moduli of Higgs bundles*

Let $M_\chi$ be either (a) the moduli space of 1-dimensional semistable sheaves $F$ on a toric del Pezzo surface (e.g. $\mathbb{P}^2$) with $\chi(F) = \chi$, or (b) the moduli space of semistable Higgs bundles $(E, \theta)$ with respect to an effective divisor $D$ on a curve of degree $\deg(D) > 2g - 2$ satisfying $\chi(E) = \chi$. Although the topology of the (possibly singular) variety $M_\chi$ relies heavily on $\chi$, we show that the intersection cohomology of $M_\chi$ is indepedent of $\chi$. This proves conjectures of Bousseau and Toda. In this talk, we will discuss particularly the role played by integrable systems in the $\chi$-independence phenomenon. This is based on joint work in progress with Davesh Maulik.

**SHIYU SHEN**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 16:00]
*Topological mirror symmetry for parabolic Higgs bundles*

I will present work on establishing the correspondence between the (appropriately defined) Hodge numbers of the moduli spaces of parabolic Higgs bundles for the structure groups $SL_n$and $PGL_n$, building on previous work of Groechenig-Wyss-Ziegler on the non-parabolic case. I will first describe the strategy used by Groechenig-Wyss-Ziegler, which combines p-adic integration with the generic duality between the Hitchin systems. Then I will talk about the new ingredients that come into play in the parabolic setting.

# Applications and Recent Developments in Discontinuous Dynamical Systems / Applications et Avancées Récentres dans la Théorie des Systèmes Dynamiques Manifestant des Discontinuités

**Org: Kevin Church** (McGill) and/et **Stacey Smith ?** (Ottawa)

## Schedule/Horaire

| **Saturday December 5** | **samedi 5 décembre** |
|---|---|
| 14:00 - 14:30 | Stacey Smith ? (Ottawa), *Using non-smooth models to determine thresholds for microbial pest management* (p. 80) |
| 14:30 - 15:00 | Everaldo de Mello Bonotto (Universidade de Sau Paulo), *Impulsive semidynamical systems* (p. 78) |
| 15:00 - 15:30 | Tyler Meadows (University of Idaho), *Self-cycling fermentation with a produced compound* (p. 80) |
| 15:30 - 16:00 | Gabriel Duchesne (McGill), *Rigorous computations of periodic solutions for the pulse-harvested Hutchinson equation* (p. 79) |
| 16:00 - 16:30 | Aili Wang (Baoji University of Arts and Sciences) (p. 81) |

| **Sunday December 6** | **dimanche 6 décembre** |
|---|---|
| 14:00 - 14:30 | Kexue Zhang (Calgary), *A unified asymptotic stability result for time-delay systems with delayed impulses* (p. 81) |
| 14:30 - 15:00 | Kevin Church (McGill), *Spectral theory for impulsive delay differential equations* (p. 79) |
| 15:00 - 15:30 | Elena Braverman (Calgary), *Stabilization of cycles with impulse stochastic control* (p. 78) |
| 15:30 - 16:00 | Marcia Federson (Universidade de Sau Paulo), *An overview on stability results for impulsive and measure functional differential equations* (p. 79) |
| 16:00 - 16:30 | Xinzhi Liu (Waterloo), *Impulsive Formation Control of Multi-Agent Systems* (p. 79) |

| **Monday December 7** | **lundi 7 décembre** |
|---|---|
| 14:00 - 14:30 | Gail Wolkowicz (McMaster), *Bifurcation analysis of an impulsive system describing Partial Nitritation and Anammox in a hybrid reactor* (p. 81) |
| 14:30 - 15:00 | Frithjof Lutscher (Ottawa), *Population dynamics of discrete breeders* (p. 79) |
| 15:00 - 15:30 | Iain Moyles (York), *A model of phosphorus recycling at the plant scale* (p. 80) |
| 15:30 - 16:00 | Marco Tosato (York), *Multi-cycle Periodic Solutions of a Differential Equation with Delay that Switches Periodically* (p. 80) |
| 16:00 - 16:30 | Gergely Rost (Szeged University) (p. 80) |

## Abstracts/Résumés

**EVERALDO DE MELLO BONOTTO**, University of Sao Paulo
[Saturday December 5 / samedi 5 décembre, 14:30]
*Impulsive semidynamical systems*

Impulsive systems are used to describe the evolution of process whose continuous dynamics are interrupted by abrupt changes of state. In this talk, we present an overview of the theory of impulsive semidynamical systems.

**ELENA BRAVERMAN**, University of Calgary
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Stabilization of cycles with impulse stochastic control*

We consider models of population dynamics and stabilize a prescribed cycle or an equilibrium of the difference equation using impulse stochastic control. Our technique, inspired by the Kolmogorov's Law of Large Numbers, activates a stabilizing effect of stochastic perturbation and allows for stabilization using a much wider range for the control parameter than would be possible in the absence of noise. Our main general result applies to both Prediction-Based and Target-Oriented Controls. This analysis is the first to make use of the stabilizing effects of noise for Prediction-Based Control ; the stochastic version has been examined in the literature, but only the destabilizing effect of noise was demonstrated. A stochastic variant of Target-Oriented Control has never been considered, to the best of our knowledge, and we propose a specific form that uses a point equilibrium or one point on a cycle as a target. We demonstrate our results numerically on the logistic, Ricker and Maynard Smith models. This is joint work with C. Kelly (University College Cork) and A. Rodkina (University of the West Indies).

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**KEVIN CHURCH**, McGill
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Spectral theory for impulsive delay differential equations*

I will present some recent work on spectral theory for impulsive functional differential equations, with an emphasis on systems with discrete delays. For systems with periodic structure, this includes the associated Floquet theory. I will conclude with some applications to stability and bifurcation in mathematical models from ecology and infectious diseases.

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**GABRIEL DUCHESNE**, McGill University
[Saturday December 5 / samedi 5 décembre, 15:30]
*Rigorous computations of periodic solutions for the pulse-harvested Hutchinson equation*

I will present a rigorous numerical method to prove the existence of periodic solutions for the pulse-harvested Hutchinson equation. I will also briefly explain how we can extend this method to prove the existence of a global branch of periodic solutions.

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**MARCIA FEDERSON**, Universidade de São Paulo, Brazil
[Sunday December 6 / dimanche 6 décembre, 15:30]
*An overview on stability results for impulsive and measure functional differential equations*

In this talk, we present results on stability, uniform stability and asymptotic stability for measure functional differential equations via generalized ODEs in the sense of J. Kurzweil. Impulsive problems are dealt with as a consequence of the main results.

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**XINZHI LIU**, University of Waterloo
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Impulsive Formation Control of Multi-Agent Systems*

As one of the most significant issues in the distributed coordination of multi-agent systems, formation control has received increased attention in recent years due to its wide applications in satellite formation flying, exploration, surveillance and rescue. The formation control problem aims to design suitable protocols such that a group of agents can reach a desired geometric structure from arbitrary initial positions. This talk discusses multi-group formation of multi-agent systems with multiple leaders. An impulsive protocol is proposed to take into consideration of intermittent communications among agents on a sequence of discrete times. It is shown, by employing results from graph theory and dynamical systems, that agents may be divided into multiple subgroups to follow different leaders while maintaining desired sub-formation configurations.

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**FRITHJOF LUTSCHER**, University of Ottawa
[Monday December 7 / lundi 7 décembre, 14:30]
*Population dynamics of discrete breeders*

Many species are discrete (annual) breeders who, between reproductive events, consume resources and may die. Their resource often reproduces continuously or has short, overlapping generations. An accurate model for such life cycles needs to represent both, the discrete and the continuous processes in the community.

I will present a basic model for a single consumer and its resource in a two-season environment. I will give some basic properties of the model and explain how it differs from the purely continuous and the purely discrete analogues that have been studied for many decades. Then I will expand the model in two aspects: (i) I will consider coexistence mechanisms for many discrete-breeder consumers on a single limiting resource, and (ii) I will introduce spatial movement and present conditions for Turing pattern formation in such systems. This is joint work with Yunfeng Geng and Xiaoying Wang.

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**TYLER MEADOWS**, University of Idaho
[Saturday December 5 / samedi 5 décembre, 15:00]
*Self-cycling fermentation with a produced compound*

Self-cycling fermentation is a bioengineering process that is used in biofuel production and wastewater treatment. Due to some large differences in time-scales, the process can be modeled using a system of impulsive differential equations. Recently, engineers have been exploring different methods to trigger the discontinuous portion of the dynamics, called the decanting process. We examine a model of the self-cycling fermentation process in which the concentration of a produced compound is used to trigger the decanting process.

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**IAIN MOYLES**, York University
[Monday December 7 / lundi 7 décembre, 15:00]
*A model of phosphorus recycling at the plant scale*

We present a model of phosphorus in soil that is taken up by a plant through its root systems. We consider the transformation of nutrient from labile forms in soil to above-ground biomass which is lost as leaf litter and is re-supplied to soil due to bacterial degradation. Since the plant roots are of a finite length, the removal term is discontinuous across the soil domain. Asymptotic analysis allows us to perform a model reduction that captures the phosphorus profile in various aspects of the soil. This has important implications in regional phosphorus management.

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**GERGELY ROST**, Szeged University
[Monday December 7 / lundi 7 décembre, 16:00]

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**STACEY SMITH ?**, The University of Ottawa
[Saturday December 5 / samedi 5 décembre, 14:00]
*Using non-smooth models to determine thresholds for microbial pest management*

Releasing infectious pests could successfully control and eventually maintain the number of pests below a threshold level. To address this from a mathematical point of view, two non-smooth microbial pest-management models with threshold policy are proposed and investigated in the present paper. First, we establish an impulsive model with state-dependent control to describe the cultural control strategies, including releasing infectious pests and spraying chemical pesticide. We examine the existence and stability of an order-1 periodic solution, the existence of order-k periodic solutions and chaotic phenomena of this model by analyzing the properties of the Poincaré map. Secondly, we establish and analyze a Filippov model. By examining the sliding dynamics, we investigate the global stability of both the pseudo-equilibria and regular equilibria. The findings suggest that we can choose appropriate threshold levels and control intensity to maintain the number of pests at or below the economic threshold. The modelling and control outcomes presented here extend the results for the system with impulsive interventions at fixed moments.

**MARCO TOSATO**, York University
[Monday December 7 / lundi 7 décembre, 15:30]
*Multi-cycle Periodic Solutions of a Differential Equation with Delay that Switches Periodically*

We analyse the dynamics of a scalar Delay Differential Equation with delay that periodically switches between two constant values. Such an equation arises naturally from structured vector populations involved in a range of vector-borne diseases spreading in a periodically varying environment. In particular, we show the example of a tick population model and how it can be described by this equation.

Then, we examine if and how the two different time lags and the switching time influence the existence and patterns of periodic solutions. We pay particular attention to the patterns involving multi-cycles within the prime period of the periodic solutions.

**AILI WANG**, Baoji University of Arts and Sciences
[Saturday December 5 / samedi 5 décembre, 16:00]

**GAIL WOLKOWICZ**, McMaster University
[Monday December 7 / lundi 7 décembre, 14:00]
*Bifurcation analysis of an impulsive system describing Partial Nitritation and Anammox in a hybrid reactor*

Low-energy nitrogen removal under mainstream conditions is a technology that has received significant attention in recent years as the water industry drives towards long-term sustainability goals. Simultaneous partial nitritation-Anammox (PN/A) is one process that can provide substantial energy reduction and lower sludge yields. Mathematical modeling of the PN/A process offers engineers insights into the operating conditions necessary to maximize its potential. Laureni et al., Water Res. (2019) published a reduced mechanistic model of the process operated as a sequencing batch reactor, highlighting the effect of three key operating parameters on performance (Anammox biofilm activity, dissolved oxygen concentration, and fraction of solids wasted). Their analysis was limited to simulation with relatively few discrete parameter sets. We demonstrate using bifurcation theory applied to an impulsive system that the parameter space can be partitioned into regions in which the system converges to different fixed points that represent different outcomes: either the washout of nitrite oxidizing bacteria or their survival. Mapping process performance data onto these spaces allows engineers to target suitable operating regimes for specific objectives. We note that the nitrogen removal efficiency is maximized close to the curve of transcritical bifurcation points that separates the regions in parameter space where nitrite oxidizing bacteria washout from the region in which they survive. Further, control of solids washout and Anammox biofilm activity can also reduce oxygen requirements while maintaining an appropriate Hydraulic Retention Time. This approach is useful given the possibility for using such a methodology for models of increasing complexity.

**KEXUE ZHANG**, University of Calgary
[Sunday December 6 / dimanche 6 décembre, 14:00]
*A unified asymptotic stability result for time-delay systems with delayed impulses*

In this talk, we present a result of asymptotic stability of time-delay systems with delay-dependent impulses. This unified stability criterion can be applied to a variety of impulsive systems, such as systems with stabilizing continuous dynamics and destabilizing (or stabilizing) impulses, systems with destabilizing continuous evolution and stabilizing impulses, or systems with marginal stable continuous dynamics or marginal stable impulse effects. The unified stability criterion provides the (reverse) average dwell-time conditions on the impulse time sequences, and it is more general than the existing results in the sense that the derived stability guarantee does not require the uniform lower (and/or upper) bound of the impulse intervals. This is joint work with Elena Braverman (Calgary).

# Arithmetic Statistics / Statistique Arithmétique

Org: **Chantal David** (Concordia), **Matilde Lalin** (UdeM) and/et **Jerry Wang** (Waterloo)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Neha Prabhu (Chennai Mathematical Institue), *A joint distribution theorem with applications to extremal primes for elliptic curves* (p. 85) |
| 13:30 - 14:00 | Anup Dixit (Chennai Mathematical Institute), *On the classification problem for general Dirichlet series* (p. 84) |
| 14:00 - 14:30 | Lucile Devin (Chalmers University of Technology and University of Gothenburg), *Chebyshev's bias and sums of two squares* (p. 83) |
| 14:30 - 15:00 | Alexandra Florea (Columbia University), *Non-vanishing for cubic $L$-functions* (p. 84) |
| 15:30 - 16:00 | Quanli Shen (University of Lethbridge), *The fourth moment of quadratic Dirichlet $L$-functions* (p. 86) |
| 16:00 - 16:30 | Alia Hamieh (University of Northern British Columbia), *Mean squares of long Dirichlet polynomials with the divisor function $\tau_2(n)$* (p. 84) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Ahmet Guloglu (Bilkent University), *Non-vanishing of Cubic Twists of L-functions* (p. 84) |
| 14:30 - 15:00 | Asif Zaman (Toronto), *An approximate form of Artin's holomorphy conjecture and nonvanishing of Artin L-functions* (p. 87) |
| 15:00 - 15:30 | Amita Malik (AIM), *Bias statistics for the zeros of L-functions* (p. 85) |
| 15:30 - 16:00 | Allysa Lumley (CRM), *Primes in short intervals: Heuristics and calculations* (p. 85) |
| 16:00 - 16:30 | Will Sawin (Columbia), *Measures from moments for random groups* (p. 86) |
| 16:30 - 17:00 | Seoyoung Kim (Queen's University), *From the Birch and Swinnerton-Dyer conjecture to Nagao's conjecture* (p. 84) |
| 17:00 - 17:30 | Stanley Xiao (University of Toronto), *The number of quartic-$D_4$ fields having monogenic cubic resolvent ordered by conductor* (p. 86) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Arul Shankar (University of Toronto), *The 2-torsion subgroups of the class groups in families of cubic fields* (p. 86) |
| 14:30 - 15:00 | Emilia Alvarez (University of Bristol), *Moments of the logarithmic derivative of characteristic polynomials from $SO(N)$ and $USp(2N)$* (p. 82) |
| 15:00 - 15:30 | Emma Bailey (University of Bristol), *Moments of Moments of $L$-functions* (p. 83) |
| 15:30 - 16:00 | Antoine Comeau-Lapointe (Concordia University), *One-level density of the family of twists of an elliptic curve over function fields* (p. 83) |
| 16:00 - 16:30 | Martin Cech (Concordia University), *Mean values of real Dirichlet characters and double Dirichlet series* (p. 83) |
| 16:30 - 17:00 | Brad Rodgers (Queen's University), *Primes in short intervals in number fields* (p. 85) |
| 17:00 - 17:30 | Wanlin Li (CRM), *The Central Value of Dirichlet L-functions over Rational Function Fields* (p. 85) |

## Abstracts/Résumés

**EMILIA ALVAREZ**, University of Bristol
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Moments of the logarithmic derivative of characteristic polynomials from $SO(N)$ and $USp(2N)$*

I will discuss recent work with Nina Snaith on asymptotics of moments of the logarithmic derivative of characteristic polynomials of orthogonal $SO(N)$ and symplectic $USp(2N)$ random matrices, evaluated near the point 1. The leading order behaviour in this regime as N tends to infinity is governed by the likelihood that the matrices in each ensemble have an eigenvalue at or near the point 1. These results follow recent work of Bailey, Bettin, Blower, Conrey, Prokhorov, Rubinstein and Snaith, where they compute these asymptotics in the case of unitary random matrices.

**EMMA BAILEY**, University of Bristol
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Moments of Moments of $L$-functions*

This talk will present results on the 'moments of moments' for the random matrix groups associated with the symmetry classes for families of $L$-functions (motivated by the work of Keating and Snaith, and Katz and Sarnak). We also formulate the moments of moments of $\zeta(1/2+it)$ which, under a conjecture of Conrey et al., have a multiple contour integral representation. For such a representation, we are able to prove that the moments of moments coincide with the random matrix result. This talk includes work joint with Theo Assiotis and Jon Keating.

**MARTIN CECH**, Concordia University
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Mean values of real Dirichlet characters and double Dirichlet series*

We will study the double sum of Jacobi symbols

$$\sum_{n\leq X}\sum_{m\leq Y}\left(\frac{m}{n}\right).$$

An asymptotic formula valid for all values of $X, Y$ was found by Conrey, Farmer and Soundararajan by using Poisson summation and then estimating the sums of Gauss sums that arise in the computation. We will study the sum using Mellin inversion twice and investigating the analytic properties of a double Dirichlet series. This leads to the same asymptotic with an improved error term.

**ANTOINE COMEAU-LAPOINTE**, Concordia University
[Sunday December 6 / dimanche 6 décembre, 15:30]
*One-level density of the family of twists of an elliptic curve over function fields*

We fix an elliptic curve $E/\mathbb{F}_q(t)$ and consider the family $\{E\otimes\chi_D\}$ of $E$ twisted by quadratic Dirichlet characters. The one-level density of their $L$-functions is shown to follow orthogonal symmetry for test functions with Fourier transform supported inside $(-1,1)$. As an application, we obtain an upper bound of 3/2 on the average analytic rank. By splitting the family according to the sign of the functional equation, we obtain that at least $12.5\%$ of the family have rank zero, and at least $37.5\%$ have rank one. The Katz and Sarnak philisophy predicts that those percentages should both be $50\%$ and the average analytic rank should be $1/2$. We finish by computing the one-level density of $E$ twisted by Dirichlet characters of order $\ell$ coprime to $q$ where we obtain a restriction of $(-1/2,1/2)$ on the support.

**LUCILE DEVIN**, Chalmers University of Technology and Gothenburg University
[Friday December 4 / vendredi 4 décembre, 14:00]
*Chebyshev's bias and sums of two squares*

Studying the secondary terms of the Prime Number Theorem in Arithmetic Progressions, Chebyshev claimed that there are more prime numbers congruent to 3 modulo 4 than to 1 modulo 4. This claim was explained and quantified by Rubinstein and Sarnak. We will see how their framework can be adapted to other questions on the distribution of prime numbers. In particular, we will present a new Chebyshev-like claim : there are "more" prime numbers that can be written as a sum of two squares with the even square larger than the odd square than the other way around.

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**ANUP DIXIT**, Chennai Mathematical Institute
[Friday December 4 / vendredi 4 décembre, 13:30]
*On the classification problem for general Dirichlet series*

A typical $L$-function comes equipped with a functional equation, which gives rise to invariants such as degree and conductor. A natural converse question is whether we can determine the $L$-function from these invariants. We consider this problem in the context of general Dirichlet series, where we define the degree and conductor using growth conditions. Under certain constraints, we show that there are only finitely many general Dirichlet series with a given degree and conductor.

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**ALEXANDRA FLOREA**, Columbia University
[Friday December 4 / vendredi 4 décembre, 14:30]
*Non-vanishing for cubic $L$-functions*

Chowla conjectured that $L(1/2, \chi)$ never vanishes, for $\chi$ any Dirichlet character. Soundararajan showed that more than $87.5\%$ of the values $L(1/2, \chi_d)$, for $\chi_d$ a quadratic character, do not vanish. Much less is known about cubic characters. Baier and Young showed that more than $X^{6/7-\epsilon}$ of $L(1/2, \chi)$ are non-vanishing, for $\chi$ a primitive, cubic character of conductor of size up to $X$. I will talk about recent joint work with C. David and M. Lalin, where we show that a positive proportion of these central $L$-values are non-vanishing in the function field setting. This is achieved by computing the first mollified moment using techniques previously developed by the authors in their work on the first moment of cubic $L$–functions, and by obtaining a sharp upper bound for the second mollified moment, building on work of Soundararajan, Harper and Lester–Radziwill.

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**AHMET GULOGLU**, Bilkent University
[Saturday December 5 / samedi 5 décembre, 14:00]
*Non-vanishing of Cubic Twists of L-functions*

By looking at the one-level density for the family of Hecke L-functions associated with primitive cubic Dirichlet characters defined over the Eisenstein field, we show that a positive proportion of the L-functions associated with a thin subfamily of these characters do not vanish at the central point s = 1/2.

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**ALIA HAMIEH**, University of Northern British Columbia
[Friday December 4 / vendredi 4 décembre, 16:00]
*Mean squares of long Dirichlet polynomials with the divisor function $\tau_2(n)$*

In this talk, I report on a joint work with Nathan Ng. We prove an asymptotic formula for mean values of long Dirichlet polynomials with coefficients $\tau_2(n)$. This establishes a special case of a conjecture of Conrey and Gonek (1998) that gives an asymptotic estimate for the mean square of the Dirichlet polynomial associated with the divisor function $\tau_k(n)$. Our asymptotic formula has all lower order terms with a power savings error term.

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**SEOYOUNG KIM**, Queen's University
[Saturday December 5 / samedi 5 décembre, 16:30]
*From the Birch and Swinnerton-Dyer conjecture to Nagao's conjecture*

Let $E$ be an elliptic curve over $\mathbb{Q}$ with discriminant $\Delta_E$. For primes $p$ of good reduction, let $N_p$ be the number of points modulo $p$ and write $N_p = p + 1 - a_p$. In 1965, Birch and Swinnerton-Dyer formulated a conjecture which implies

$$\lim_{x\to\infty} \frac{1}{\log x} \sum_{\substack{p\le x \\ p\nmid \Delta_E}} \frac{a_p \log p}{p} = -r + \frac{1}{2},$$

where $r$ is the order of the zero of the $L$-function $L_E(s)$ of $E$ at $s = 1$, which is predicted to be the Mordell-Weil rank of $E(\mathbb{Q})$. We show that if the above limit exits, then the limit equals $-r + 1/2$. We also relate this to Nagao's conjecture. This is a recent joint work with M. Ram Murty.

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**WANLIN LI**, MIT
[Sunday December 6 / dimanche 6 décembre, 17:00]
*The Central Value of Dirichlet L-functions over Rational Function Fields*

The central value of a Dirichlet L-function over $\mathbb{F}_q(t)$ is governed by the Zeta function of a smooth project curve over $\mathbb{F}_q$. Using this connection to geometry, we show a lower bound on the number of quadratic characters with conductor $\le X$ whose L-functions vanish at the central point. The existence of infinitely many such characters is in contrast with the situation over the rational numbers, where a conjecture of Chowla predicts there should be no such L-functions. Towards this direction, for each fixed $q$, we give an explicit upper bound on the number of such quadratic characters. This upper bound decreases as $q$ grows and it goes to $0\%$ as $q \to \infty$. In this talk, I will also discuss Dirichlet characters of odd prime order $\ell$ and the central value of their L-functions. Some of the results in this talk are joint work with Jordan Ellenberg and Mark Shusterman.

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**ALLYSA LUMLEY**, Centre de Reserches Mathématiques
[Saturday December 5 / samedi 5 décembre, 15:30]
*Primes in short intervals: Heuristics and calculations*

We formulate, using heuristic reasoning, precise conjectures for the range of the number of primes in intervals of length $y$ around $x$, where $y \ll (\log x)^2$. In particular, we conjecture that the maximum grows surprisingly slowly as $y$ ranges from $\log x$ to $(\log x)^2$. We will show that our conjectures are somewhat supported by available data, though not so well that there may not be room for some modification. This is joint work with Andrew Granville.

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**AMITA MALIK**, American Institute of Mathematics
[Saturday December 5 / samedi 5 décembre, 15:00]
*Bias statistics for the zeros of L-functions*

In this talk, we discuss the arithmetic statistics for the bias density function concerning the distribution of the fractional part of the zeros of L-functions. This bias was first noted by Rademacher in 1956 in the case of the Riemann zeta function and further elucidated by Ford-Zaharescu and Ford-Soundararajan-Zaharescu more recently.

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**NEHA PRABHU**, Indian Institute of Science Education and Research-Pune, India
[Friday December 4 / vendredi 4 décembre, 13:00]
*A joint distribution theorem with applications to extremal primes for elliptic curves*

An extremal prime $p$ for an elliptic curve $E$ is one for which $|a_p(E)| = [2\sqrt{p}]$ i.e., $a_p(E)$ is maximal or minimal in view of the Hasse bound. Although an asymptotic for the number of extremal primes up to $x$ for a fixed non-CM elliptic curve seems out of reach, upper bounds have been proved recently. In this talk, assuming GRH, we present a joint distribution result involving the Chebotarev density theorem. As a consequence, we obtain an upper bound for the number of primes satisfying $a_p(E) = [2\sqrt{p}] \mod \ell$ for a sufficiently large prime $\ell$. This is joint work with Amita Malik.

**BRAD RODGERS**, Queen's University
[Sunday December 6 / dimanche 6 décembre, 16:30]
*Primes in short intervals in number fields*

In this talk I hope to discuss different analogies for the notion of a short interval in algebraic number fields, and in particular discuss a classical conjecture of Goldston and Montgomery about the distribution of primes in short intervals in this more general setting. As we will see for some notions of a short interval their conjecture appears to carry over naturally, while for other notions it appears to not. This is based off the computation of sums of singular series in this setting. This is joint work with Vivian Kuperberg and Edva Roditty-Gershon.

**WILL SAWIN**, Columbia University
[Saturday December 5 / samedi 5 décembre, 16:00]
*Measures from moments for random groups*

In probability theory, it is useful to prove that a given measure is determined by its moments. In arithmetic statistics, we often want a result like this for a measure on groups, e.g. the Cohen-Lenstra measure on finite abelian $\ell$-groups (which predicts the distribution of the $\ell$-part of the class groups of imaginary quadratic fields). In this setting, "moments" are the expected number of surjections from a random group to a fixed group. I present a new approach to proving a measure is determined by its moments that works even for non-abelian groups, and is applicable in particular to the measure Liu, Wood, and Zureick-Brown used to predict the distribution of the Galois groups of the maximal unramified extension of a random number field.

**ARUL SHANKAR**, University of
[Sunday December 6 / dimanche 6 décembre, 14:00]
*The 2-torsion subgroups of the class groups in families of cubic fields*

The Cohen–Lenstra–Martinet conjectures have been verified in only two cases. Davenport–Heilbronn compute the average size of the 3-torsion subgroups in the class group of quadratic fields and Bhargava computes the average size of the 2-torsion subgroups in the class groups of cubic fields. The values computed in the above two results are remarkably stable. In particular, work of Bhargava–Varma shows that they do not change if one instead averages over the family of quadratic or cubic fields satisfying any finite set of splitting conditions.

However for certain "thin" families of cubic fields, namely, families of monogenic and n-monogenic cubic fields, the story is very different. In this talk, we will determine the average size of the 2-torsion subgroups of the class groups of fields in these thin families. Surprisingly, these values differ from the Cohen–Lenstra–Martinet predictions! We will also provide an explanation for this difference in terms of the Tamagawa numbers of naturally arising reductive groups. This is joint work with Manjul Bhargava and Jon Hanke.

**QUANLI SHEN**, University of Lethbridge
[Friday December 4 / vendredi 4 décembre, 15:30]
*The fourth moment of quadratic Dirichlet $L$-functions*

In 2010, Soundararajan and Young established the asymptotic formula for the second moment of quadratic twists of a cusp form under the generalized Riemann hypothesis (GRH). They also unconditionally obtained the sharp lower bound which matches Keating-Snaith's conjecture. In this talk, I will discuss the fourth moment of quadratic Dirichlet $L$-functions. Largely based on Soundararajan and Young's work, we obtained the asymptotic formula under GRH, and also the sharp lower bound unconditionally.

**STANLEY XIAO**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 17:00]
*The number of quartic-$D_4$ fields having monogenic cubic resolvent ordered by conductor*

In this talk we discuss how to count quartic fields whose Galois group is isomorphic to the dihedral group $D_4$ and whose ring of integers has a monogenic cubic resolvent ring, ordered by their Artin conductor. In particular we give an asymptotic formula for the number of such fields having a given signature. The techniques we develop also enable us to count such quartic fields by discriminant (but we do not obtain an asymptotic formula) and also elliptic curves with a marked 2-torsion point by discriminant. This is joint work with Cindy Tsang.

**ASIF ZAMAN**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 14:30]
*An approximate form of Artin's holomorphy conjecture and nonvanishing of Artin L-functions*

Let $k$ be a number field and $G$ be a finite group, and let $\mathfrak{F}_k^G$ be a family of number fields $K$ such that $K/k$ is normal with Galois group isomorphic to $G$. Together with Robert Lemke Oliver and Jesse Thorner, we prove for many families that for almost all $K \in \mathfrak{F}_k^G$, all of the $L$-functions associated to Artin representations whose kernel does not contain a fixed normal subgroup are holomorphic and non-vanishing in a wide region.

I will discuss these results and some of their arithmetic applications. For example, we prove a strong effective prime ideal theorem that holds for almost all fields in several natural large degree families, including the family of degree $n$ $S_n$-extensions for any $n \geq 2$ and the family of prime degree $p$ extensions (with any Galois structure) for any prime $p \geq 2$. Other applications relate to bounds on $\ell$-torsion subgroups of class groups, the extremal order of class numbers, and the subconvexity problem for Dedekind zeta functions.

# Combinatorial Designs / Design combinatoire

Org: **Peter Dukes** (UVic), **Karen Meagher** (Regina) and/et **Brett Stevens** (Carleton)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Stefan Glock (ETH Zurich), *Approximate Steiner triple systems of large girth* (p. 90) |
| 13:30 - 14:00 | Curtis Bright (Waterloo), *A Resolution of Lam's Problem via Satisfiability Solvers* (p. 88) |
| 14:00 - 14:30 | Iren Darijani (Memorial), *Colourings of star systems* (p. 89) |
| 15:30 - 16:00 | Daniel Horsley (Monash), *An Evans-style result for block designs* (p. 90) |
| 16:00 - 16:30 | Tao Feng (BJTU), *Novák's conjecture on cyclic Steiner triple systems and its generalization* (p. 90) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Joanna Niezen (Victoria), *Sarvate-Beam Group Divisible Designs* (p. 92) |
| 14:30 - 15:00 | Kevin Halasz (SFU), *Near transversals in group-based latin squares* (p. 90) |
| 15:00 - 15:30 | Coen del Valle (Victoria), *Block designs of dimension three* (p. 89) |
| 15:30 - 16:00 | Trent Marbach (Ryerson University), *The localization number of designs* (p. 91) |
| 16:00 - 16:30 | Kirsten Nelson (Carleton), *Interleaved Sequences* (p. 92) |
| 16:30 - 17:00 | Mahsa Nasrollahi (Regina), *The Erdős-Ko-Rado theorem for 2-intersecting families of perfect matchings* (p. 91) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Esther Lamken, *Applications of incomplete pairwise balanced designs* (p. 91) |
| 14:30 - 15:00 | David Pike (Memorial), *Colourings of Group Divisible Designs* (p. 92) |
| 15:00 - 15:30 | Mateja Sajna (Ottawa), *Bipartite 2-factorizations of complete multigraphs via layering* (p. 92) |
| 15:30 - 16:00 | Peter Danziger (Ryerson), *Directed cycle decompositions of complete digraphs* (p. 89) |
| 16:00 - 16:30 | Andrea Burgess (UNB), *On the Oberwolfach Problem for single-flip 2-factors via graceful labellings* (p. 88) |
| 16:30 - 17:00 | Hadi Kharaghani (Lethbridge), *On Equiangular Tight Frames* (p. 91) |

## Abstracts/Résumés

**CURTIS BRIGHT**, University of Windsor
[Friday December 4 / vendredi 4 décembre, 13:30]
*A Resolution of Lam's Problem via Satisfiability Solvers*

Lam's problem is to determine if a projective plane of order ten exists—a long-standing question since the 1800s when finite projective geometry was first studied. Lam's problem was experimentally resolved via a huge case breakdown and exhaustive computer search in the late 1980s. Despite this fantastic achievement, the resolution relied on special-purpose search code that was never independently verified.

We provide an independent resolution of Lam's problem by reducing the problem to a satisfiability (SAT) problem in Boolean logic that we solve with a combination of SAT solvers and computer algebra systems. Our resolution provides a collection of certificates that a third party can use to verify the nonexistence of a projective plane of order ten.

**ANDREA BURGESS**, University of New Brunswick
[Sunday December 6 / dimanche 6 décembre, 16:00]
*On the Oberwolfach Problem for single-flip 2-factors via graceful labellings*

The *Oberwolfach problem*, OP$(F)$, first posed by Ringel in 1967, asks for a decomposition of the complete graph $K_v$ into copies of a given 2-factor $F$ of order $v$. We give a solution whenever $F$ has a sufficiently large odd cycle meeting a specified lower bound and, in addition, $F$ has a *single-flip* automorphism (i.e. an involutory automorphism which acts as a reflection on exactly one cycle of $F$). For even orders $v$, we give analogous results for the maximum packing and minimum covering variants of the problem for single-flip 2-factors with a sufficiently large even cycle. Our methods involve applying a doubling construction to graceful labellings of 2-regular graphs with a vertex removed, and allow us to explicitly construct solutions to the Oberwolfach Problem with well-behaved automorphisms.

This is joint work with Peter Danziger and Tommaso Traetta.

**PETER DANZIGER**, Ryerson universtiy
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Directed cycle decompositions of complete digraphs*

We consider the problem of decomposing the complete directed graph $K_n^*$ into directed cycles of given lengths. We give general necessary conditions for a directed cycle decomposition of $K_n^*$ into $t$ directed cycles of lengths $m_1, m_2, \ldots, m_t$ to exist and provide a construction for creating such decompositions in the case where there is one 'large' cycle.

We give a complete solution in the case when there are exactly three cycles of lengths $\alpha, \beta, \gamma \neq 2$. Somewhat surprisingly, the general necessary conditions turn out not to be sufficient in this case. In particular, taking $\gamma \geq \beta \geq \alpha > 2$, we show that when $\gamma = n$, $\alpha + \beta > n + 2$ and $\alpha + \beta \equiv n \pmod 4$, $K_n^*$ is not decomposable.

Joint work with A.C. Burgess and M.T. Javed

**IREN DARIJANI**, University of Lethbridge
[Friday December 4 / vendredi 4 décembre, 14:00]
*Colourings of star systems*

An $e$-star is a complete bipartite graph $K_{1,e}$. An $e$-star system of order $n > 1$, $S_e(n)$, is a partition of the edges of the complete graph $K_n$ into $e$-stars. An $e$-star system is said to be $k$-colourable if its vertex set can be partitioned into $k$ sets (called colour classes) such that no $e$-star is monochromatic. The system $S_e(n)$ is $k$-chromatic if $S_e(n)$ is $k$-colourable but is not $(k-1)$-colourable. If every $k$-colouring of an $e$-star system can be obtained from some $k$-colouring $\phi$ by a permutation of the colours, we say that the system is uniquely $k$-colourable. In this talk, we will first see some results on colourings of 3-star systems. Next, we generalize these results for $e$-star systems for any $e \geq 3$. Finally, we see some other results on unique colourings of $e$-star systems that for any $e \geq 3$.

**COEN DEL VALLE**, University of Victoria
[Saturday December 5 / samedi 5 décembre, 15:00]
*Block designs of dimension three*

The dimension of a block design is the maximum positive integer $d$ such that any $d$ points are contained in a proper subdesign.

This talk will discuss the currently known existence results of pairwise balanced designs PBD$(v, K)$ of dimension three, for the sets of block sizes $K = \{3, 4\}$, and $K = \{3, 5\}$. Also to be discussed is dimension three triple systems of arbitrary index, whose existence is a consequence of the existence of the aforementioned pairwise balanced designs.

This is based on work with Peter Dukes, extending previous work by Dukes and Joanna Niezen.

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**TAO FENG**, Beijing Jiaotong University
[Friday December 4 / vendredi 4 décembre, 16:00]
*Novák's conjecture on cyclic Steiner triple systems and its generalization*

Novák conjectured in 1974 that for any cyclic Steiner triple systems of order $v$ with $v \equiv 1 \pmod 6$, it is always possible to choose one block from each block orbit so that the chosen blocks are pairwise disjoint.

In this talk, we shall consider the generalization of this conjecture to cyclic $(v, k, \lambda)$-designs with $1 \leq \lambda \leq k-1$. Superimposing multiple copies of a cyclic symmetric design shows that the generalization cannot hold for all $v$, but we conjecture that it holds whenever $v$ is sufficiently large compared to $k$. We confirm that the generalization of the conjecture holds when $v$ is prime and $\lambda = 1$ and also when $\lambda \leq (k-1)/2$ and $v$ is sufficiently large compared to $k$. As a corollary, we show that for any $k \geq 3$, with the possible exception of finitely many composite orders $v$, every cyclic $(v, k, 1)$-design without short orbits is generated by a $(v, k, 1)$-disjoint difference family.

This is joint work with Daniel Horsley and Xiaomiao Wang.

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**STEFAN GLOCK**, ETH Zürich
[Friday December 4 / vendredi 4 décembre, 13:00]
*Approximate Steiner triple systems of large girth*

A Steiner triple system of order $n$ is a set of triples in an $n$-set such that every pair is contained in exactly one triple. Erdős conjectured in 1973 that for fixed g and any sufficiently large 'admissible' order $n$, there exists a Steiner triple system of order $n$ with girth at least $g$, meaning that there are no $j$ points which span at least $j$-2 triples for all $3 < j < g$. We motivate this notion of sparseness and discuss the state of the art of the conjecture. Our contribution is an approximate solution using probabilistic methods.

The talk is based on joint work with Daniela Kühn, Allan Lo and Deryk Osthus.

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**KEVIN HALASZ**, Simon Fraser University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Near transversals in group-based latin squares*

Latin squares (of order $n$) are $n \times n$ arrays in which each row and each column is a permutation of the integers $[0, n-1]$. We say a latin square $L$ is group-based if it is possible to order the elements of a group $G = \{g_0, g_1, \ldots, g_{n-1}\}$ so that $L_{i,j} = k$ if and only if $g_i \cdot g_j = g_k$.

A famous conjecture, variously attributed to Ryser, Brualdi, and Stein, asserts that in every latin square of order $n$ it is possible to find a collection of $n-1$ cells which intersects each row and column, and contains each symbol, at most once—such a collection of cells is known as a near transversal. In this talk we will outline the proof that group-based latin squares satisfy the Ryser-Brualdi-Stein conjecture. We will then explain why the resolution of this special case is far from the end of the discussion of near transversals in group-based latin squares.

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**DANIEL HORSLEY**, Monash University
[Friday December 4 / vendredi 4 décembre, 15:30]
*An Evans-style result for block designs*

A now-proven conjecture of Evans states that any partial latin square with at most $n-1$ filled cells can be completed to a latin square. This is tight: there are uncompletable partial latin squares with $n$ filled cells. This talk will discuss the analogous problem for block designs.

An $(n, k, 1)$-*design* is a collection of $k$-subsets (*blocks*) of a set of $n$ *points* such that each pair of points occur together in exactly one block. If this restriction is relaxed to require only that each pair of points occur together in at most one block we instead have a *partial* $(n, k, 1)$-*design*. I will outline a proof that any partial $(n, k, 1)$-design with at most $\frac{n-1}{k-1} - k + 1$ blocks is completable to a $(n, k, 1)$-design provided that $n$ is sufficiently large and obeys the obvious necessary conditions for an $(n, k, 1)$-design to exist. This result is tight for all $k$. I will also mention some related results concerning edge decompositions of almost complete graphs into copies of $K_k$. All of this work is joint with Ajani De Vas Gunasekara.

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**HADI KHARAGHANI**, University of Lethbridge
[Sunday December 6 / dimanche 6 décembre, 16:30]
*On Equiangular Tight Frames*

**Résumé**

A family of lines through the origin in a Euclidean space is called equiangular if the absolute value of the inner product of each pair of lines is a constant. A $d \times n$, $d < n$ matrix $F$ with real entries is a Frame if the absolute value of the off-diagonal entries of $F^T F$ is a constant. A $d \times n$ Frame is Tight if the rows are pairwise orthogonal and it is Flat if the absolute value of the entries stays the same. A new construction method makes use of Block Shapiro-Golay pairs. Applications lead to a class of Quasi-symmetric designs and Self-Complementary Codes attaining Grey-Rankin Bound.

This is joint work with Thomas Pender and Sho Suda.

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**ESTHER LAMKEN**
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Applications of incomplete pairwise balanced designs*

In this talk, I will describe applications of our existence results for incomplete pairwise balanced designs, IPBD$((v; w), K)$. IPBDs provide a surprisingly powerful tool for constructing designs with substructures. We describe two basic techniques for applications: using an IPBD as a 'template' in constructions and using IPBDs instead of PBDs in PBD-closure. Several examples will be given to illustrate the power of these techniques. These examples include using IPBDs to construct incomplete mutually orthogonal latin squares and resolvable designs with sub-designs. All of this work is joint work with Peter Dukes.

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**TRENT MARBACH**, Ryerson University
[Saturday December 5 / samedi 5 décembre, 15:30]
*The localization number of designs*

We study the localization number of incidence graphs of designs. In the localization game played on a graph, the cops attempt to determine the location of an invisible robber via distance probes. The localization number of a graph $G$, written $\zeta(G)$, is the minimum number of cops needed to ensure the robber's capture. We present work giving bounds and exact values for the incidence graphs of a number of classes of designs.

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**MAHSA NASROLLAHI**, University of Regina
[Saturday December 5 / samedi 5 décembre, 16:30]
*The Erdős-Ko-Rado theorem for 2-intersecting families of perfect matchings*

The *Erdős-Ko-Rado* (EKR) theorem is a classical result in extremal combinatorics. It states that if $n$ and $k$ are such that $n \geq 2k$, then any intersecting family $\mathcal{F}$ of $k$-subsets of $[n] = \{1, 2, \ldots, n\}$ has size at most $\binom{n-1}{k-1}$. Moreover, if $n > 2k$, then equality holds if and only if $\mathcal{F}$ is a *canonical* intersecting family; that is, $\bigcap_{A \in \mathcal{F}} A = \{i\}$, for some $i \in [n]$.

The EKR theorem can be extended to various combinatorial objects. In this presentation, I will talk about an extension of the EKR theorem to 2-intersecting families of perfect matchings. In particular, I prove that any 2-intersecting family of perfect matchings of $K_{2k}$ has size at most $(2k-5)\times(2k-7)\times\ldots 3\times 1$, for any $k\geq 3$.

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**KIRSTEN NELSON**, Carleton University
[Saturday December 5 / samedi 5 décembre, 16:00]
*Interleaved Sequences*

A covering array CA$(N;t,k,v)$ is a $N\times k$ array over an alphabet of $v$ elements such that for any $t$-set of columns, each possible arrangement of $t$ alphabet elements occurs at least once in a row. Finding the smallest number of rows $N$ in the array is a central problem, with many good bounds and construction methods for some, but not all, sets of parameters. Covering arrays can be made by taking a sequence with a coverage property and circulating it into a matrix. In this talk we examine interleaved sequences, created by combining a base sequence of period $s$ with nice coverage properties and a shift sequence $e$ of length $T$, consisting of elements from $Z(q)\cup\infty$ . We will discuss what properties are inherited from the base sequence, and under which conditions this is possible. Finally we demonstrate the potential for interleaved sequences to create $\epsilon$-almost covering arrays, where all but $\epsilon\binom{k}{t}$ of tuples are covered for a 'small' $\epsilon$.

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**JOANNA NIEZEN**, University of Victoria
[Saturday December 5 / samedi 5 décembre, 14:00]
*Sarvate-Beam Group Divisible Designs*

The existence of Sarvate-Beam designs is explored, named after its founders D.G. Sarvate and W. Beam. In an adesign, the number of times a specified pair of points occurs together in a block is called the pair frequency. A Sarvate-Beam design is an adesign where the set of pair frequencies cover an interval of distinct nonnegative integers. The main result of this work is to completely settle the existence of uniform Sarvate-Beam group divisible designs with blocks of size three where the smallest pair frequency is zero. Higher starting frequencies are also considered and mostly settled. A case of special interest are Sarvate-Beam group divisible designs with three uniform groups, which has a nice geometric interpretation. This work is joint with Dr. Peter Dukes.

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**DAVID PIKE**, Memorial University of Newfoundland
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Colourings of Group Divisible Designs*

A group divisible design (GDD) consists of a set $V$ of points, a set $\mathcal{G}$ of subsets of $V$ called groups that partition $V$, and a set $\mathcal{B}$ of subsets of $V$ called blocks such that each pair of points that does not occur together in a group occurs together in exactly one block. A colouring of a design is a labelling of its points with colours so that no block is monochromatic; i.e., it is a function $f:V\to C$ where $C$ is a set of elements called colours, such that $|\{f(x):x\in B\}|\geqslant 2$ for each $B\in\mathcal{B}$. The chromatic number of a design is the least number of colours for which the design admits such a colouring. We will discuss colourings of GDDs, particularly those for which each group has the same size $g$ and each block has the same size $k$.

This is joint work with A.C. Burgess, P. Danziger, J.H. Dinitz and D.M. Donovan.

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**MATEJA SAJNA**, University of Ottawa
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Bipartite 2-factorizations of complete multigraphs via layering*

Layering is in principle a simple method that allows us to obtain a type-specific 2-factorization of a complete multigraph (or complete multigraph minus a 1-factor) from existing 2-factorizations of complete multigraphs and complete multigraphs minus

a 1-factor. This technique is particularly effective when constructing bipartite 2-factorizations; that is, 2-factorizations with all cycles of even length.

In this talk, we shall give a thorough introduction to layering, and then describe new bipartite 2-factorizations of complete multigraphs obtained by layering. In particular, for complete multigraphs and bipartite 2-factors with no 2-cycles, we obtain a complete solution to the Oberwolfach Problem and an almost complete solution to the Hamilton-Waterloo Problem.

This is joint work with Amin Bahmanian.

# Computations with Arithmetic Groups / Approche Calculatoire aux Groupes Arithmétiques

**Org: Haluk Sengun** (The University of Sheffield) and/et **John Voight** (Dartmouth)

## Schedule/Horaire

### Thursday December 3 — jeudi 3 décembre

| | |
|---|---|
| 9:30 - 10:00 | Marc Masdeu (Universitat Autònoma de Barcelona), *Quaternionic rigid meromorphic cocycles* (p. 96) |
| 10:00 - 10:30 | Graham Ellis (National University of Ireland, Galway), *An algorithm for computing Hecke operators* (p. 95) |
| 10:45 - 11:15 | Angelica Babei (Centre de recherches mathématiques), *Zeros of period polynomials for Hilbert modular forms* (p. 94) |
| 11:15 - 11:45 | Ben Breen (Clemson University), *A trace formula for Hilbert modular forms* (p. 95) |
| 12:00 - 12:30 | Avner Ash (Boston College), *Cohomology of congruence subgroups of $SL_3(Z)$ and real quadratic fields* (p. 94) |

### Tuesday December 8 — mardi 8 décembre

| | |
|---|---|
| 9:30 - 10:00 | Cecile Armana (Université de Franche-Comté), *Sturm bounds for Drinfeld-type automorphic forms over function fields* (p. 94) |
| 10:00 - 10:30 | Neil Dummigan (University of Sheffield), *Congruences involving non-parallel weight Hilbert modular forms* (p. 95) |
| 10:45 - 11:15 | Fang-Ting Tu (Louisiana State University), *A Geometric Interpretation of a Whipple's ${}_7F_6$ Formula* (p. 96) |
| 11:15 - 11:45 | Mark McConnell (Princeton University) (p. 96) |
| 12:00 - 12:30 | Mathilde Gerbelli-Gauthier (McGill University), *Limit multiplicity of non-tempered representations and endoscopy.* (p. 95) |

## Abstracts/Résumés

**CECILE ARMANA**, Universite de Franche-Comte
[Tuesday December 8 / mardi 8 décembre, 9:30]
*Sturm bounds for Drinfeld-type automorphic forms over function fields*

Sturm bounds say how many successive Fourier coefficients suffice to determine a modular form. For classical modular forms, they also provide bounds for the number of Hecke operators generating the Hecke algebra. I will present Sturm bounds for Drinfeld-type automorphic forms over the function field $\mathbb{F}_q(t)$. Their proof involve refinements of a fundamental domain for a corresponding Bruhat-Tits tree under the action of a congruence subgroup. This is a joint work with Fu-Tsun Wei.

**AVNER ASH**, Boston College
[Thursday December 3 / jeudi 3 décembre, 12:00]
*Cohomology of congruence subgroups of $SL_3(Z)$ and real quadratic fields*

Given the congruence subgroup $\Gamma = \Gamma_0(N)$ of $SL_3(Z)$ and the real quadratic field $E = Q(\sqrt{d})$, we compare the homology of $\Gamma$ with coefficients in the Steinberg modules of $E$ and $Q$. This leads to a connecting homomorphism whose image $H$ is a "natural" (in particular Hecke-stable) subspace of $H^3(\Gamma, Q)$. The units $O_E^\times$ are the main ingredient in the construction of elements of $H$. We performed computations to determine $H$ for a variety of levels $N \leq 169$ and all $d \leq 10$. On the basis of the results we conjecture exactly what the image should be in general. This is joint work with Dan Yasaki.

**ANGELICA BABEI**, Centre de recherches mathématiques, Université de Montréal
[Thursday December 3 / jeudi 3 décembre, 10:45]
*Zeros of period polynomials for Hilbert modular forms*

The study of period polynomials for classical modular forms has emerged due to their role in Eichler cohomology. In particular, the Eichler-Shimura isomorphism gives a correspondence between cusp eigenforms and their period polynomials. The coefficients of period polynomials also encode critical $L$-values for the associated modular form and thus contain rich arithmetic information. Recent works have considered the location of the zeros of period polynomials, and it has been shown that in various settings, their zeros lie on a circle centered at the origin. In this talk, I will describe joint work with Larry Rolen and Ian Wagner, where we introduce period polynomials for Hilbert modular forms of level one and prove that their zeros lie on the unit circle. In particular, I will detail some of the computational tools we used in our proof.

**BEN BREEN**, Clemson University
[Thursday December 3 / jeudi 3 décembre, 11:15]
*A trace formula for Hilbert modular forms*

We present an explicit trace formula for Hilbert modular forms. The Jacquet-Langlands correspondence relates spaces of Hilbert modular forms to spaces of quaternionic modular forms ; the latter being far more amenable to computations. We discuss how to compute traces of Hecke operators on spaces of quaternionic modular forms and provide explicit examples for some definite quaternion algebras.

**NEIL DUMMIGAN**, University of Sheffield
[Tuesday December 8 / mardi 8 décembre, 10:00]
*Congruences involving non-parallel weight Hilbert modular forms*

When newforms are congruent, the modulus appears in a near-central adjoint L-value. When those newforms are complex conjugates, it actually appears in the other critical values too. The Bloch-Kato conjecture then demands non-zero elements of that order in the associated Selmer groups. These are provided by conjectural congruences involving non-parallel weight Hilbert modular forms. An experimental example of such a congruence showed up following computations of algebraic modular forms for a definite orthogonal group, for the genus of even unimodular lattices of rank 12 over the golden ring.

**GRAHAM ELLIS**, National University of Ireland, Galway
[Thursday December 3 / jeudi 3 décembre, 10:00]
*An algorithm for computing Hecke operators*

I will describe an approach to computing Hecke operators on the integral cuspidal cohomology of congruence subgroups of $SL_2(\mathcal{O}_d)$ over various rings of quadratic integers $\mathcal{O}_d$. The approach makes use of an explicit contracting homotopy on a classifying space for $SL_2(\mathcal{O}_d)$. The approach, which has been partially implemented, is also relevant for computations on congruence subgroups of $SL_m(\mathbf{Z})$, $m \geq 2$ (where it has been fully implemented for $m = 2$).

**MATHILDE GERBELLI-GAUTHIER**, Centre de Recherches Mathématiques
[Tuesday December 8 / mardi 8 décembre, 12:00]
*Limit multiplicity of non-tempered representations and endoscopy.*

How fast do Betti numbers grow in a congruence tower of compact arithmetic manifolds ? The question can be reformulated in terms of limit multiplicity of representations. If the representation is discrete series, the rate of growth is known to be proportional to the volume of the manifold ; otherwise the growth is sub-linear in the volume. Sarnak-Xue have conjectured

that bounds on multiplicity growth can be expressed in terms of the failure of representations to be tempered. I will confirm some instances of the Sarnak-Xue conjecture for unitary groups using the fact that some non-tempered representations arise as endoscopic transfer, and give applications to cohomology growth.

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**MARC MASDEU**, Universitat Autònoma de Barcelona
[Thursday December 3 / jeudi 3 décembre, 9:30]
*Quaternionic rigid meromorphic cocycles*

Rigid meromorphic cocycles were introduced by Darmon and Vonk as a conjectural $p$-adic extension of the theory of singular moduli to real quadratic base fields. They are certain cohomology classes of $\mathrm{SL}_2(\mathbb{Z}[1/p])$ which can be evaluated at real quadratic irrationalities and the values thus obtained are conjectured to lie in algebraic extensions of the base field.

I will present joint work with X.Guitart and X.Xarles, in which we generalize (and somewhat simplify) this construction to the setting where $\mathrm{SL}_2(\mathbb{Z}[1/p])$ is replaced by an order in an indefinite quaternion algebra over a totally real number field $F$. These quaternionic cohomology classes can be evaluated at elements in almost totally complex extensions $K$ of $F$, and we conjecture that the corresponding values lie in algebraic extensions of $K$. I will show some new numerical evidence for this conjecture, along with some interesting questions allowed by this flexibility.

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**MARK MCCONNELL**, Princeton University
[Tuesday December 8 / mardi 8 décembre, 11:15]

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**FANG-TING TU**, Louisiana State University
[Tuesday December 8 / mardi 8 décembre, 10:45]
*A Geometric Interpretation of a Whipple's ${}_7F_6$ Formula*

This talk is based on a joint work with Wen-Ching Winnie Li and Ling Long. We consider hypergeometric motives corresponding to a formula due to Whipple which relates certain hypergeometric values ${}_7F_6(1)$ and ${}_4F_3(1)$. From identities of hypergeometric character sums, we explain a special structure of the Galois representation behind Whipple's formula leading to a decomposition that can be described by Hecke eigenforms. In this talk, I will use an example to demonstrate our approach and relate the hypergeometric values to periods of modular forms.

# Creative Assessments in the COVID-19 times / L'Évaluation Créative au Temps de la COVID

Org: **Andie Burazin** (Toronto), **Lauren DeDieu** (Calgary) and/et **Miroslav Lovric** (McMaster)

## Schedule/Horaire

| Monday December 7 | lundi 7 décembre |
|---|---|
| 14:00 - 14:30 | Amenda Chow and Iain Moyles (York), *Choose your own adventure in a multi-variable calculus course for engineering students* (p. 97) |
| 14:30 - 15:00 | Dan Wolczuk and Paul McGrath (Waterloo), *Using Virtual Escape Rooms to Promote Student-Student Interactions* (p. 98) |
| 15:00 - 15:30 | Sean Fitzpatrick (Lethbridge), *Deconstructing Exams for Remote Learning* (p. 97) |
| 15:30 - 16:00 | Samantha-Jo Caetano (Toronto), *Trump vs. Biden - who will win ?* (p. 97) |
| 16:00 - 16:30 | Jerrod Smith (Calgary), *Peer and Open-ended Assessment in Linear Algebra and Intro Proof Courses* (p. 98) |
| 16:30 - 17:00 | Anton Mosunov (Waterloo), *Let's Think Together: Using Oral Assessments to Develop Students' Thought Process* (p. 98) |

## Abstracts/Résumés

**SAMANTHA-JO CAETANO**, University of Toronto
[Monday December 7 / lundi 7 décembre, 15:30]
*Trump vs. Biden - who will win ?*

Fall of 2020 has been riddled with hardships. One thing that unites us, is our general interest in following the 2020 American Federal Presidential election. Rohan Alexander and I are currently instructing a third-year "Surveys, Sampling and Observational Studies" course at the University of Toronto, and the final problem set due in our course has our students using data and statistical modelling to predict the outcome of the 2020 election. In this presentation I will go over the specific requirements of this assessment, some of the positive feedback received and some of the obstacles we faced in the creation and implementation of this problem set.

**AMENDA CHOW AND IAIN MOYLES**, York University
[Monday December 7 / lundi 7 décembre, 14:00]
*Choose your own adventure in a multi-variable calculus course for engineering students*

We focus on the various styles of final assessments used in a multi-variable calculus course. Between both presenters, we have taught this course several times since 2016. For the pandemic influenced semester (Winter 2020), students had to complete a subset of carefully crafted word problems that required students to recognize the concept in the course that would solve it. For the semester following (Summer 2020), the final assessment was a group project, which required groups to come up with one practical real world problem and solve this using the mathematical concepts taught in the course. We will present samples of these assessments and discuss student reactions to these more creative styles of final assessments compared to traditional questions found in an in-person proctored written final exam. We also discuss how we used these styles of assessments to gauge the depth of student learning and student dishonesty, and whether our time spent implementing them was worth it.

**SEAN FITZPATRICK**, University of Lethbridge
[Monday December 7 / lundi 7 décembre, 15:00]
*Deconstructing Exams for Remote Learning*

The shift to remove learning has come with many challenges, not least of which is designing authentic assessments that are less likely to encourage academic misconduct. One thing was clear: large, high stakes exams weren't going to work, unless one was willing to use intrusive surveillance techniques. (I wasn't.)

My considerations were as follows:

- I want assessment to be a learning tool, not a measuring tool. I want students to learn from their feedback and believe growth is possible.

- I have too many students and too few resources to do something like mastery grading.

- I'm not so great at designing highly engaging problems, but pretty OK at course design.

With this in mind, I decided to "deconstruct" my exams (in the culinary sense, of taking them apart). A midterm and final became 5 chapter tests. The single day timed test became a week-long cycle, with several components: a chapter review, an individual test, a group test, and a test "wrapper".

I'll describe each of these components, and why I chose them, and discuss the effectiveness of this approach, for both academic integrity and student success.

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**ANTON MOSUNOV**, University of Waterloo
[Monday December 7 / lundi 7 décembre, 16:30]
*Let's Think Together: Using Oral Assessments to Develop Students' Thought Process*

MATH 135 is one of the fundamental courses in the Faculty of Mathematics at the University of Waterloo. It is the course where students learn how to prove mathematical statements rigorously. Since the goal is to teach students a particular thought process, I decided to hold an oral midterm to give students an opportunity to reflect on problems that they have never seen before along with their instructor. In my presentation, I will tell you more about this experience, and share my personal view on the advantages and disadvantages of this approach. If time allows, I will also give a demonstration of the midterm, which was held using the Bongo platform.

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**JERROD SMITH**, University of Calgary
[Monday December 7 / lundi 7 décembre, 16:00]
*Peer and Open-ended Assessment in Linear Algebra and Intro Proof Courses*

I'll talk about my experiences, and my students reactions, to some peer-assessment activities and open-ended questions in a second course in linear algebra and a first-year honours course introducing students to mathematical writing. Rubrics used to assess these activities (and some ideas on how to improve them) will also be discussed.

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**DAN WOLCZUK AND PAUL MCGRATH**, University Of Waterloo
[Monday December 7 / lundi 7 décembre, 14:30]
*Using Virtual Escape Rooms to Promote Student-Student Interactions*

Even during the best of times a common concern in online courses is the lack of student-student interactions. Given that the majority of our incoming first year science students have only online courses this term, we made it a priority to get the students to work collaboratively in our calculus course. Rather than using typical group projects, which many students dread, we came up with the idea of creating something different and fun: virtual escape rooms.

In this presentation, we will first give a quick overview of our virtual escape rooms and how we used these to encourage the students not only to work together but also to form term-long study groups. We will then discuss the students' view of our virtual escape rooms based on the results of three surveys and the unsolicited feedback we received.

# Derived Categories and (Non)commutative Algebraic Geometry / Catégories Dérivées et Géométrie Algébrique (Non Commutative

Org: **Matthew Ballard** (USC), **Nitin Chidambaram** (Alberta) and/et **David Favero** (Alberta)

## Schedule/Horaire

| **Monday December 7** | **lundi 7 décembre** |
|---|---|
| 14:00 - 15:00 | Tony Pantev (Penn) (p. 100) |
| 15:00 - 16:00 | Katrina Honigs (Oregon), *An obstruction to weak approximation on some Calabi-Yau threefolds* (p. 99) |
| 16:00 - 17:00 | Sabin Cautis (UBC), *Categorical structure of Coulomb branches of 4D N=2 gauge theories* (p. 99) |

| **Tuesday December 8** | **mardi 8 décembre** |
|---|---|
| 11:00 - 12:00 | Ellen Kirkman (Wake Forest), *Degree bounds for Hopf actions on Artin-Schelter regular algebras* (p. 100) |
| 13:00 - 14:00 | Colin Ingalls (Carleton), *Explicit coverings of families of elliptic surfaces by squares of curves* (p. 99) |
| 14:00 - 15:00 | Alicia Lamarche (Utah) (p. 100) |
| 15:30 - 16:30 | Dylan Allegretti (UBC) (p. 99) |
| 16:30 - 17:30 | Max Lieblich (Washington) (p. 100) |

## Abstracts/Résumés

**DYLAN ALLEGRETTI**, UBC
[Tuesday December 8 / mardi 8 décembre, 15:30]

**SABIN CAUTIS**, UBC
[Monday December 7 / lundi 7 décembre, 16:00]
*Categorical structure of Coulomb branches of 4D N=2 gauge theories*

We will discuss the categorical structure of Coulomb branches. For concreteness we focus on the massless case which is just the category of coherent sheaves on the affine Grassmannian (the coherent Satake category).

These categories are conjecturally governed by a cluster algebra structure. We describe a solution of this conjecture in the case of general linear groups and discuss its extension to more general Coulomb branches of 4D N=2 gauge theories. This is joint work with Harold Williams.

**KATRINA HONIGS**, University of Oregon
[Monday December 7 / lundi 7 décembre, 15:00]
*An obstruction to weak approximation on some Calabi-Yau threefolds*

There has been recent interest in whether existence and density of Q-rational points is preserved under derived equivalence. After giving a short introduction to this question, I will be discussing recent work joint with Hashimoto, Lamarche and Vogt in which we examine Q-points on a family of derived equivalent Calabi-Yau threefolds. These threefolds were constructed and analyzed in detail as complex varieties by Hosono and Takagi in the context of mirror symmetry. One family of threefolds occurs as a linear section of a double quintic symmetroid, and we are able to give a general condition under which a Brauer class obstructs weak approximation, though it cannot obstruct the existence of Q-rational points.

**COLIN INGALLS**, Carleton University
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Explicit coverings of families of elliptic surfaces by squares of curves*

We show that, for each $n > 0$, there is a family of elliptic surfaces which are covered by the square of a curve of genus $2n+1$, and whose Hodge structures have an action by $\mathbb{Q}(\sqrt{-n})$. By considering the case n=3, we show that one particular family of K3 surfaces are covered by the square of genus 7. Using this, we construct a correspondence between the square of a curve of genus 7 and a general K3 surface in $\mathbb{P}^4$ with 15 ordinary double points up to isogeny. This gives an explicit proof of the Kuga-Satake-Deligne correspondence for these K3 surfaces and any K3 surfaces isogenous to them, and further, a proof of the Hodge conjecture for the squares of these surfaces. We conclude that the motives of these surfaces are Kimura-finite. Our analysis gives a birational equivalence between a moduli space of curves with additional data and the moduli space of these K3 surfaces with a specific elliptic fibration. This is joint work with Adam Logan and Owen Patashnick.

**ELLEN KIRKMAN**, Wake Forest University
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Degree bounds for Hopf actions on Artin-Schelter regular algebras*

In 1915 E. Noether proved that for a field $\Bbbk$ of characteristic zero and a finite group $G$ acting naturally on a polynomial ring $\Bbbk[x_1, \ldots, x_n]$, the degrees of minimal generators of the subring of invariants are bounded above by the order of the group. In 2011, using Castelnuovo-Mumford regularity, P. Symonds proved that for a general field $\Bbbk$, an upper bound is $n(|G|-1)$ when $n \geq 2$ and $|G| > 1$. Replacing $\Bbbk[x_1, \ldots, x_n]$ by an Artin-Schelter regular algebra $A$ and $G$ by a semisimple Hopf algebra $H$, we prove analogues of results of Noether, Fogarty, Fleischmann, Derksen, Sidman, Chardin and Symonds on bounds on the degrees of generators of the subring of invariants and on the degrees of syzygies of modules over the invariant subring. We further explore Castelnuovo-Mumford regularity and related weighted sums of homological and internal degrees in complexes of graded $A$-modules for noncommutative algebras. This is joint work with Robert Won and James J. Zhang.

**ALICIA LAMARCHE**, Utah
[Tuesday December 8 / mardi 8 décembre, 14:00]

**MAX LIEBLICH**, Washington
[Tuesday December 8 / mardi 8 décembre, 16:30]

**TONY PANTEV**, Penn
[Monday December 7 / lundi 7 décembre, 14:00]

# Discrete Analysis / Analyse Discrète

Org: **Tess Anderson** (Purdue), **Leo Goldmakher** (Williams) and/et **Brandon Hanson** (Georgia)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Sam Chow (Warwick), *Bohr sets in diophantine approximation* (p. 101) |
| 13:36 - 14:06 | Marina Iliopoulou (Kent), *A discrete Kakeya-type inequality* (p. 102) |
| 14:12 - 14:42 | Aled Walker (CRM Montreal), *Effective results on the structure of sumsets* (p. 104) |
| 14:48 - 15:18 | Sarah Peluse (IAS), *Modular zeros in the character table of the symmetric group* (p. 103) |
| 15:24 - 15:54 | Fernando Shao (University of Kentucky), *Gowers uniformity of primes in arithmetic progressions* (p. 104) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 13:30 - 14:00 | Oleksiy Klurman (Bristol), *Zeros of Fekete polynomials* (p. 102) |
| 14:06 - 14:36 | Zane Li (Indiana University), *Connections between decoupling and efficient congruencing* (p. 102) |
| 14:42 - 15:12 | Larry Guth (MIT), *Incidence estimates for well spaced rectangles* (p. 102) |
| 15:18 - 15:48 | Hong Wang (IAS), *Small cap decouplings* (p. 104) |
| 15:54 - 16:24 | Ruxiang Zhang (IAS), *Local smoothing for the wave equation in 2+1 dimensions* (p. 104) |
| 16:30 - 17:00 | Dominique Kemp (Indiana University) (p. 102) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 13:30 - 14:00 | Michael Curran (Oxford), *Khovanskii's Theorem and Effective Results on Sumset Structure* (p. 101) |
| 14:06 - 14:36 | Amita Malik (AIM), *Partitions into primes in arithmetic progression* (p. 103) |
| 14:42 - 15:12 | Jose Madrid (UCLA), *Improving estimates for discrete polynomial averages and related problems* (p. 103) |
| 15:18 - 15:48 | Felipe Ramirez (Wesleyan University), *Remarks about inhomogeneous pair correlations* (p. 103) |
| 15:54 - 16:24 | Ayla Gafni (University of Mississippi), *Asymptotics of Restricted Partition Functions* (p. 102) |
| 16:30 - 17:00 | Freddie Manners (UC San Diego) (p. 103) |

## Abstracts/Résumés

**SAM CHOW**, University of Warwick
[Friday December 4 / vendredi 4 décembre, 13:00]
*Bohr sets in diophantine approximation*

The correspondence between Bohr sets and generalised arithmetic progressions is a much-loved motif in additive combinatorics. We discuss the theory, and some applications, in the context of diophantine approximation.

**MICHAEL CURRAN**, University of Oxford
[Sunday December 6 / dimanche 6 décembre, 13:30]
*Khovanskii's Theorem and Effective Results on Sumset Structure*

A remarkable theorem due to Khovanskii asserts that for any finite subset $A$ of an abelian group, the cardinality of the $h$-fold sumset $hA$ grows like a polynomial for all sufficiently large $h$. However, neither the polynomial nor what sufficiently large means are understood in general. We obtain an effective version of Khovanskii's theorem for any $A \subset \mathbb{Z}^d$ whose convex hull is a

simplex ; previously such results were only available for $d = 1$. Our approach also gives information about the structure of $hA$, answering a recent question posed by Granville and Shakan.

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**AYLA GAFNI**, University of Mississippi
[Sunday December 6 / dimanche 6 décembre, 15:54]
*Asymptotics of Restricted Partition Functions*

Given a set $\mathcal{A} \subset \mathbb{N}$, the restricted partition function $p_{\mathcal{A}}(n)$ counts the number of integer partitions of $n$ with all parts in $\mathcal{A}$. In this talk, we will explore the features of the restricted partitions function $p_{\mathbb{P}_k}(n)$ where $\mathbb{P}_k$ is the set of $k$-th powers of primes. Powers of primes are both sparse and irregular, which makes $p_{\mathbb{P}_k}(n)$ quite an elusive function to understand. We will discuss some of the challenges involved in studying restricted partition functions and what is known in the case of primes, $k$-th powers, and $k$-th powers of primes.

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**LARRY GUTH**, MIT
[Saturday December 5 / samedi 5 décembre, 14:42]
*Incidence estimates for well spaced rectangles*

We discuss estimating the overlap of thin rectangles in the plane in terms of how many rectangles clump together in fatter rectangles. This question can be seen as a generalization of the Szemeredi-Trotter theorem in incidence geometry, where straight lines are replaced by thin rectangles. Although the Szemeredi-Trotter theorem is sharp, there remain serious open problems involving these analogous questions for thin rectangles. We discuss a recent approach to the tube problem using Fourier analysis. This approach connects to decoupling and to the local smoothing problem for the wave equation.

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**MARINA ILIOPOULOU**, University of Kent
[Friday December 4 / vendredi 4 décembre, 13:36]
*A discrete Kakeya-type inequality*

The Kakeya conjectures of harmonic analysis claim that congruent tubes that point in different directions rarely meet. In this talk we discuss the resolution of an analogous problem in a discrete setting (where the tubes are replaced by lines), and provide some structural information on quasi-extremal configurations. This is joint work with A. Carbery.

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**DOMINIQUE KEMP**, Indiana University
[Saturday December 5 / samedi 5 décembre, 16:30]

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**OLEKSIY KLURMAN**, University of Bristol
[Saturday December 5 / samedi 5 décembre, 13:30]
*Zeros of Fekete polynomials*

The study of the location of zeros of polynomials with coefficients constrained in different sets has a very rich history. The case of random polynomials has been extensively studied and the asymptotic number of real zeros has been computed in various cases (Gaussian, Bernoulli etc). The problem is subtler in a deterministic case. The goal of the talk is to briefly survey some developments in this subject and discuss recent progress for the family of Fekete polynomials. This is part of a joint work with Y. Lamzouri and M. Munsch.

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**ZANE LI**, Indiana University, Bloomington
[Saturday December 5 / samedi 5 décembre, 14:06]
*Connections between decoupling and efficient congruencing*

We discuss a short proof of decoupling for the moment curve that is inspired from nested efficient congruencing. Connections between decoupling and efficient congruencing will also be highlighted. This talk is based off joint work with Shaoming Guo, Po-Lam Yung and Pavel Zorin-Kranich.

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**JOSE MADRID**, University of California Los Angeles
[Sunday December 6 / dimanche 6 décembre, 14:42]
*Improving estimates for discrete polynomial averages and related problems*

For a polynomial $P$ mapping the integers into the integers, define an averaging operator $A_N f(x) := \frac{1}{N}\sum_{k=1}^{N} f(x+P(k))$ acting on functions on the integers. We prove sufficient conditions for the $\ell^p$-improving inequality

$$\|A_N f\|_{\ell^q(\mathbb{Z})} \lesssim_{P,p,q} N^{-d(\frac{1}{p}-\frac{1}{q})}\|f\|_{\ell^p(\mathbb{Z})}, \qquad N \in \mathbb{N},$$

where $1 \leq p \leq q \leq \infty$. For a range of quadratic polynomials, the inequalities established are sharp, up to the boundary of the allowed pairs of $(p,q)$. For degree three and higher, the inequalities are close to being sharp. In the quadratic case, we appeal to discrete fractional integrals as studied by Stein and Wainger. In the higher degree case, we appeal to the Vinogradov Mean Value Theorem, established by Bourgain, Demeter, and Guth. We will also discuss some related problems for discrete averaging operators.

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**AMITA MALIK**, American Institute of Mathematics
[Sunday December 6 / dimanche 6 décembre, 14:06]
*Partitions into primes in arithmetic progression*

In this talk, we discuss the number of ways to write a given integer as a sum of primes in an arithmetic progression. While the study of asymptotics for the number of ordinary partitions goes back to Hardy and Ramanujan, partitions into primes were recently re-visited by Vaughan. As a special case, we obtain an improvement in Vaughan's asymptotic formula for the number of partitions into primes.

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**FREDDIE MANNERS**, UC San Diego
[Sunday December 6 / dimanche 6 décembre, 16:30]

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**SARAH PELUSE**, Institute for Advanced Study and Princeton University
[Friday December 4 / vendredi 4 décembre, 14:48]
*Modular zeros in the character table of the symmetric group*

In 2017, Miller conjectured, based on computational evidence, that for any fixed prime $p$ the density of entries in the character table of $S_n$ that are divisible by $p$ goes to 1 as $n \to \infty$. I'll describe a proof of this conjecture, which is joint work with K. Soundararajan, along with proofs of some earlier results for small primes. I will also discuss the still open problem of determining the asymptotic density of zeros in the character table of $S_n$, where it is not clear from computational data what one should expect.

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**FELIPE RAMIREZ**, Wesleyan University
[Sunday December 6 / dimanche 6 décembre, 15:18]
*Remarks about inhomogeneous pair correlations*

A sequence $a_n$ of natural numbers is said to have metric Poissonian pair correlations (MPPC) if for almost every real number $\alpha$ the associated sequence $\alpha a_n (\mathrm{mod} 1)$ on the circle has asymptotically Poissonian pair correlations. Informally speaking, this

means that the points of the sequence clump together to the same extent that they would if they had been picked randomly. For example, the sequence of natural numbers does not have MPPC, while the sequence of square numbers does. Generally, if a sequence has too much additive structure, like the natural numbers, then it will not have MPPC. If it has very little additive structure, like the squares or the powers of 2, then it will have MPPC. But there is a zone in between "too much additive structure" and "very little additive structure" where the picture is not so clear, and there has been a lot of work devoted to finding an "additive energy threshold" separating sequences with MPPC from those without. I will survey this work, and I will discuss an associated inhomogeneous problem where the corresponding questions seem to be easier to answer.

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**FERNANDO SHAO**, University of Kentucky
[Friday December 4 / vendredi 4 décembre, 15:24]
*Gowers uniformity of primes in arithmetic progressions*

A celebrated theorem of Green-Tao asserts that the set of primes is Gowers uniform, allowing them to count asymptotically the number of k-term arithmetic progressions in primes up to a threshold. In this talk I will discuss results of this type for primes restricted to arithmetic progressions. These can be viewed as generalizations of the classical Bombieri-Vinogradov theorem. I will also discuss a number of applications; for example, the set of primes $p$ obeying $\{\sqrt{2}p^2\} < 0.1$ exhibit bounded gaps. This is joint work with Joni Teravainen.

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**ALED WALKER**, Centre de Recherches Mathématiques
[Friday December 4 / vendredi 4 décembre, 14:12]
*Effective results on the structure of sumsets*

Given a finite set $A \subset \mathbb{Z}^d$ with convex hull $\mathrm{conv}(A)$, we have a trivial inclusion between the iterated sumset and the dilated convex hull, namely $NA \subset (N\,\mathrm{conv}(A)) \cap \mathbb{Z}^d$. But does equality ever hold? In fact there is an easily-described exceptional set $E_N(A)$ for which $E_N(A) \cap NA = \emptyset$, but one may nonetheless ask: does equality hold up to these exceptions?

Granville–Shakan recently showed that, if $N$ is large enough, the answer to this question is yes, equality does hold. However, for all $d \geqslant 2$ their results gave only an ineffective lower bound on what 'large enough' should mean. In this talk we will describe two new pieces of work on this question: a new bound in the case $d = 1$, which is tight for several infinite families of sets $A$, and the first effective bounds for arbitrary $A$ when $d \geqslant 2$. These results are joint work with Granville and with Granville–Shakan respectively. If time permits, we will describe the connections between this work and Khovanskii's theorem (that the size of $NA$ is a polynomial in $N$, for large enough $N$).

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**HONG WANG**, Institute for Advanced Study
[Saturday December 5 / samedi 5 décembre, 15:18]
*Small cap decouplings*

We will discuss some incidence estimates for tubes (and planks) using basic Fourier analysis, based on the joint work with Guth and Solomon. Then we show how these incidence estimates are used to prove decoupling inequalities. This is joint work with Ciprian Demeter and Larry Guth.

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**RUXIANG ZHANG**, Institute for Advanced Study
[Saturday December 5 / samedi 5 décembre, 15:54]
*Local smoothing for the wave equation in 2+1 dimensions*

Sogge's local smoothing conjecture for the wave equation predicts that the local $L^p$ space-time estimate gains a fractional derivative of order almost $1/p$ compared to the fixed time $L^p$ estimates, when $p > 2n/(n-1)$. Jointly with Larry Guth and

Hong Wang, we recently proved the conjecture in $\mathbb{R}^{2+1}$. I will talk about a sharp square function estimate we proved which implies the local smoothing conjecture in dimensions $2+1$. A key ingredient in the proof is an incidence type theorem.

**Org: Sergi Elizalde** (Dartmouth), **Steven Karp** (LaCIM, UQAM), **Nadia Lafreniere** (Dartmouth) and/et **Alejandro Morales** (UMass Amherst)

## Schedule/Horaire

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Matjaž Konvalinka (University of Ljubljana), *Some natural extensions of the parking space* (p. 108) |
| 14:30 - 15:00 | Vasu Tewari (University of Pennsylvania), *Refined mixed Eulerian numbers* (p. 109) |
| 15:00 - 15:30 | Svetlana Poznanovikj (Clemson University), *Hecke insertion and maximal increasing and decreasing sequences in fillings of polyominoes* (p. 109) |
| 16:00 - 16:30 | Colleen Robichaux (University of Illinois Urbana-Champaign), *An Efficient Algorithm for Deciding the Vanishing of Schubert Polynomial Coefficients* (p. 109) |
| 16:30 - 17:00 | David Keating (University of California, Berkeley), *A Vertex Model for LLT Polynomials* (p. 108) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Justine Falque (Université Paris-Sud), *3-dimensional Catalan objets: a (partial) overview and a new bijection* (p. 106) |
| 14:30 - 15:00 | Sam Hopkins (University of Minnesota), *Promotion of Kreweras words* (p. 107) |
| 15:00 - 15:30 | Maria Gillespie (Colorado State University), *Parking functions and a projective embedding of* $\overline{M}_{0,n}$ (p. 107) |
| 16:00 - 16:30 | Ali Assem Mahmoud (University of Ottawa), *On the Enumerative Structures in QFT* (p. 109) |
| 16:30 - 17:00 | Nathan Williams (University of Texas, Dallas), *Strange Expectations in Affine Weyl Groups* (p. 110) |

### Tuesday December 8 — mardi 8 décembre

| | |
|---|---|
| 11:00 - 11:30 | Arvind Ayyer (Indian Institute of Science), *Toppleable permutations and excedances* (p. 106) |
| 11:30 - 12:00 | Ilse Fischer (University of Vienna), *Bijective proofs of (skew) Schur polynomial factorizations* (p. 107) |
| 12:00 - 12:30 | Helen Jenne (Université de Tours), *Double-dimer condensation and the dP3 Quiver* (p. 108) |
| 13:00 - 13:30 | Marni Mishna (Simon Fraser University), *Enumerating excursions on Cayley graphs* (p. 109) |
| 13:30 - 14:00 | Joel Lewis (George Washington University), *Hurwitz numbers for reflection groups* (p. 108) |

## Abstracts/Résumés

**ARVIND AYYER**, Indian Institute of Science
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Toppleable permutations and excedances*

Recall that an excedance of a permutation $\pi$ is any position $i$ such that $\pi_i > i$. Inspired by the work of Hopkins, McConville and Propp (Elec. J. Comb., 2017) on sorting using toppling, we say that a permutation is toppleable if it gets sorted by a certain sequence of toppling moves. We will show that the number of toppleable permutations on $n$ letters is the same as the number of permutations on $n$ letters for which excedances happen exactly at $\{1, \ldots, \lfloor (n-1)/2 \rfloor)$. Time permitting, we will show bijectively that this is also the number of acyclic orientations with unique sink of the complete bipartite graph $K_{\lceil n/2 \rceil, \lfloor n/2 \rfloor + 1}$. This is joint work with D. Hathcock and P. Tetali (arXiv:2010.11236).

**JUSTINE FALQUE**, LIGM, Univ. Marne-la-Vallée
[Sunday December 6 / dimanche 6 décembre, 14:00]
*3-dimensional Catalan objets: a (partial) overview and a new bijection*

A variant of the famous Catalan numbers, the sequence of 3-dimensional Catalan numbers counts the standard Young tableaux of shape (n,n,n) (whereas the classical Catalan numbers count those of shape (n,n)).

This talk will dwell on three combinatorial objects that are counted by the 3-dimensional Catalan numbers: first, 1234-avoiding up-down permutations ; second, a certain class of weighted Dyck paths ; and finally, product-coproduct prographs (introduced by Borie). We will outline how these objects relate to each other, and present a recently discovered bijection between the former two. Depending on the time left, we will discuss how the geometrical nature of PC prographs could be exploited to try to obtain a poset or even lattice structure on these objects.

**ILSE FISCHER**, University of Vienna
[Tuesday December 8 / mardi 8 décembre, 11:30]
*Bijective proofs of (skew) Schur polynomial factorizations*

Schur polynomials and their generalizations appear in various different contexts. They are the irreducible characters of polynomial representations of the general linear group and an important basis of the space of symmetric functions. They are accessible from a combinatorial point of view as they are multivariate generating functions of semistandard tableaux associated with a fixed integer partition. Recently, Ayyer and Behrend discovered for a wide class of partitions factorizations of Schur polynomials with an even number of variables where half of the variables are the reciprocals of the others into symplectic and/or orthogonal group characters, thereby generalizing results of Ciucu and Krattenthaler for rectangular shapes. We present bijective proofs of such identities. (Joint work with Arvind Ayyer.)

**MARIA GILLESPIE**, Colorado State University
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Parking functions and a projective embedding of $\overline{M}_{0,n}$*

We present a new class of parking functions, which we call *column restricted parking functions* or *CPF*'s, arising in the study of the compact moduli space $\overline{M}_{0,n}$ of genus $0$ stable curves with $n$ marked points. The space $\overline{M}_{0,n}$ embedded into the product of projective spaces $\mathbb{P}^1 \times \mathbb{P}^2 \times \cdots \times \mathbb{P}^{n-3}$, and we give give an explicit combinatorial formula for the multidegrees of this embedding in terms of CPF's of height $n-3$. This combinatorial interpretation implies that the *total degree* of the embedding (defined as the sum of the multidegrees) is equal to the total number of CPF's of height $n-3$, and we show that these are enumerated by the double factorial $(2(n-3)-1)!! = (2n-7)(2n-9)\cdots(5)(3)(1)$. This is joint work with Renzo Cavalieri and Leonid Monin.

If time permits, we will mention new joint work with Sean Griffin and Jake Levinson, in which we find an explicit bijection between CPF's and boundary points on $\overline{M}_{0,n}$ that is compatible with a geometric recursion defining the multidegrees.

**SAM HOPKINS**, University of Minnesota
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Promotion of Kreweras words*

Kreweras words are words consisting of n A's, n B's, and n C's in which every prefix has at least as many A's as B's and at least as many A's as C's. Equivalently, a Kreweras word is a linear extension of the poset Vx[n]. Kreweras words were introduced in 1965 by Kreweras, who gave a remarkable product formula for their enumeration. Subsequently they became a fundamental example in the theory of lattice walks in the quarter plane. We study Schützenberger's promotion operator on the set of Kreweras words. In particular, we show that 3n applications of promotion on a Kreweras word merely swaps the B's

and C's. Doing so, we provide the first answer to a question of Stanley from 2009, asking for posets with "good" behavior under promotion, other than the four families of shapes classified by Haiman in 1992. Our proof uses webs (in the sense of Kuperberg) and we obtain some interesting enumerative corollaries about webs. This is joint work with Martin Rubey.

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**HELEN JENNE**, CNRS, Institut Denis Poisson, Université de Tours
[Tuesday December 8 / mardi 8 décembre, 12:00]
*Double-dimer condensation and the dP3 Quiver*

In this talk we will discuss an application of double-dimer condensation to a problem in cluster algebras, which is ongoing joint work with Tri Lai and Gregg Musiker. Double-dimer condensation is a recurrence satisfied by the partition function for double-dimer configurations of a planar bipartite graph. A similar identity for the number of dimer configurations of a planar bipartite graph was established nearly 20 years ago by Kuo.

In 2017, Lai and Musiker gave combinatorial interpretations for many toric cluster variables in the cluster algebra associated to the cone over the del Pezzo surface dP3. Specifically, they used Kuo condensation to show that most toric cluster variables have Laurent expansions agreeing with the partition functions for dimer configurations. However, in some cases, the dimer model was not sufficient. We show that in these cases, the Laurent expansions agree with partition functions for double-dimer configurations.

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**DAVID KEATING**, UC Berkeley
[Saturday December 5 / samedi 5 décembre, 16:30]
*A Vertex Model for LLT Polynomials*

In the talk we will describe a novel Yang-Baxter integrable vertex model. From this vertex model we will construct a certain class of partition functions that we will show are equal to the LLT polynomials of Lascoux, Leclerc, and Thibon. Using the vertex model formalism, we give alternate proofs of many properties of these polynomials, including symmetry and a Cauchy identity. This is based on joint work with Sylvie Corteel, Andrew Gitlin, and Jeremy Meza.

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**MATJAŽ KONVALINKA**, University of Ljubljana
[Saturday December 5 / samedi 5 décembre, 14:00]
*Some natural extensions of the parking space*

We construct a family of $S_n$-modules indexed by $c \in \{1, \ldots, n\}$ with the property that upon restriction to $S_{n-1}$ they recover the classical parking function representation of Haiman. The construction of these modules relies on an $S_n$-action on a set that is closely related to the set of parking functions. We compute the characters of these modules and use the resulting description to classify them up to isomorphism, and compute the number of isomorphism classes. Based on empirical evidence, we conjecture that when $c = 1$, our representation is $h$-positive and is in fact the (ungraded) extension of the parking function representation constructed by Berget and Rhoades.

Berget and Rhoades asked whether the permutation representation obtained by the action of $S_{n-1}$ on parking functions of length $n - 1$ can be extended to a permutation action of $S_n$. We answer this question in the affirmative, by realizing our module in two different ways.

This is joint work with Robin Sulzgruber and Vasu Tewari.

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**JOEL LEWIS**, George Washington University
[Tuesday December 8 / mardi 8 décembre, 13:30]
*Hurwitz numbers for reflection groups*

In the symmetric group, the Hurwitz numbers count factorizations of a given permutation as a product of a fixed number of transpositions, subject to the requirement that the factors used act transitively on $\{1, \ldots, n\}$. We study the analogous problem

when the symmetric group is replaced by any Weyl group $W$, counting factorizations as a product of reflections subject to the requirement that the factors generate $W$. We find a beautiful uniform formula generalizing the result in the symmetric group, and describe some interesting features of the (case-by-case) proof.

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**ALI ASSEM MAHMOUD**, University of Ottawa
[Sunday December 6 / dimanche 6 décembre, 16:00]
*On the Enumerative Structures in QFT*

The aim of this talk is to display some enumerative results that are directly applied in quantum field theory. We shall see how the number of connected chord diagrams can be used to count one-particle-irreducible (1PI) diagrams in Yukawa theory. This translation of Feynman diagrams simplified the process of calculating the asymptotic behaviour of the corresponding Green functions.

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**MARNI MISHNA**, Simon Fraser University
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Enumerating excursions on Cayley graphs*

Given a finitely generated group with generating set S, we study the cogrowth sequence, which is the number of words of length n over the alphabet S that are equal to one. This is related to the probability of return for walks in a Cayley graph with steps from S. This talk will survey the connections between the structure of the group, and properties of the cogrowth sequence via the nature of its generating function. We will then show that the cogrowth sequence is not P-recursive when G is an amenable group of superpolynomial growth, answering a question of Garrabant and Pak. In addition, we compute the exponential growth of the cogrowth sequence for certain infinite families of free products of finite groups and free groups. Work in collaboration with Jason Bell and Haggai Liu

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**SVETLANA POZNANOVIKJ**, Clemson University
[Saturday December 5 / samedi 5 décembre, 15:00]
*Hecke insertion and maximal increasing and decreasing sequences in fillings of polyominoes*

We will give a proof that the number of 01-fillings of a given stack polyomino (a polyomino with justified rows whose lengths form a unimodal sequence) with at most one 1 per column which do not contain a fixed-size northeast chain and a fixed-size southeast chain, depends only on the set of row lengths of the polyomino. The proof is via a bijection between fillings of stack polyominoes which differ only in the position of one row and uses Hecke insertion and jeu de taquin for increasing tableaux. We will discuss how this work relates to other results about chains in fillings of polyominoes as well as graphs and set partitions and mention some possible and impossible extensions.

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**COLLEEN ROBICHAUX**, University of Illinois at Urbana-Champaign
[Saturday December 5 / samedi 5 décembre, 16:00]
*An Efficient Algorithm for Deciding the Vanishing of Schubert Polynomial Coefficients*

Schubert polynomials form a basis of all polynomials and appear in the study of cohomology rings of flag manifolds. The vanishing problem for Schubert polynomials asks if a coefficient of a Schubert polynomial is zero. We give a tableau criterion to solve this problem, from which we deduce the first polynomial time algorithm. These results are obtained from new characterizations of the Schubitope, a generalization of the permutahedron defined for any subset of the $n \times n$ grid. In contrast, we show that computing these coefficients explicitly is $\#\mathrm{P}-$complete. This is joint work with Anshul Adve and Alexander Yong.

**VASU TEWARI**, University of Pennsylvania
[Saturday December 5 / samedi 5 décembre, 14:30]
*Refined mixed Eulerian numbers*

Mixed Eulerian numbers were introduced by Postnikov as mixed volumes of hypersimplices, and they can be considered as a far-reaching generalization of classical Eulerian numbers. In this talk, we will introduce a refinement of these numbers by 'inserting a $q$' in the setup. We will subsequently provide combinatorial and probabilistic interpretations for these *remixed Eulerian numbers*. Time permitting, we will discuss our main motivation: combinatorics of Schubert polynomials and the permutahedral variety.

This is a report on work in progress with Philippe Nadeau.

**NATHAN WILLIAMS**, University of Texas at Dallas
[Sunday December 6 / dimanche 6 décembre, 16:30]
*Strange Expectations in Affine Weyl Groups*

We extend our previous work on computing expected values of quadratic forms on coroot points in the Sommers region from simply-laced affine Weyl groups to all affine Weyl groups. In type A, our uniform formula recovers Drew Armstrong's conjecture for the average number of boxes in a simultaneous core. This is joint work with Marko Thiel and Eric Stucky.

# Equidistribution on Arithmetic Manifolds / Équidistributions sur les Variétés Arithmétiques

Org: **Ilya Khayutin** (Northwestern) and/et **Simon Marshall** (Wisconsin)

## Schedule/Horaire

### Monday December 7 — lundi 7 décembre

| | |
|---|---|
| 14:00 - 14:30 | Amir Mohammadi (University of California, San Diego), *Effective results in homogeneous dynamics* (p. 114) |
| 14:30 - 15:00 | Asaf Katz (University of Michigan), *An application of Margulis' inequality to effective equidistribution* (p. 113) |
| 15:00 - 15:30 | Shai Evra (Princeton University), *Ramanujan Conjecture and the Density Hypothesis* (p. 111) |
| 15:30 - 16:00 | Mikolaj Fraczyk (The University of Chicago), *Density hypothesis in horizontal families* (p. 112) |
| 16:00 - 16:30 | Nicholas Miller (University of California, Berkeley), *Geodesic submanifolds of hyperbolic manifolds* (p. 114) |
| 16:30 - 17:00 | Alex Kontorovich (Rutgers University), *Applications of Thin Orbits* (p. 113) |

### Tuesday December 8 — mardi 8 décembre

| | |
|---|---|
| 11:00 - 11:30 | Lam Pham (Hebrew University), *Arithmetic Groups and the Lehmer conjecture* (p. 114) |
| 11:30 - 12:00 | Arie Levit (Yale University), *Quantitative weak uniform discreteness* (p. 113) |
| 12:00 - 12:30 | Mathilde Gerbelli-Gauthier (McGill University), *Limit multiplicity of non-tempered representations and endoscopy.* (p. 112) |
| 13:00 - 13:30 | Will Sawin (Columbia University), *The mixing conjecture over function fields* (p. 114) |
| 13:30 - 14:00 | Junehyuk Jung (Brown University), *Intersections of geodesics on the modular surface* (p. 113) |
| 14:00 - 14:30 | Lindsay Dever (Bryn Mawr College), *Ambient prime geodesic theorems on compact hyperbolic 3-manifolds* (p. 111) |
| 14:30 - 15:00 | Matthew Young (Texas A&M University), *Moments and hybrid subconvexity for symmetric-square L-functions* (p. 115) |
| 15:30 - 16:00 | Wenyu Pan (The University of Chicago), *Exponential mixing of geodesic flows for geometrically finite hyperbolic manifolds with cusps* (p. 114) |
| 16:00 - 16:30 | Thomas Hille (Northwestern University), *Bounds for the Least Solution of Homogeneous Quadratic Diophantine Inequalities.* (p. 112) |
| 16:30 - 17:00 | Alireza Salehi Golsefidy (University of California, San Diego), *Two new concepts for compact groups: Spectral independence and local randomness* (p. 112) |

## Abstracts/Résumés

**LINDSAY DEVER**, Bryn Mawr College

[Tuesday December 8 / mardi 8 décembre, 14:00]

*Ambient prime geodesic theorems on compact hyperbolic 3-manifolds*

The study of hyperbolic 3-manifolds draws deep connections between number theory, geometry, topology, and quantum mechanics. Specifically, the closed geodesics on a manifold are intrinsically related to the eigenvalues of Maass forms via the Selberg trace formula and are parametrized by their length and holonomy. The trace formula for spherical Maass forms can be used to prove the Prime Geodesic Theorem, which provides an asymptotic count of geodesics up to a certain length. In 1999, Sarnak and Wakayama established a count of geodesics by both length and holonomy that shows that holonomies of geodesics of increasing lengths become equidistributed throughout the circle. In this talk, I will present new results including a count of geodesics in shrinking intervals of length and holonomy, which implies effective equidistribution of holonomy.

**SHAI EVRA**, Princeton
[Monday December 7 / lundi 7 décembre, 15:00]
*Ramanujan Conjecture and the Density Hypothesis*

The Generalized Ramanujan Conjecture (GRC) for GL(n) is a central open problem in modern number theory. Its resolution is known to yield several important applications. For instance, the Ramanujan-Petersson conjecture for GL(2), proven by Deligne, was a key ingredient in the work of Lubotzky-Phillips-Sarnak on Ramanujan graphs. One can also state analogues (Naive) Ramanujan Conjectures (NRC) for other reductive groups. However, in the 70's Kurokawa and Howe-Piatetski-Shapiro proved that the (NRC) fails even for quasi-split classical groups. In the 90's Sarnak-Xue put forth a Density Hypothesis version of the (NRC), which serves as a replacement of the (NRC) in applications. In this talk I will describe a possible approach to proving the Density Hypothesis for definite classical groups, by invoking deep and recent results coming from the Langlands program: The endoscopic classification of automorphic representations of classical groups due to Arthur, and the proof of the Generalized Ramanujan-Petersson Conjecture.

**MIKOLAJ FRACZYK**, University of Chicago
[Monday December 7 / lundi 7 décembre, 15:30]
*Density hypothesis in horizontal families*

Let G be a real semi simple Lie group with an irreducible unitary representation $\pi$. The non-temperedness of $\pi$ is measured by the real parameter $p(\pi)$ which is defined as the infimum of $p \geq 2$ such that $\pi$ has non-zero matrix coefficients in $L^p(G)$. Sarnak and Xue conjectured that for any arithmetic lattice $\Gamma \subset G$ and principal congruence subgroup $\Gamma(q) \subset \Gamma$, the multiplicity of $\pi$ in $L^2(G/\Gamma(q))$ is at most $O(V(q)^{2/p(\pi)+\epsilon})$ where $V(q)$ is the covolume of $\Gamma(q)$. Sarnak and Xue proved this conjecture for $G = SL(2,R), SL(2,\mathbb{C})$. In a a joint work with Gergely Harcos, Peter Maga and Djordje Milicevic we prove bounds of the same quality that hold uniformly for families of pairwise non-commensurable lattices in $G = SL(2,\mathbb{R})^a \times SL(2,\mathbb{C})^b$ given as unit groups of maximal orders of quaternion algebras over number fields ("horizontal families"). I will also discuss how the multiplicity bounds depend on the Archimedean parameters and some possible extensions of our methods.

**MATHILDE GERBELLI-GAUTHIER**, Centre de Recherches Mathématiques
[Tuesday December 8 / mardi 8 décembre, 12:00]
*Limit multiplicity of non-tempered representations and endoscopy.*

How fast do Betti numbers grow in a congruence tower of compact arithmetic manifolds ? The question can be reformulated in terms of limit multiplicity of representations. If the representation is discrete series, the rate of growth is known to be proportional to the volume of the manifold ; otherwise the growth is sub-linear in the volume. Sarnak-Xue have conjectured that bounds on multiplicity growth can be expressed in terms of the failure of representations to be tempered. I will confirm some instances of the Sarnak-Xue conjecture for unitary groups using the fact that some non-tempered representations arise as endoscopic transfer, and give applications to cohomology growth.

**ALIREZA SALEHI GOLSEFIDY**, UCSD
[Tuesday December 8 / mardi 8 décembre, 16:30]
*Two new concepts for compact groups: Spectral independence and local randomness*

I will explain two new concepts for compact groups mentioned in the title. Their basic properties and their connections with the FAb property, quasi-randomness, and super-approximation will be outlined. I will present how these ideas help us show that a Borel probability measure m on the product of compact open subgroups of two locally non-isomorphic simple analytic groups has the spectral gap property when its projection to each factor has. (Joint work with Keivan Mallahi-Karai and Amir Mohammadi)

**THOMAS HILLE**, Northwestern
[Tuesday December 8 / mardi 8 décembre, 16:00]
*Bounds for the Least Solution of Homogeneous Quadratic Diophantine Inequalities.*

Let $Q$ be a non-degenerate indefinite quadratic form in $d$ variables. In the mid 80's, Margulis proved the Oppenheim conjecture, which states that if $d \geq 3$ and $Q$ is not proportional to a rational form then $Q$ takes values arbitrarily close to zero at integral points. In this talk we will discuss the problem of obtaining bounds for the least integral solution of the Diophantine inequality $|Q[x]| < \epsilon$ for any positive $\epsilon$ if $d \geq 5$. We will show how to obtain explicit bounds that are polynomial in $\epsilon^{-1}$, with exponents depending only on the signature of $Q$ or if applicable, the Diophantine properties of $Q$. This talk is based on joint work with P. Buterus, F. Götze and G. Margulis.

**JUNEHYUK JUNG**, Brown University
[Tuesday December 8 / mardi 8 décembre, 13:30]
*Intersections of geodesics on the modular surface*

Let $\alpha$ be a compact geodesic segment in the full modular surface, and let $C_D$ be the union of closed geodesics of discriminant $D$. I'm going to present a proof that the intersection points $\alpha \cap C_D$ become equidistributed along $\alpha$ as $D \to \infty$. I will then discuss how to make the theorem effective. This is a joint work with Naser Talebizadeh Sardari.

**ASAF KATZ**, University of Michigan
[Monday December 7 / lundi 7 décembre, 14:30]
*An application of Margulis' inequality to effective equidistribution*

Ratner's celebrated equidistribution theorem states that the trajectory of any point in a homogeneous space under a unipotent flow is getting equidistributed with respect to some algebraic measure. In the case where the action is horospherical, one can deduce an effective equidistribution result by mixing methods, an idea that goes back to Margulis' thesis. When the homogeneous space is non-compact, one needs to impose further "diophantine conditions" over the base point, quantifying some recurrence rates, in order to get a quantified equidistribution result.

In the talk I will discuss certain diophantine conditions, and in particular I will show how a new Margulis' type inequality for translates of horospherical orbits helps verify such conditions, a quantified equidistribution result for a large class of points, akin to the results of A. Strombreggson dealing with $SL_2$ case. In particular we deduce a fully effective quantitative equidistribution for horospherical trajectories of lattices defined over number fields, without pertaining to the strong subspace theorem.

**ALEX KONTOROVICH**, Rutgers
[Monday December 7 / lundi 7 décembre, 16:30]
*Applications of Thin Orbits*

We describe some applications of equidistribution of arithmetic manifolds to thin orbits.

**ARIE LEVIT**, Yale university
[Tuesday December 8 / mardi 8 décembre, 11:30]
*Quantitative weak uniform discreteness*

I will discuss a quantitative variant of the classical Kazhdan-Margulis theorem generalized to probability measure preserving actions of semisimple groups over local fields. More precisely, the probability that the stabilizer of a random point admits a non-trivial intersection with a small $r$-neighborhood of the identity is at most $br^d$, for some explicit constants $b, d > 0$ depending only on the semisimple group in question. Our proof involves some of the original ideas of Kazhdan and Margulis,

combined with methods of Margulis functions as well as $(C, \alpha)$-good functions on varieties. As an application, we present a new unified proof of the fact that all lattices in these groups are weakly cocompact, i.e admit a spectral gap. The talk is based on a preprint joint with Gelander and Margulis.

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**NICHOLAS MILLER**, UC Berkeley
[Monday December 7 / lundi 7 décembre, 16:00]
*Geodesic submanifolds of hyperbolic manifolds*

It is a consequence of the Margulis dichotomy that when an arithmetic hyperbolic manifold contains one totally geodesic hypersurface, it contains infinitely many. Both Reid and McMullen have asked conversely whether the existence of infinitely many geodesic hypersurfaces implies arithmeticity of the corresponding real hyperbolic manifold. In this talk, I will discuss recent results answering this question in the affirmative. This is joint work with Bader, Fisher, and Stover.

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**AMIR MOHAMMADI**, UCSD
[Monday December 7 / lundi 7 décembre, 14:00]
*Effective results in homogeneous dynamics*

Rigidity phenomena in homogeneous dynamics have been extensively studied over the past few decades with several striking results and applications. In this talk we will give an overview of the more recent activities which aim at presenting quantitative versions of some of these strong rigidity results.

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**WENYU PAN**, University of Chicago
[Tuesday December 8 / mardi 8 décembre, 15:30]
*Exponential mixing of geodesic flows for geometrically finite hyperbolic manifolds with cusps*

Let $\mathbb{H}^n$ be the hyperbolic $n$-space and $\Gamma$ be a geometrically finite discrete subgroup in $\mathrm{Isom}_+(\mathbb{H}^n)$ with parabolic elements. In the joint work with Jialun LI, we establish the exponential mixing of the geodesic flow over the unit tangent bundle $T^1(\Gamma\backslash\mathbb{H}^n)$ with respect to the Bowen-Margulis-Sullivan measure. This kind of result is known to have many immediate applications in number theory and geometry, which includes counting closed geodesics and shrinking target problems. Our approach is to construct coding for the geodesic flow and then prove a Dolgopyat-type spectral estimate for the corresponding transfer operator. I will also discuss the application of obtaining a resonance-free region for the resolvent on $\Gamma\backslash\mathbb{H}^n$.

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**LAM PHAM**, Brandeis University
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Arithmetic Groups and the Lehmer conjecture*

The Lehmer problem (1933), also referred to as the 'Lehmer conjecture', asks whether there is a uniform lower bound on the Mahler measure of algebraic integers which are not roots of unity. Although rooted in number theory, many interesting connections between the Lehmer problem and other fields, including combinatorics in finite fields and geometric group theory. Following his celebrated Arithmeticity Theorem, Margulis conjectured in his book (1991) the uniform discreteness of cocompact lattices in higher rank semisimple Lie groups and observed that it would follow from a weak form of the Lehmer conjecture. We will discuss the equivalence of these conjectures and some refinements. This is based on joint work with François Thilmany.

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**WILL SAWIN**, Columbia University
[Tuesday December 8 / mardi 8 décembre, 13:00]
*The mixing conjecture over function fields*

Michel and Venkatesh conjectured a generalization of Duke's theorem - that Galois orbits of CM points are equidistributed on a product of two modular curves. Shende and Tsimerman proved a function-field analogue of this conjecture, conditional on a hypothesis, which I verified in recent work. Also recently, Khayutin has proven the original conjecture under some assumptions, and even more recently Blomer and Brumley have proven a weaker form of the conjecture under a different set of assumptions. These proofs all use very different methods and have distinct strengths and weaknesses. I will describe some of the key ideas of the geometric approach of Shende, Tsimerman, and myself.

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**MATTHEW YOUNG**, Texas A&M
[Tuesday December 8 / mardi 8 décembre, 14:30]
*Moments and hybrid subconvexity for symmetric-square L-functions*

I will discuss some recent work on moment problems for symmetric-square L-functions. One application of this work is a hybrid subconvexity result for these L-functions, and another is a short interval Lindelof-on-average bound. I will also discuss some of the motivation for these problems, which relates these L-functions to the equidistribution of cusp forms on the modular surface. This is joint work with Rizwan Khan.

# Fibrations and Degenerations in Algebraic Geometry / Fibrations et Dégénérations en Géométrie Algébrique

**Org: Chuck Doran** (Alberta) and/et **Andrew Harder** (Lehigh)

## Schedule/Horaire

| **Friday December 4** | **vendredi 4 décembre** |
|---|---|
| 13:00 - 14:00 | Jordon Kostiuk (Brown University), *Geometric Variations of Local Systems* (p. 116) |
| 14:00 - 15:00 | Elana Kalashnikov (Harvard University) (p. 116) |
| 15:30 - 16:30 | Daniel Lopez (IMPA), *Homology supported in Lagrangian submanifolds in mirror quintic threefolds* (p. 117) |
| 16:30 - 17:30 | Tokio Sasaki (University of Miami), *Limits of geometric higher normal functions and Apéry constants* (p. 117) |

| **Saturday December 5** | **samedi 5 décembre** |
|---|---|
| 14:00 - 15:00 | Matt Kerr (Washington University at St. Louis), *Frobenius constants and limiting mixed Hodge structures* (p. 116) |
| 15:00 - 16:00 | Sukjoo Lee (University of Pennsylvania), *The mirror P=W conjecture from Homological Mirror Symmetry* (p. 117) |
| 16:00 - 17:00 | Ursula Whitcher (Mathematical Reviews) (p. 118) |

| **Sunday December 6** | **dimanche 6 décembre** |
|---|---|
| 14:00 - 15:00 | Alan Thompson (Loughborough University), *Mirror Symmetry for Fibrations and Degenerations* (p. 117) |
| 15:00 - 16:00 | Adrian Clingher (University of Missouri - St. Louis), *On K3 surfaces of Picard rank 14* (p. 116) |

## Abstracts/Résumés

**ADRIAN CLINGHER**, University of Missouri - St. Louis
[Sunday December 6 / dimanche 6 décembre, 15:00]
*On K3 surfaces of Picard rank 14*

In this talk, I will present a study of complex K3 surfaces polarized by rank-fourteen, two-elementary lattices. This study includes birational models for these surfaces, as quartic projective hypersurfaces and a description of the associated coarse moduli spaces. I will also discuss a classification of all present Jacobian elliptic fibrations. This is joint work with A. Malmendier.

**ELANA KALASHNIKOV**, Harvard University
[Friday December 4 / vendredi 4 décembre, 14:00]

**MATT KERR**, Washington University in St. Louis
[Saturday December 5 / samedi 5 décembre, 14:00]
*Frobenius constants and limiting mixed Hodge structures*

I explain how the Mellin transform of a variation of Hodge structure computes extension classes in its limit. In particular, it produces both a formula and a motive for the LMHS in the hypergeometric case.

**JORDON KOSTIUK**, Brown University
[Friday December 4 / vendredi 4 décembre, 13:00]
*Geometric Variations of Local Systems*

Geometric variations of local systems are families of variations of Hodge structure ; they typically correspond to fibrations of Kähler manifolds for which each fibre itself is fibred by codimension-one Kähler manifolds. In this talk, I introduce the formalism of geometric variations of local systems and then specialize the theory to study families of elliptic surfaces. I will explain some of the computational challenges that go into computing geometric variations of Hodge and highlight examples coming from elliptically fibred K3-surfaces and K3-surface fibred Calabi-Yau threefolds.

**SUKJOO LEE**, University of Pennsylvania
[Saturday December 5 / samedi 5 décembre, 15:00]
*The mirror P=W conjecture from Homological Mirror Symmetry*

The mirror P=W conjecture, recently formulated by A.Harder, L.Katzarkov and V.Przyjalkowski, is a refined Hodge number symmetry between a log Calabi-Yau mirror pair $(U, U^\vee)$. It predicts that the weight filtration on the cohomology $H^\bullet(U)$ is equivalent to the perverse filtration on the cohomology $H^\bullet(U^\vee)$ associated to the affinization map. One can see this phenomenon from the categorical viewpoint when $U$ admits a Fano compactification $(X, D)$ where $X$ is a smooth Fano and $D$ is a smooth anti-canonical divisor. I will go over this story and generalize it to the case when $D$ has more than one component.

**DANIEL LOPEZ**, Instituto de Matematica Pura e Aplicada (IMPA)
[Friday December 4 / vendredi 4 décembre, 15:30]
*Homology supported in Lagrangian submanifolds in mirror quintic threefolds*

In this talk, we study homology classes in the mirror quintic Calabi-Yau threefold which can be realized by Lagrangian submanifolds. We have used Picard-Lefschetz theory to establish the monodromy action and to study the orbit of Lagrangian vanishing cycles. For many prime numbers $p$ we can compute the orbit modulo $p$. We conjecture that the orbit in homology with coefficients in $\mathbb{Z}$ can be determined by these orbits with coefficients in $\mathbb{Z}_p$.

**TOKIO SASAKI**, University of Miami
[Friday December 4 / vendredi 4 décembre, 16:30]
*Limits of geometric higher normal functions and Apéry constants*

The irrationality of $\zeta(3)$ was historically proven by R. Apéry via the approximation by the ratio of two sequences of integers. For each of five Mukai Fano threefolds with Picard rank 1, V.Golyshev obtained a special value of $L$-function as the ratio of similar two sequences which arise from the quantum recursion. In terms of the mirror symmetry, this construction in the A-model side can be generalized to Fano threefolds with Picard rank 1. The Arithmetic Mirror Symmetry Conjecture states that a corresponding construction in the B-model side will be obtained from the limits of geometric higher normal functions. In this talk, we show that this conjecture holds for five Golyshev's examples by constructing specific higher Chow cycles. This is joint work with V. Golyshev and M. Kerr.

**ALAN THOMPSON**, Loughborough University
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Mirror Symmetry for Fibrations and Degenerations*

In a 2004 paper, Tyurin briefly hinted at a novel relationship between Calabi-Yau mirror symmetry and the Fano-LG correspondence. More specifically, if one can degenerate a Calabi-Yau manifold to a pair of (quasi-)Fanos, then one expects to be able

to express the mirror Calabi-Yau in terms of the corresponding Landau-Ginzburg models. Some details of this correspondence were worked out by C. F. Doran, A. Harder, and I in a 2017 paper, but much remains mysterious.

In this talk I will describe recent attempts to better understand this picture, and how it hints at a broader mirror symmetric correspondence between degeneration and fibration structures. As an example of this correspondence, I will discuss the question of finding mirrors to certain exact sequences which describe the Hodge theory of degenerations.

The material in this talk is joint work in progress with C. F. Doran.

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**URSULA WHITCHER**, Mathematical Reviews
[Saturday December 5 / samedi 5 décembre, 16:00]

# Geometric and Computational Spectral Theory / Théorie Spectrale Géométrique et Computationnelle

**Org: Alexandre Girouard** (Université Laval), **Mikhail Karpukhin** (California Institute of Technology), **Jean Lagacé** (University College London), **Michael Levitin** (University of Reading) and/et **Nilima Nigam** (Simon Fraser University)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Romain Petrides (Université Paris Diderot), *Free boundary minimal surfaces of any topological type in euclidean balls via shape optimization (Part 1)* (p. 125) |
| 13:30 - 14:00 | Henrik Mathiesen (Chicago), *Free boundary minimal surfaces of any topological type in Euclidean balls via shape optimization (Part 2)* (p. 124) |
| 14:00 - 14:30 | Jeffrey Ovall (Portland State U.), *Exploring Eigenvector Localization Using Filtered Subspace Iteration (FEAST)* (p. 124) |
| 14:30 - 15:00 | Graham Cox (Memorial), *Defining the spectral position of a Neumann domain* (p. 120) |
| 15:30 - 16:00 | Iosif Polterovich (Montréal), *The Dirichlet-to-Neumann map, the boundary Laplacian and an unpublished paper of Hörmander* (p. 125) |

### Saturday December 5 — samedi 5 décembre

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| 14:00 - 14:30 | David Sher (DePaul U.), *Inverse Steklov spectral problem for curvilinear polygons* (p. 125) |
| 14:30 - 15:00 | Suresh Eswarathasan (Dalhousie), *Entropy of $\epsilon$-logarithmic quasimodes* (p. 121) |
| 15:00 - 15:30 | Oscar Bruno (Caltech), *Domains Without Dense Steklov Nodal Sets* (p. 120) |
| 15:30 - 16:00 | Braxton Osting (Utah), *Maximal Spectral Gaps for Periodic Schroedinger Operators* (p. 124) |
| 16:00 - 16:30 | Xuwen Zhu (North Eastern), *Spectral properties of spherical conical metrics* (p. 126) |

### Sunday December 6 — dimanche 6 décembre

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| 14:00 - 14:30 | Mikhail Karpukhin (Caltech), *Continuity of eigenvalues with applications to eigenvalue optimization* (p. 123) |
| 14:30 - 15:00 | Jean Lagacé (UCL), *Geometric homogenisation theory and spectral shape optimisation* (p. 124) |
| 15:00 - 15:30 | Dima Jakobson (McGill), *Zero and negative eigenvalues of conformally covariant operators, and nodal sets in conformal geometry* (p. 123) |
| 15:30 - 16:00 | Emily Dryden (Bucknell), *Heat content of polygons* (p. 121) |
| 16:00 - 16:30 | Daniel Stern (Chicago), *Shape optimization in spectral geometry via variational methods for harmonic maps* (p. 126) |

### Monday December 7 — lundi 7 décembre

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| 14:00 - 14:30 | Asma Hassanezhad (Bristol), *Eigenvalue and multiplicity bounds for the mixed Steklov problem* (p. 122) |
| 14:30 - 15:00 | Carolyn Gordon (Dartmouth), *Comparing Hodge spectra of manifolds and orbifolds: Part 1* (p. 122) |
| 15:00 - 15:30 | Katie Gittins (Durham), *Comparing Hodge spectra of manifolds and orbifolds: Part 2.* (p. 122) |
| 15:30 - 16:00 | Sebastian Dominguez (Simon Fraser), *Steklov eigenvalues in linear elasticity* (p. 121) |
| 16:00 - 16:30 | Antoine Metras (Montréal), *Steklov extremal metrics in higher dimension* (p. 124) |

### Tuesday December 8 — mardi 8 décembre

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| 11:00 - 11:30 | Mario Schulz (Quenn Mary U. of London), *Free boundary minimal surfaces in the unit ball* (p. 125) |
| 11:30 - 12:00 | Benjamin Bogosel (Polytechnique Paris), *Shape optimization of the Steklov eigenvalues under various constraints* (p. 120) |
| 12:00 - 12:30 | Jeffrey Galkowski (UCL), *Geodesic beams and Weyl remainders* (p. 121) |

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| 13:00 - 13:30 | Dave Hewett (UCL), *Acoustic scattering by fractal screens* (p. 122) |
| 13:30 - 14:00 | Chiu-Yen Kao (Claremont Mckenna College), *Computation of free boundary minimal surfaces via extremal Steklov eigenvalue problems* (p. 123) |
| 14:00 - 14:30 | Alexandre Girouard (Laval), *Planar domains with prescribed perimeter and large Steklov spectral gap must collapse to a point* (p. 121) |

## Abstracts/Résumés

**BENJAMIN BOGOSEL**, Centre de Mathématiques Appliquées, Ecole Polytechnique
[Tuesday December 8 / mardi 8 décembre, 11:30]
*Shape optimization of the Steklov eigenvalues under various constraints*

Many recent works deal with the shape optimization of the Steklov eigenvalues. There are only a few cases where the optimal shapes are explicitly known, which motivates the study of numerical algorithms that can approximate efficiently the optimal shapes. In this presentation theoretical aspects regarding the existence of optimal shapes and numerical aspects regarding the numerical computation of Steklov eigenvalues are shown. Algorithms for optimizing numerically functionals related to the Steklov eigenvalues under volume, diameter and convexity constraints are also presented.

This work is the result of collaborations with D. Bucur, A. Giacomini, A. Henrot, F. Nacry and A. Al Sayed.

**OSCAR BRUNO**, Caltech
[Saturday December 5 / samedi 5 décembre, 15:00]
*Domains Without Dense Steklov Nodal Sets*

This talk concerns the asymptotic geometric character of the nodal set of the eigenfunctions of the Steklov eigenvalue problem in two-dimensional domains. In particular results will be mentioned which establish the existence of a dense family $\mathcal{A}$ of simply-connected two-dimensional domains with analytic boundaries for each one of which the Steklov eigenfunction's nodal lines "are not dense at scale $1/j$". This result, which addresses a question put forth under "Open Problem 10" in Girouard and Polterovich, J. Spectr. Theory, 321-359 (2017), shows that, for domains in the class $\mathcal{A}$, the Steklov nodal sets have starkly different character than anticipated: they are not dense at any shrinking scale. A variety of numerical results, including surprising graphical manifestations of the non-dense nodal character, will also be presented. Work in collaboration with Jeffrey Galkowski.

**GRAHAM COX**, Memorial University
[Friday December 4 / vendredi 4 décembre, 14:30]
*Defining the spectral position of a Neumann domain*

A Laplacian eigenfunction on a Riemannian surface provides a natural partition into Neumann domains—open subsets on which the function satisfies Neumann boundary conditions. These are a natural analogue of nodal domains, on which the eigenfunction satisfies Dirichlet boundary conditions, but their analysis ends up being much more involved.

In this talk I will explain why, on a given Neumann domain, the Neumann Laplacian has compact resolvent (and hence discrete spectrum), and the restricted eigenfunction is an eigenfunction of the Neumann Laplacian. The difficulty in proving these results is that the boundary of a Neumann domain may have cusps and cracks, and hence is not necessarily continuous, so standard density and compactness results for Sobolev spaces are not available. This problem can be overcome using special geometric properties of the Neumann domain boundary, which is made up of gradient flow lines for the corresponding eigenfunction.

These results allow one to define the spectral position of a Neumann domain. (Unlike a nodal domain, the restricted eigenfunction on a Neumann domain is never the ground state.) Finally, I will present a formula for computing the spectral position using the Dirichlet-to-Neumann map. This is joint work with Ram Band and Sebastian Egger.

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**SEBASTIAN DOMINGUEZ**, University of Saskatchewan
[Monday December 7 / lundi 7 décembre, 15:30]
*Steklov eigenvalues in linear elasticity*

In this talk we discuss Steklov eigenvalues for the Lamé operator in linear elasticity. In this eigenproblem the spectral parameter appears in a Robin-type boundary condition, linking the traction and the displacement. To establish the existence of a countable spectrum for this problem, we present an extension of Korn's inequality. We also show that a proposed conforming Galerkin scheme provides convergent approximations to the true eigenvalues. Finally, a standard finite element method is used to conduct numerical experiments on 2D and 3D domains.

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**EMILY DRYDEN**, Bucknell University
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Heat content of polygons*

Imagine heating up a planar domain to uniform temperature and freezing its boundary at temperature zero. If we measure the heat content of the domain over time, what geometric information can we obtain? Does this geometric information uniquely determine planar domains? We will investigate these questions for planar polygons. This talk is based on joint work with Madelyne Brown and Jeffrey Langford.

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**SURESH ESWARATHASAN**, Dalhousie University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Entropy of $\epsilon$-logarithmic quasimodes*

Consider $(M, g)$ a hyperbolic surface without boundary and its semiclassical Laplacian $-\hbar^2\Delta_g$. It has been shown that for sequences of $-\hbar^2\Delta_g$-eigenfunctions $\{\psi_\hbar\}_\hbar$ (with central energy $E > 0$) and corresponding semiclassical measure $\mu_{sc}$, the Kolmogorov-Sinai entropy $H_{KS}(\mu_{sc})$ is bounded below by $\frac{1}{2}$.
In this talk, we discuss the semiclassical measures $\mu_{sc}$ of special sums of $-\hbar^2\Delta_g$ eigenfunctions, namely *$\epsilon$-logarithmic quasimodes* $\Psi_\hbar$ (with central energy $E > 0$) where $\epsilon > 0$. We show that for any $c \in [0, \frac{1}{2}]$, there exists $\epsilon = \epsilon(c)$ and a family of $\{\Psi_\hbar\}_\hbar$ of $\epsilon$-logarithmic quasimodes whose $H_{KS}(\mu_{sc})$ is bounded below by $c$. This continues/generalizes some work of Anantharaman-Koch-Nonnenmacher, amongst others.

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**JEFFREY GALKOWSKI**, University College London
[Tuesday December 8 / mardi 8 décembre, 12:00]
*Geodesic beams and Weyl remainders*

In this talk we discuss quantitative improvements for Weyl remainders under dynamical assumptions on the geodesic flow. We consider a variety of Weyl type remainders including asymptotics for the eigenvalue counting function as well as for the on and off diagonal spectral projector. These improvements are obtained by combining the geodesic beam approach to understanding eigenfunction concentration together with an appropriate decomposition of the spectral projector into quasimodes for the Laplacian. One striking consequence of these estimates is a quantitatively improved Weyl remainder on all product manifolds. This is joint work with Y. Canzani.

**ALEXANDRE GIROUARD**, Université Laval
[Tuesday December 8 / mardi 8 décembre, 14:00]
*Planar domains with prescribed perimeter and large Steklov spectral gap must collapse to a point*

In 2014, Gerasim Kokarev proved that the first nonzero Steklov eigenvalue of a compact surface $\Omega$ of genus 0 satisfies $\overline{\sigma}_1(\Omega) := \sigma_1(\Omega)|\partial\Omega| \leq 8\pi$. In a recent joint work with Jean Lagacé, we proved that this inequality is sharp by constructing a sequence of domains in the sphere $\mathbb{S}^2 \subset \mathbb{R}^3$ that saturates it. In an ongoing project with Mikhail Karpukhin and Jean Lagacé, we went further and proved the saturation of Kokarev inequality for planar domains: there exists a sequence $\Omega^\epsilon \subset \mathbb{R}^2$ such that $\overline{\sigma}_1(\Omega^\epsilon) \xrightarrow{\epsilon\to 0} 8\pi$. In this talk I will present a quantitative improvement of Kokarev's inequality, which sheds light on geometric and topological properties of such maximizing sequences for $\overline{\sigma}_1$. A particularly striking consequence is that any sequence $\Omega^\epsilon \subset \mathbb{R}^2$ with prescribed perimeter $|\Omega^\epsilon| = 1$ and $\sigma_1(\Omega^\epsilon) \xrightarrow{\epsilon\to 0} 8\pi$ accumulates at a point: Diameter$(\Omega^\epsilon) \xrightarrow{\epsilon\to 0} 0$. Another consequence is a quantitative lower bound on the number of connected components of the boundary $\partial\Omega$, which must grow to $+\infty$.

**KATIE GITTINS**, Durham University
[Monday December 7 / lundi 7 décembre, 15:00]
*Comparing Hodge spectra of manifolds and orbifolds: Part 2.*

We consider the Hodge Laplacian acting on differential forms on closed Riemannian orbifolds. It is interesting to investigate whether it is possible to glean information about the singularities from the spectral data. We focus on whether orbifolds with singularities are spectrally distinguished from smooth manifolds. We apply the heat invariants for differential forms to obtain several positive results in this direction. For example, we obtain that the spectra of the Laplacian for functions and 1-forms together can detect the presence of singularities for orbifolds of dimension at most 3. Time-permitting, we may also discuss some negative results by presenting counterexamples.

This is based on joint work with Carolyn Gordon, Magda Khalile, Ingrid Membrillo Solis, Mary Sandoval and Elizabeth Stanhope.

**CAROLYN GORDON**
[Monday December 7 / lundi 7 décembre, 14:30]
*Comparing Hodge spectra of manifolds and orbifolds: Part 1*

We address the question: To what extent does spectral data encode information about the singularities of a closed Riemannian orbifold ? Following a brief introduction to orbifolds and a partial history of results on the question above, we will focus on the Hodge Laplacian acting on differential forms. We address the small time heat asymptotics, paying particular attention to the contributions of the orbifold singularities to the heat invariants.

This talk is based on joint work with Katie Gittins, Magda Khalile, Ingrid Membrillo Solis, Mary Sandoval and Elizabeth Stanhope.

**ASMA HASSANEZHAD**, University of Bristol
[Monday December 7 / lundi 7 décembre, 14:00]
*Eigenvalue and multiplicity bounds for the mixed Steklov problem*

We will discuss how some of the eigenvalue and multiplicity bounds known for the Steklov problem can be extended and improved for the mixed Steklov problem. The main focus will be in the 2-dimensional setting. But we also discuss the higher-dimensional setting when we consider eigenvalue bounds.

The main part of the talk is based on joint work with T. Arias-Marco, E. Dryden, C. Gordon, A. Ray and E. Stanhope.

**DAVE HEWETT**, University College London
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Acoustic scattering by fractal screens*

We study time-harmonic acoustic scattering in $\mathbb{R}^n$ ($n = 2, 3$) by a fractal planar screen, assumed to be a non-empty bounded subset $\Gamma$ of the hyperplane $\Gamma_\infty = \mathbb{R}^{n-1} \times \{0\}$. We consider two distinct cases: (i) $\Gamma$ is a relatively open subset of $\Gamma_\infty$ with fractal boundary (e.g. the interior of the Koch snowflake in the case $n = 3$); (ii) $\Gamma$ is a compact fractal subset of $\Gamma_\infty$ with empty interior (e.g. the Sierpinski triangle in the case $n = 3$). In both cases our numerical simulation strategy involves approximating the fractal screen $\Gamma$ by a sequence of smoother "prefractal" screens, for which we compute the scattered field using boundary element methods that discretise the associated boundary integral equations. We prove sufficient conditions on the mesh sizes guaranteeing convergence to the limiting fractal solution, using the framework of Mosco convergence. We also provide numerical examples illustrating our theoretical results.

**DIMA JAKOBSON**, McGill
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Zero and negative eigenvalues of conformally covariant operators, and nodal sets in conformal geometry*

We first describe conformal invariants that arise from nodal sets and negative eigenvalues of conformally covariant operators (such as Yamabe or Paneitz operator). We discuss applications to curvature prescription problems. We prove that the Yamabe operator can have an arbitrarily large number of negative eigenvalues on any manifold of dimension greater than 2. We show that 0 is generically not an eigenvalue of the conformal Laplacian. If time permits, we shall discuss related results on manifolds with boundary, as well as for weighted graphs. This is joint work with Y. Canzani, R. Gover, R. Ponge, A. Hassannezhad, M. Levitin, M. Karpukhin, G. Cox and Y. Sire.

**CHIU-YEN KAO**, Claremont McKenna College
[Tuesday December 8 / mardi 8 décembre, 13:30]
*Computation of free boundary minimal surfaces via extremal Steklov eigenvalue problems*

Recently Fraser and Schoen showed that the solution of a certain extremal Steklov eigenvalue problem on a compact surface with boundary can be used to generate a free boundary minimal surface, i.e., a surface contained in the ball that has (i) zero mean curvature and (ii) meets the boundary of the ball orthogonally (doi:10.1007/s00222-015-0604-x). We develop numerical methods that use this connection to realize free boundary minimal surfaces. Namely, on a compact surface, $\Sigma$, with genus $\gamma$ and $b$ boundary components, we maximize $\sigma_j(\Sigma, g)\ L(\partial\Sigma, g)$ over a class of smooth metrics, $g$, where $\sigma_j(\Sigma, g)$ is the $j$-th nonzero Steklov eigenvalue and $L(\partial\Sigma, g)$ is the length of $\partial\Sigma$. Our numerical method involves (i) using conformal uniformization of multiply connected domains to avoid explicit parameterization for the class of metrics, (ii) accurately solving a boundary-weighted Steklov eigenvalue problem in multi-connected domains, and (iii) developing gradient-based optimization methods for this non-smooth eigenvalue optimization problem. For genus $\gamma = 0$ and $b = 2, \ldots, 9, 12, 15, 20$ boundary components, we numerically solve the extremal Steklov problem for the first eigenvalue. The corresponding eigenfunctions generate a free boundary minimal surface, which we display in striking images. For higher eigenvalues, numerical evidence suggests that the maximizers are degenerate, but we compute local maximizers for the second and third eigenvalues with $b = 2$ boundary components and for the third and fifth eigenvalues with $b = 3$ boundary components. This is joint work with Braxton Osting (University of Utah) and Édouard Oudet (Université Grenoble Alpes).

**MIKHAIL KARPUKHIN**, California Institute of Technology
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Continuity of eigenvalues with applications to eigenvalue optimization*

In this talk we discuss a general framework of eigenvalues associated to Radon measures on Riemannian manifolds. This setup

unifies a variety of classical eigenvalue problems, including Laplacian and Steklov problems. A simple condition on a sequence of measures $\mu_n$ that guarantees the continuity of corresponding eigenvalues is provided. We give applications to eigenvalue optimization problems. The talk is based on a joint work with J. Lagacé and A. Girouard.

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**JEAN LAGACÉ**, University College London
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Geometric homogenisation theory and spectral shape optimisation*

In this talk, I will discuss how we can obtain upper bounds for Laplace eigenvalues from bounds for Steklov eigenvalues. This will be done through geometric homogenisation methods, in order to approximate the Laplace spectrum of any surface by the Steklov spectrum of a domain in that surface. The usual theory of homogenisation uses the periodic structure of Euclidean space to describe limits of singular problems, and I will discuss how it can be adapted deterministically to a setting without notions of periodicity.

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**HENRIK MATHIESEN**, University of Chicago
[Friday December 4 / vendredi 4 décembre, 13:30]
*Free boundary minimal surfaces of any topological type in Euclidean balls via shape optimization (Part 2)*

This is a continuation of R. Petrides' talk giving some more applications of our recent work on gap results in glueing constructions for eigenvalues.

I will discuss two further consequences. How our glueing results give some information on the asymptotic behaviour of the free boundary minimal surfaces associated to maximizers for the first Steklov eigenvalue, and our proof of rigidity of the first conformal Steklov eigenvalue on annuli.

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**ANTOINE METRAS**, University of Montreal
[Monday December 7 / lundi 7 décembre, 16:00]
*Steklov extremal metrics in higher dimension*

Since the original papers of Fraser and Schoen in 2012, which highlighted the relation between extremal metrics for the Steklov normalized eigenvalue $\bar{\sigma}(\Sigma, g) = \sigma(\Sigma, g)|\partial\Sigma|$ on surface and free boundary minimal surface in $B^m$, those two subjects have been highly studied.

In higher dimension $n \geq 3$, how the Steklov eigenvalues should be normalized (by volume ? boundary volume ? a mixed of both ?) is not a priori clear. In this talk I will discuss how only one choice of normalization allows for Stekov extremal metrics. I will also talk about the connection between Steklov conformal-extremal metrics on $M^n$, n-harmonic maps and the need to consider the Steklov problem with boundary density.

Based on joint work with Mikhail Karpukhin.

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**BRAXTON OSTING**, University of Utah
[Saturday December 5 / samedi 5 décembre, 15:30]
*Maximal Spectral Gaps for Periodic Schroedinger Operators*

The spectrum of a Schroedinger operator with periodic potential generally consists of bands and gaps. In this paper, for fixed m, we consider the problem of maximizing the gap-to-midgap ratio for the m-th spectral gap over the class of potentials which are pointwise bounded and have fixed periodicity. In one dimension, we prove that the optimal potential is a unique step-function attaining the imposed minimum and maximum values on exactly m intervals. In two-dimensions, we develop an efficient rearrangement method for this problem and apply it to study properties of extremal potentials. Using an explicit parametrization of two-dimensional Bravais lattices, we also consider how the optimal value varies over equal-area lattices. This is joint work with Chiu-Yen Kao.

**JEFFREY OVALL**, Portland State University
[Friday December 4 / vendredi 4 décembre, 14:00]
*Exploring Eigenvector Localization Using Filtered Subspace Iteration (FEAST)*

Domain geometry and properties of the coefficients of selfadjoint elliptic operators can cause certain eigenvectors to be highly localized in relatively small subdomains. Such localization phenomena have generated a lot of interest in the physics and mathematics communities since the late 1950s, but the underlying mechanisms driving localization are still not fully understood, despite advances on the mathematical side during the last decade. Computational approaches for identifying likely regions of localizations and approximating localized eigenvectors and/or their corresponding eigenvalues have emerged in the past two years. We present a new approach in which filtered subspace iteration is applied to a perturbed version of the selfadjoint operator, where the complex perturbation is chosen to highlight eigenvectors that are localized in a user-specified region. Preliminary theoretical and computational results will be presented.

**ROMAIN PETRIDES**, Université de Paris
[Friday December 4 / vendredi 4 décembre, 13:00]
*Free boundary minimal surfaces of any topological type in euclidean balls via shape optimization (Part 1)*

Maximal metrics for the isoperimetric problem for Steklov eigenvalues on Riemannian surfaces arise as induced metrics of free boundary minimal surfaces in Euclidean balls. Then it is natural to perform a variational method on Steklov eigenvalues in order to build new minimal surfaces. The program of building free boundary minimal surfaces into Euclidean balls of any topological type is now completed by this method. It is a consequence of new gap results on first eigenvalues with respect to the topology in a recent joint work with H. Matthiesen. I will give some idea of the glueing construction and the asymptotic analysis behind these results.

**IOSIF POLTEROVICH**, Université de Montréal
[Friday December 4 / vendredi 4 décembre, 15:30]
*The Dirichlet-to-Neumann map, the boundary Laplacian and an unpublished paper of Hörmander*

In late 1950s, Lars Hörmander wrote a paper on the connection between the Dirichlet-to-Neumann map and the boundary Laplacian. The manuscript has not been published until two years ago. Interestingly enough, it contains the main ideas needed to deduce the inequalities between the Steklov and Laplace eigenvalues, obtained in a series of recent articles starting with the work of Provenzano-Stubbe. We discuss the Hörmander's approach as well as some related results, in particular, on the asymptotics of Steklov eigenvalues for non-smooth domains. The talk is based on a joint work in progress with A. Girouard, M. Karpukhin and M. Levitin.

**MARIO SCHULZ**, Queen Mary University of London
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Free boundary minimal surfaces in the unit ball*

The study of extremals for Steklov eigenvalues has revitalised the theory of free boundary minimal surfaces. One of the most basic open questions can be phrased as follows: Can a surface of any given topology be realised as a free boundary minimal surface in the Euclidean unit ball ? We will answer this question for surfaces with connected boundary and arbitrary genus.

**DAVID SHER**, DePaul University
[Saturday December 5 / samedi 5 décembre, 14:00]
*Inverse Steklov spectral problem for curvilinear polygons*

Consider the Steklov spectral problem on curvilinear polygons in $\mathbb{R}^2$. Assuming all angles are less than $\pi$, the high-energy asymptotics of the Steklov spectrum are known. Specifically, the spectrum is asymptotic to the zero set of an explicit trigonometric polynomial constructed from the side lengths and the angles of the polygon. Here we consider the corresponding inverse spectral problem. We show that the Steklov spectrum of a curvilinear polygon determines the number of vertices, the ordered sequence of side lengths, and - up to a natural equivalence relation - the angles of that curvilinear polygon. This is joint work with S. Krymski, M. Levitin, L. Parnovski, and I. Polterovich.

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**DANIEL STERN**, University of Chicago
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Shape optimization in spectral geometry via variational methods for harmonic maps*

I'll describe joint work with Mikhail Karpukhin, relating the problem of maximizing Laplacian eigenvalues over unit-area metrics on a given Riemann surface to natural min-max constructions of harmonic maps to high-dimensional spheres. I'll explain how our methods give a new approach to producing extremal metrics for the first and second Laplacian eigenvalues, while yielding new estimates and rigidity results for related shape optimization problems in spectral geometry.

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**XUWEN ZHU**, Northeastern University
[Saturday December 5 / samedi 5 décembre, 16:00]
*Spectral properties of spherical conical metrics*

This talk will focus on the recent works on the spectral properties of constant curvature metrics with conical singularities on surfaces. The motivation comes from earlier works joint with Rafe Mazzeo on the study of deformation of such spherical metrics with large cone angles, which suggests that there is a deep connection between the geometric properties of the moduli space and the analytical properties of the associated singular Laplace operator. In this talk I will talk about a joint work with Bin Xu on spectral characterization of the monodromy of such metrics, and work in progress with Mikhail Karpukhin on the relation of spectral properties with harmonic maps.

# Graph Theory / Théorie des graphes

**Org: Danielle Cox** (Mount Saint Vincent University), **Kyle Mackeigan** (Dalhousie University) and/et **Todd Mullen** (University of Saskatchewan)

## Schedule/Horaire

| Friday December 4 | vendredi 4 décembre |
|---|---|
| 13:00 - 13:30 | Lucas Mol (University of Winnipeg), *The Threshold Dimension of a Graph* (p. 130) |
| 13:30 - 14:00 | Ben Cameron (Guelph), *The mean subtree order of a graph under edge addition* (p. 128) |
| 14:00 - 14:30 | Iain Beaton (Dalhousie University), *The Average Order of Dominating Sets of a Graph* (p. 128) |
| 14:30 - 15:00 | Jeannette Janssen (Dalhousie University), *Simultaneous embeddings of nested interval graphs* (p. 129) |
| 15:30 - 16:00 | Margaret-Ellen Messinger (Mount Allison), *Reconfiguration for Dominating Sets* (p. 129) |
| 16:00 - 16:30 | Robert Bailey (Grenfell Campus, MUN), *On the 486-vertex distance-regular graphs of Koolen–Riebeek and Soicher* (p. 127) |

| Saturday December 5 | samedi 5 décembre |
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| 14:00 - 14:30 | Melissa Huggan (Ryerson), *The Orthogonal Colouring Game* (p. 129) |
| 14:30 - 15:00 | Nancy Clarke (Acadia University), *Surrounding Cops and Robber* (p. 128) |
| 15:00 - 15:30 | Todd Mullen (University of Saskatchewan), *Recent Results in Diffusion* (p. 130) |
| 15:30 - 16:00 | Danny Dyer (MUN), *Gracefully labelling triangular cacti using Skolem sequences* (p. 128) |
| 16:00 - 16:30 | Ahmad Alkasasbeh (MUN), *Graceful Labellings of Variable Windmills Using Skolem Sequences* (p. 127) |
| 16:30 - 17:00 | Kyle MacKeigan (Dalhousie University), *Orthogonal Colourings of Graphs* (p. 129) |
| 17:00 - 17:30 | Chris Duffy (University of Saskatchewan), *Homomorphisms to Reflexive Oriented and Edge-Coloured Graphs* (p. 128) |

## Abstracts/Résumés

**AHMAD ALKASASBEH**, Memorial University of Newfoundland
[Saturday December 5 / samedi 5 décembre, 16:00]
*Graceful Labellings of Variable Windmills Using Skolem Sequences*

A windmill is a graph obtained by identifying a set of graphs (the "vanes") at a single common vertex. In this work, we introduce graceful and near graceful labellings of several families of windmills. In particular, we use Skolem-like sequences to prove (near) graceful labellings exist for all possible windmills with $C_3$ and $C_4$ vanes, and infinite families of 3,5-windmills and 3,6-windmills.

Joint work with Danny Dyer and Jared Howell.

**ROBERT BAILEY**, Grenfell Campus, MUN
[Friday December 4 / vendredi 4 décembre, 16:00]
*On the 486-vertex distance-regular graphs of Koolen–Riebeek and Soicher*

In this talk, we consider three imprimitive distance-regular graphs with 486 vertices and diameter 4: the Koolen–Riebeek graph (which is bipartite), the Soicher graph (which is antipodal), and the incidence graph of a symmetric transversal design obtained from the affine geometry $\mathrm{AG}(5,3)$ (which is both). We will show that each of these is preserved by the same rank-9 action of the group $3^5 : (2 \times M_{10})$, and the connection is explained using the ternary Golay code.

Ths is joint work with Daniel Hawtin (University of Rijeka, Croatia).

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**IAIN BEATON**, Dalhousie University
[Friday December 4 / vendredi 4 décembre, 14:00]
*The Average Order of Dominating Sets of a Graph*

This talk focuses on the average order of dominating sets of a graph. We find the extremal graphs for the maximum and minimum value over all graphs on $n$ vertices, while for trees we prove that the star minimizes the average order of dominating sets. We prove the average order of dominating sets in graphs without isolated vertices is at most $3n/4$, but provide evidence that the actual upper bound is $2n/3$. Finally, we show that the normalized average, while dense in $[1/2, 1]$, tends to $\frac{1}{2}$ for almost all graphs. Joint work with Jason Brown.

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**BEN CAMERON**, University of Guelph
[Friday December 4 / vendredi 4 décembre, 13:30]
*The mean subtree order of a graph under edge addition*

For a graph $G$, the *mean subtree order* is the average order of a subtree of $G$. The mean subtree order was introduced for trees by Jamison in a series of seminal papers in the 1980s. Very recently, Chin, Gordon, MacPhee, and Vincent extended this notion to graphs and conjectured that for every connected graph, adding an edge between any pair of distinct vertices will increase the mean subtree order. In this talk, we show that the conjecture is false by constructing graphs of order $n$ where the addition of a single edge can decrease the mean subtree order by as much as $n/3$ asymptotically. We then amend the original conjecture and prove it in the special case that $G$ is a tree.

(This is joint work with Lucas Mol)

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**NANCY CLARKE**, Acadia University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Surrounding Cops and Robber*

A variation of the Cops and Robber game is introduced in which the cops win by occupying each of the robber's neighbouring vertices. The surrounding copnumber is analogous to the copnumber. We present a variety of results for this parameter, including exact values for several classes of graphs as well as more general bounds. Classes of interest include graph products, graphs arising from combinatorial designs, and generalized Petersen graphs.

This is joint work with A. Burgess, R. Cameron, P. Danziger, S. Finbow, C. Jones, and D. Pike.

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**CHRIS DUFFY**, University of Saskatchewan
[Saturday December 5 / samedi 5 décembre, 17:00]
*Homomorphisms to Reflexive Oriented and Edge-Coloured Graphs*

In the study of graph homomorphisms, the existence of non-trivial homomorphisms to reflexive targets isn't particularly interesting ; if the target has at least one edge between a pair of distinct vertices, such a homomorphism always exists. For oriented and 2-edge-coloured graphs, however, the picture is much more complicated. In this talk we examine non-trivial homomorphism of such graphs to reflexive targets. Among other things we study the structure of such graphs that admit only proper homomorphisms to reflexive targets.

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**DANNY DYER**, Memorial University of Newfoundland
[Saturday December 5 / samedi 5 décembre, 15:30]
*Gracefully labelling triangular cacti using Skolem sequences*

Graceful labelling arose in the context of finding graph decompositions, but has since become an interesting question in its own right. We examine the use of Skolem sequences to gracefully label triangular windmills with pendants, and show there is hope to similarly label triangular snakes. Joint work with Ahmad Alkasasbeh and Nabil Shalaby.

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**MELISSA HUGGAN**, Ryerson University
[Saturday December 5 / samedi 5 décembre, 14:00]
*The Orthogonal Colouring Game*

The Orthogonal Colouring Game is a combinatorial game in which two players alternately colour vertices of a pair of isomorphic graphs while respecting the properness and the orthogonality of the colouring. Each player aims to maximise her score, which is the number of coloured vertices in the copy of the graph she owns.

An involution $\sigma$ of a graph $G$ is strictly matched if its fixed point set induces a clique and any non-fixed point $v \in V(G)$ is connected with its image $\sigma(v)$ by an edge.

In this talk, we introduce the game and our main result that the second player has a strategy to force a draw in this game for graphs that admit a strictly matched involution.

This is joint work with Stephan Dominique Andres, Fionn Mc Inerney, and Richard J. Nowakowski.

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**JEANNETTE JANSSEN**, Dalhousie University
[Friday December 4 / vendredi 4 décembre, 14:30]
*Simultaneous embeddings of nested interval graphs*

A proper interval graph is a graph that has an adjacency matrix which is diagonally increasing: rows and columns are unimodal, with the maximum occurring at the diagonal. It is well-known that proper interval graphs have a unit interval representation: vertices can be embedded in R so that vertices are adjacent if and only if their embedded values are within a threshold distance d from each other. We extend this notion to diagonally increasing (symmetric) matrices that have interval values greater than 1. Such matrices can be written as the sum of adjacency matrices of a nested family of proper interval graphs. we study the question whether it is possible, given a diagonally increasing matrix A, we can find an embedding which is a unit interval representation for all graphs in the nested family simultaneously. This is joint work with Zhiyuan (Owen) Zhang.

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**KYLE MACKEIGAN**, Dalhousie
[Saturday December 5 / samedi 5 décembre, 16:30]
*Orthogonal Colourings of Graphs*

Two colourings of a graph are orthogonal if they have the property that when two vertices have the same colour in one of the colourings, then those vertices must have different colours in the other colours. In this talk, open orthogonal colouring conjectures are answered. Then, orthogonal colourings of tensor and Cartesian product graphs are discussed.

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**MARGARET-ELLEN MESSINGER**, Mount Allison University
[Friday December 4 / vendredi 4 décembre, 15:30]
*Reconfiguration for Dominating Sets*

Given a problem and a set of feasible solutions to that problem, the associated *reconfiguration problem* involves determining whether one feasible solution to the original problem can be transformed to a different feasible solution through a sequence of allowable moves, with the condition that the intermediate stages are also feasible solutions.

Any reconfiguration problem can be modelled with a *reconfiguration graph*, where the vertices represent feasible solutions and two vertices are adjacent if and only if the corresponding feasible solutions can be transformed to each other via *one* allowable move.

Our interest is in reconfiguring dominating sets of graphs. The *domination reconfiguration graph* of a graph $G$, denoted $\mathcal{D}(G)$, has a vertex corresponding to each dominating set of $G$ and two vertices of $\mathcal{D}(G)$ are adjacent if and only if the corresponding dominating sets differ by the deletion or addition of a single vertex. We are interested in properties of domination reconfiguration graphs. For example, it is easy to see that they are always connected and bipartite. While none has a Hamilton cycle, we explore families of graphs whose reconfiguration graphs have Hamilton paths.

This is joint work with: K. Adaricheva, Hofstra University, C. Bozeman, Mount Holyoke College, N. Clarke, Acadia University, R. Haas, University of Hawaii at Manoa, K. Seyffarth, University of Calgary, and H. Smith, Davidson College

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**LUCAS MOL**, University of Winnipeg
[Friday December 4 / vendredi 4 décembre, 13:00]
*The Threshold Dimension of a Graph*

Let $G$ be a graph. A set of vertices $S$ of $G$ is called a *resolving set* of $G$ if every vertex of $G$ is uniquely determined by its vector of distances to the vertices in $S$. One can think of the vertices in a resolving set as "landmark" vertices. If an agent is sitting at some vertex of the graph, and its distance to every landmark vertex is known, then one can determine the exact location of the agent.

Imagine that there is a cost associated with each landmark vertex. Then one would be interested in finding a resolving set of minimum cardinality in $G$; this is the well-studied *metric dimension* of $G$. Imagine further that we can add edges to $G$ in a highly cost effective manner. Then one would be interested in finding a resolving set of minimum cardinality across all graphs $H$ obtained by adding edges to $G$; we introduce this parameter as the *threshold dimension* of $G$.

We give a more geometrical description of those graphs with threshold dimension $b$, characterizing them as graphs that have certain constrained embeddings in the strong product of $b$ paths. We provide a sharp bound on the threshold dimension of $G$ in terms of the chromatic number. We also study *irreducible graphs* – those for which the threshold dimension is equal to the metric dimension. This is joint work with Matthew Murphy and Ortrud Oellermann.

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**TODD MULLEN**, University of Saskatchewan
[Saturday December 5 / samedi 5 décembre, 15:00]
*Recent Results in Diffusion*

Diffusion is a variant of Chip-Firing in which every vertex sends a chip to each of its poorer neighbours at every time step. Duffy et al. conjectured in the original paper on the topic (2018) that Diffusion is always a periodic process with only periods of length 1 and 2. This was proven by Long and Narayanan (2019). We discuss recent work on this model, some of which arose from Long and Narayanan's proof. This work includes the number of unique configurations that exist on paths and complete graphs up to a definition of equality and some different period lengths that arise from altering the firing rules. This is joint work with Richard Nowakowski (Dalhousie) and Danielle Cox (MSVU).

# Hacking COVID-19: Share your innovative ways to deal with teaching online / Passer à travers la COVID-19 : Partage d'expériences d'enseignement à distance.

**Org: Judy Larsen** (University of the Fraser Valley) and/et **Miroslav Lovric** (McMaster University)

CMESG Working Group

## Schedule/Horaire

| Saturday December 5 | samedi 5 décembre |
|---|---|
| 15:00 - 17:00 | CMESG Working Group, *Hacking COVID-19: Sharing experiences with online teaching* (p. 131) |

| Sunday December 6 | dimanche 6 décembre |
|---|---|
| 15:00 - 17:00 | CMESG Working Group, *Hacking COVID-19: Sharing experiences with online teaching* (p. 131) |

## Abstracts/Résumés

**CMESG WORKING GROUP**

[Saturday December 5 / samedi 5 décembre, 15:00]

*Hacking COVID-19: Sharing experiences with online teaching*

Building on the tradition of CMESG annual meetings, this working group meeting will consist of two 90-minute sessions, scheduled for Saturday and Sunday afternoon, starting at 3pm (EDT).

We have all transitioned into various forms of online teaching this past year. Our practices have been contested and challenged, and we likely now have ideas for how to improve our teaching strategies in future terms. This working group will focus on sharing participant experiences with online teaching, towards emerging implications for future practice. More specifically, on day 1, we will generate discussion about what participants have been doing in their classrooms, how it has worked, and what they plan to change next term. Participants will be invited to share their concerns, both academic and personal, pertaining to COVID-19 related teaching modifications. On day 2, we will have a sequence of mini pecha-kucha style presentations, where participants will have opportunities to share their tips and strategies about technology (beyond the usual), assessment, and encouraging student engagement and motivation. We will end both days with a general discussion to draw out key ideas.

The success of this working group depends heavily (no pressure!) on your contributions and willingness to share your successes and failures. All CMS and CMESG members are welcome.

**CMESG WORKING GROUP**

[Sunday December 6 / dimanche 6 décembre, 15:00]

*Hacking COVID-19: Sharing experiences with online teaching*

# History and Philosophy of Mathematics / Histoire et philosophie des mathématiques

**Org: Maritza Branker** (Niagara)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Craig Fraser (IHSPT-Toronto), *Henri Poincaré's Development of Hamilton-Jacobi Theory* (p. 133) |
| 13:30 - 14:00 | Yelda Nasifoglu (Oxford), *The changing nature of mathematical diagrams in the seventeenth century* (p. 134) |
| 14:00 - 14:30 | Juan Fernández González and Dirk Schlimm (McGill), *From a doodle to a theorem: a case study in mathematical discovery* (p. 133) |
| 14:30 - 15:00 | Margaret E. Schotte (York), *'Demonstrate all this with diagrams': Recovering mathematical practice from early modern navigation exams* (p. 134) |
| 15:30 - 16:00 | David Waszek (McGill), *From notational change to substantial discovery: Leibniz, Bernoulli, and the exponential notation for differentials* (p. 135) |
| 16:00 - 16:30 | William Dou (University of Hawaii-Manoa), *What Does "Aligning" Mean ? Practices of Justification across Chinese Logic and Mathematics* (p. 133) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Mariya Boyko (Independent scholar), *Socialist competition and its role in Soviet mathematics education* (p. 132) |
| 14:30 - 15:00 | Maryam Vulis (St Johns University), *The Life and Work of Zygmunt Janiszewski (1888 -1920)* (p. 134) |
| 15:00 - 15:30 | Tom Drucker (University of Wisconsin-Whitewater) (p. 133) |
| 15:30 - 16:00 | Sandra Visokolskis (National University of Cordoba, Argentina), *Fourier's Resolution of the Heat Equation by Transduction: A Contemporary Approach.* (p. 134) |
| 16:00 - 16:30 | Brenda Davison (SFU) (p. 133) |
| 16:30 - 17:00 | Maritza Branker (Niagara University), *Euphemia Lofton Haynes: her forgotten legacy* (p. 132) |

## Abstracts/Résumés

**MARIYA BOYKO**, University of Toronto, Prodigy Education
[Saturday December 5 / samedi 5 décembre, 14:00]
*Socialist competition and its role in Soviet mathematics education*

The Kolmogorov mathematics school curriculum reform, which was implemented in the USSR in the 1960s and 1970s, was criticized by Soviet educators. The conceptual and theoretical character of the curriculum created anxiety about mathematics among many students. Another factor that contributed to students' discomfort with mathematics was the political doctrine known as "socialist competition." Citizens and enterprises were encouraged to compete with each other to achieve greater productivity and success. Success in mathematics was a key part of academic achievement in the Soviet education system. Students who struggled were judged to be poor performers in the spirit of socialist competition, a situation that created additional anxiety about mathematics.

Kolmogorov and his colleagues attempted to make mathematics more palatable by publishing various kinds of extracurricular literature. A more positive attitude to mathematics would result from hearing about the many practical applications of mathematical concepts. However, it could be argued that this literature contributed to students' academic anxiety even further, because the topics discussed were often challenging and unfamiliar, and were not discussed in detail in the school curriculum itself.

**MARITZA BRANKER**, Niagara University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Euphemia Lofton Haynes: her forgotten legacy*

Euphemia Lofton Haynes became the first African American woman to receive a Ph.D in mathematics in 1943. She received her doctorate from the Catholic University of America after completing a Masters in education at the University of Chicago in 1930. Her legacy is understated but pervasive, she had an impact on many of the D.C. schools as well as founding the math department at Miner Teachers College (University of the District of Columbia). We cover the highlights of her career in this talk.

**BRENDA DAVISON**, SFU
[Saturday December 5 / samedi 5 décembre, 16:00]

**WILLIAM DOU**, University of Hawaii at Manoa
[Friday December 4 / vendredi 4 décembre, 16:00]
*What Does "Aligning" Mean ? Practices of Justification across Chinese Logic and Mathematics*

Mainstream philosophers of mathematics argue that philosophy should be concerned with the construction of mathematics from logical concepts alone. In this paper, I reverse the direction of construction, suggesting that the Mohists, ancient Chinese logicians, borrowed from mathematical practice to develop their systems of logic. I argue that the Mohist Canon, the logical text of the Mohists, helps to clarify the long-known developmental connection between Chinese astronomical and mathematical practice, by showing how a mathematical concept developed from its astronomical instance. Besides sharing concepts in common, ancient Chinese astronomers and mathematicians also shared models of justification or explanation. I summarize Karine Chemla's account of the practice of justification in Chinese mathematical texts and compare it with astronomical and logical practices of explanation. I conclude that these practices are similar, and that it is probable that the Mohists modeled their non-mathematical logic on the practices of mathematical justification available to them.

**TOM DRUCKER**, University of Wisconsin-Whitewater
[Saturday December 5 / samedi 5 décembre, 15:00]

**CRAIG FRASER**, University of Toronto
[Friday December 4 / vendredi 4 décembre, 13:00]
*Henri Poincaré's Development of Hamilton-Jacobi Theory*

This presentation is based on joint research carried out by the presenter with Michiyo Nakane, Seijo University, Tokyo.

In his work in celestial mechanics Poincaré made fundamental use of what is known today as Hamilton-Jacobi theory. His knowledge of this subject was drawn from Carl Jacobi's writings as well as the work of such mathematical astronomers as Félix Tisserand. Poincaré's contributions appear in several of his publications beginning with his famous prize memoir on the three-body problem of 1890. The primary exposition is contained in his Les méthodes nouvelles de la mécanique céleste (1892-1899), particularly volume 3 of 1899. Poincaré's formulation of the theory influenced German quantum physicists in the early twentieth century, and also became part of standard literature in the calculus of variations. The present paper examines Poincaré's work, looking particularly at how he extended and reinterpreted key ideas from Jacobi.

**JUAN FERNÁNDEZ GONZÁLEZ AND DIRK SCHLIMM**, McGill University
[Friday December 4 / vendredi 4 décembre, 14:00]
*From a doodle to a theorem: a case study in mathematical discovery*

In this paper we present the genesis of a theorem in geometry, the Midpoint Path Theorem, from the original idea to the published version. It makes it possible to multiply the length of a line segment by $0 < r/s < 1$, a rational number, by constructing only midpoints and a straight line. This can be achieved with a compass and a straightedge. We explore the narrative behind the discovery, with first-hand insights by its author. Some general aspects of this case study of mathematical practice are discussed.

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**YELDA NASIFOGLU**, University of Oxford
[Friday December 4 / vendredi 4 décembre, 13:30]
*The changing nature of mathematical diagrams in the seventeenth century*

Euclid's Elements of Geometry is one of the few classical texts to have been handed down with diagrams. Rather than static illustrations, however, the diagrams were integral to the text and served as maps to the step-by-step construction of the propositions. In the classical mathematical tradition, one read geometry manually with compass and rule in hand. Although the iconography of the early modern period continued to suggest that reading, studying, and producing geometry were mediated through drawing, as the boundaries between theory and practice became blurred, the status of diagrams underwent significant changes. While they could serve heuristic purposes, diagrams were now mostly being treated as illustrations or representations that facilitated the reading of the mathematical text, which in turn became progressively more algebraic in nature. Indeed, towards the end of the seventeenth century, the diagrams would often be grouped into plates relegated to the back of the book. With analytical geometry, which had the advantage of accommodating the increasing demands for accuracy during this period, the idea of geometric construction would become more abstract, obviating the need for drawing.

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**MARGARET E. SCHOTTE**, York University
[Friday December 4 / vendredi 4 décembre, 14:30]
*'Demonstrate all this with diagrams': Recovering mathematical practice from early modern navigation exams*

Navigators in early modern Europe faced rigorous professional examinations. Those of the Dutch East India Company, in particular, required candidates to solve advanced mathematical problems. Drawing on the few surviving examples of these 17th- and 18th-century exams, this paper will explore how these examinations shaped classroom curricula and student practice. By responding to the examiners' instructions—to consult tables, draw diagrams, and show their work—these mariners learned to use trigonometric and logarithmic tables, and became comfortable with a variety of other mathematical techniques. Exams should be seen not just as the culmination of maritime training programs, but also as a starting point: the moment when a wide range of practitioners began to engage with the nuts and bolts of celestial navigation.

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**SANDRA VISOKOLSKIS**, National University of Cordoba
[Saturday December 5 / samedi 5 décembre, 15:30]
*Fourier's Resolution of the Heat Equation by Transduction: A Contemporary Approach.*

The paper explores the Leibnizian analytical style of calculus problem solving as an obstacle that Fourier (1768-1830) had to avoid a posteriori in his attempt to solve the heat problem. Leibniz's school seeks for an algorithmic, symbolical, and blind reasoning which "was based on a 'subversion' of the semantics in favour of a consistent formalism" (Mancosu 1996: 173), and was followed by d'Alembert (1717-1783), restricting mathematical analysis to continuous functions given by a single equation, in the old sense. Although Euler (1701-1787) 'tolerated' continuous curves with piecewise slopes and curvatures, he nevertheless restricted the acceptance of trigonometric series as representative basis of any function, a task in which Fourier successfully advanced, although its procedures were criticized by the physical-mathematical community of his time, as lacking in rigor and mathematical generality. We propose to show how Fourier solves the heat problem confronting this inherited tradition, from the application of what now call transduction (Visokolskis 2009, 2018, 2020), a non-deductive reasoning contributing to the construction of one or more hypotheses that explain the emergence of some creative insight, in response to a problem that motivates and drives the creative process.

**MARYAM VULIS**, Maryam Vulis
[Saturday December 5 / samedi 5 décembre, 14:30]
*The Life and Work of Zygmunt Janiszewski (1888 -1920)*

The 1918 influenza pandemic claimed the life of the Polish mathematician Zygmunt Janiszewski. Born in Warsaw in 1888, Zygmunt Janiszewski studied mathematics in Zurich, Munich, and Gottingen, and eventually in Paris, where he wrote his doctorate thesis Sur les continus irréductibles entre deux points (1911) in topology. At the invitation of Waclaw Sierpinski, Janiszewski came to Lvov and in 1913, right before WWI, obtained his habilitation at the University of Lvov. After spending time serving in the WWI with the Polish legion, Janiszewski returned to Warsaw as a professor at the University of Warsaw. Zygmunt Janiszewski' s concern for the future of Polish mathematics was reflected in this article "On the needs of Mathematics in Poland" in which Janiszewski urged Polish mathematicians to concentrate on the narrow field in order to achieve excellence and establish a journal dedicated to one area of interest. Zygmunt Janiszewski indeed played a vital role in organizing mathematics at the University of Warsaw and put forth the journal Fundamenta Mathematicae. The Polish mathematician was a remarkable person - a mathematician and educator, who was concerned about mathematics education in Poland and donated his prize and inheritance money to public education

**DAVID WASZEK**, McGill University
[Friday December 4 / vendredi 4 décembre, 15:30]
*From notational change to substantial discovery: Leibniz, Bernoulli, and the exponential notation for differentials*

This paper revisits a famous episode of mathematical discovery in which it is often said that notations played a crucial role: Leibniz and Johann Bernoulli's discovery of an 'analogy between powers and differences', that is, of an analogy between the powers of a sum:

$$(x+y)^e = x^e + \frac{e}{1}x^{e-1}y^1 + \frac{e\cdot e-1}{1\cdot 2}x^{e-2}y^2 + \frac{e\cdot e-1\cdot e-2}{1.2.3}x^{e-3}y^3 \text{ etc.}$$

and the differentials of a product:

$$d^e(xy) = d^e x d^0 y + \frac{e}{1}d^{e-1}x\cdot d^1 y + \frac{e\cdot e-1}{1\cdot 2}d^{e-2}x\cdot d^2 y + \frac{e\cdot e-1\cdot e-2}{1\cdot 2\cdot 3}d^{e-3}x\cdot d^3 y \text{ etc.}$$

This discovery followed close on the heels of a notational innovation, namely Leibniz's introduction of an 'exponential' notation for differentials—for instance $d^2x$ for $ddx$ and $d^3x$ for $dddx$, but also $d^{-1}x = \int x$—and the two developments are often presented as obviously related.

The goal of this talk is twofold: first, to clarify whether the notation indeed played a role by disentangling the specific contribution it may have made to the discovery from the motivations Leibniz may have had to introduce it in the first place ; second, to contribute to a general investigation of how it is that notational choices—which may seem like mere abbreviations—can in fact shape the course of mathematical research. We shall see that, in this case, the notation did indeed make two significant contributions: it brought out a pattern in a particular formula which would have been less salient—harder to notice—otherwise ; and it transformed what could be expressed in simple ways, thereby shaping further exploration.

**Org: Agnès Beaudry** (University of Colorado Boulder), **Martin Frankland** (University of Regina)
and/et **Donald Stanley** (University of Regina)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Kristine Bauer (University of Calgary), *Operads of functors with derivatives* (p. 137) |
| 13:30 - 14:00 | Apurva Nakade (University of Western Ontario), *Discrete Chern-Simons via 2-group bundles on elliptic curves* (p. 139) |
| 14:00 - 14:30 | Sacha Ikonicoff (University of Calgary), *Unstable algebras over an operad* (p. 138) |
| 14:30 - 15:00 | Katharine Adamyk (University of Western Ontario), *Lifting A(1)-Modules* (p. 136) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Brandon Doherty (University of Western Ontario), *Cubical models of (infinity,1)-categories* (p. 137) |
| 14:30 - 15:00 | Dorette Pronk (Dalhousie University), *Three approaches toward orbifold mapping objects* (p. 139) |
| 15:00 - 15:30 | Nicholas Meadows (Carleton University), *Spectral Sequences in $(\infty, 1)$-categories* (p. 139) |
| 15:30 - 16:00 | Niny Arcila Maya (University of British Columbia), *Decomposition of topological Azumaya algebra with involution* (p. 138) |
| 16:00 - 16:30 | Rachel Hardeman (University of Calgary) (p. 138) |
| 16:30 - 17:00 | Luis Scoccola (Michigan State University), *Homotopy coherence in applied topology* (p. 140) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Sander Kupers (University of Toronto), *The rational homotopy type of certain diffeomorphism groups* (p. 138) |
| 14:30 - 15:00 | Marzieh Bayeh (University of Ottawa), *Higher Equivariant and Invariant Topological Complexities* (p. 137) |
| 15:00 - 15:30 | Ivan Limonchenko (University of Toronto), *On homotopy theory of polyhedral products with Golod face rings* (p. 138) |
| 15:30 - 16:00 | Steven Amelotte (University of Rochester), *The homotopy type of the fibre of the $p^{th}$ power map on loop spaces of spheres* (p. 136) |
| 16:00 - 16:30 | Kate Poirier (New York City College of Technology), *Polyhedra for V-infinity algebras, string topology, and moduli spaces* (p. 139) |

## Abstracts/Résumés

**KATHARINE ADAMYK**, Western University
[Friday December 4 / vendredi 4 décembre, 14:30]
*Lifting A(1)-Modules*

The Steenrod algebra, $\mathcal{A}$, arises topologically as the algebra of stable operations on cohomology. For any nonnegative integer $n$, we consider $\mathcal{A}(n)$, a particular subalgebra of $\mathcal{A}$. Given an $\mathcal{A}(n)$-module, $M$, for some $n$, we can ask whether it lifts to a module over $\mathcal{A}$. (That is, whether there exists any $\mathcal{A}$-module whose underlying $\mathcal{A}(n)$-module is $M$.)

In this talk, we will focus on lifting $\mathcal{A}(1)$-modules. Some obstructions to these lifting problems are detected via a spectral sequence that computes localized $\mathrm{Ext}$ groups. The computation of this spectral sequence can be simplified by a classification theorem for a particular class of $\mathcal{A}(1)$-modules.

**STEVEN AMELOTTE**, University of Rochester
[Sunday December 6 / dimanche 6 décembre, 15:30]
*The homotopy type of the fibre of the $p^{th}$ power map on loop spaces of spheres*

The problem of decomposing the fibre of the $p^{\text{th}}$ power map on loop spaces of spheres into a product of indecomposable factors has a long history with relations to the homotopy exponents of spheres, Kervaire invariant one classes, the Kahn–Priddy theorem and classifying spaces for the fibre of the double suspension. In this talk I will discuss the remaining unresolved cases and outline a proof that, for odd primes $p$, the decomposition problem for $\Omega S^{2n+1}\{p\}$ is equivalent to the $p$-primary Kervaire invariant problem.

**KRISTINE BAUER**, University of Calgary
[Friday December 4 / vendredi 4 décembre, 13:00]
*Operads of functors with derivatives*

The Goodwillie functor calculus tower is an approximation of a homotopy functor which resembles the Taylor series approximation of a function in ordinary calculus. In 2004-05, several authors observed that the homogeneous layers of certain Goodwillie towers form an operad. Ching first observed that the identity functor of spaces has this behaviour. McCarthy and Minasian observed similar operads for functors of operad algebras which are monoids.

In 2011, Cockett and Seely used the notion of categorical differentiation to construct a Faa di Bruno formula, and an associated category Faa(X), which encapsulates the higher order chain rules for derivatives.

The goal of this talk is to explain why one should expect an operad structure associated to the layers of functor calculus towers from the perspective of ordinary calculus. This is an update of a program of research by Johnson, Yeakel and I which shows that the functor associating a functor of abelian categories to its sequence of derivatives is monoidal. This explains the operads arising from functor calculus towers as a consequences of differentiation.

**MARZIEH BAYEH**, University of Ottawa
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Higher Equivariant and Invariant Topological Complexities*

The topological complexity was introduced by Farber to estimate the complexity of the configuration space of a robot or a mechanical system.

Later, Rudyak introduced a series of invariants $\{TC_n(X)\}$, called the higher topological complexity, which is related to a motion planning algorithm with $n$ points as the input (in addition to the initial and terminal states of the robot, some intermediate states are given as well).

If the configuration space admits an action of a topological group $G$ (for example having a symmetry on the mechanical system or its configuration space), then it is worth considering a motion planning algorithm that is compatible with the action. There are different approaches to define an equivariant version of topological complexity.

In this talk we will consider two of those approaches and discuss a generalization of each invariant in the realm of higher topological complexity.

**BRANDON DOHERTY**, University of Western Ontario
[Saturday December 5 / samedi 5 décembre, 14:00]
*Cubical models of (infinity,1)-categories*

We discuss the construction of a new model structure on the category of cubical sets with connections whose cofibrations are the monomorphisms and whose fibrant objects are defined by the right lifting property with respect to inner open boxes, the cubical analogue of inner horns. We also discuss the proof that this model structure is Quillen equivalent to the Joyal model

structure on simplicial sets via the triangulation functor. This talk is based on joint work with Chris Kapulkin, Zachery Lindsey, and Christian Sattler, arXiv:2005.04853.

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**RACHEL HARDEMAN**, University of Calgary
[Saturday December 5 / samedi 5 décembre, 16:00]

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**SACHA IKONICOFF**, University of Calgary
[Friday December 4 / vendredi 4 décembre, 14:00]
*Unstable algebras over an operad*

The aim of this talk is the study of algebraic operations that naturally appear on classical unstable modules over the Steenrod algebra, especially (but not exclusively) those modules that do not come from topological spaces, such as Brown-Gitler modules or Carlsson modules. We will show how the theory of algebraic operads fits into this framework. In characteristic 2, we will define a notion of unstable algebra over an operad relatively to a commutative operation of the operad. Under some hypotheses on the operad $\mathcal{P}$, on the operation $\star \in \mathcal{P}(2)^{\mathfrak{S}_2}$, and on the unstable module $M$, we will identify the free $\star$-unstable $\mathcal{P}$-algebra generated by $M$ to a free $\mathcal{P}$-algebra. This will allow us to recollect some results of Steenrod-Epstein and Serre regarding the cohomology of Eilenberg-MacLane spaces, as well as a result of D. Davis on the Carlsson module of weight 1.

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**SANDER KUPERS**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 14:00]
*The rational homotopy type of certain diffeomorphism groups*

This talk concerns joint work with Oscar Randal-Williams which aims to understand the topological group of diffeomorphisms of an even-dimensional disc, fixing its boundary pointwise. This is one of the most important objects in geometric topology. I will explain how we computed many of its rational homotopy groups, and describe what we expect the final answer to be.

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**IVAN LIMONCHENKO**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 15:00]
*On homotopy theory of polyhedral products with Golod face rings*

In 1950s J.-P.Serre proved that Poincaré series of a commutative local Noetherian ring is bounded by a certain rational function depending on the Betti numbers of the Koszul complex and the minimal number of generators in the maximal ideal. In 1962 E.S.Golod showed that Serre's inequality turns into equality if and only if multiplication and all Massey products in Koszul homology of a local ring are trivial. J.Backelin proved in 1982 that Poincaré series of monomial rings are rational ; among monomial rings there is the well-known class of Stanley-Reisner rings (or, face rings) of simplicial complexes.

In this talk we will discuss homotopy theory of polyhedral products over simplicial complexes having Golod face rings over fields. We will describe this class of Stanley-Reisner rings in terms of their Poincaré series, Koszul homology, and the loop homology algebra structure of moment-angle-complexes. Much more can be said if only flag simplicial complexes are considered. We will see how the methods and objects of toric topology allow us to obtain topological interpretations of the algebraic properties of Poincaré series and Koszul homology of Stanley-Reisner rings as well as to get new results.

The talk is partially based on an ongoing research project joint with Kouyemon Iriye, Daisuke Kishimoto, and Taras Panov.

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**NINY ARCILA MAYA**, University of British Columbia
[Saturday December 5 / samedi 5 décembre, 15:30]
*Decomposition of topological Azumaya algebra with involution*

A topological Azumaya algebra with an involution is a topological generalization of the concept of a central simple algebra with an involution. We give conditions for positive integers $m$ and $n$ and the space $X$ such that a topological Azumaya algebra with an involution of degree $mn$ over $X$ can be decomposed as the tensor product of topological Azumaya algebras with involution of degrees $m$ and $n$.

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**NICHOLAS MEADOWS**, Carleton University
[Saturday December 5 / samedi 5 décembre, 15:00]
*Spectral Sequences in $(\infty, 1)$-categories*

Many spectral sequences in algebraic topology and other areas, can be realized as the spectral sequence associated to a (co)simplicial space. Examples include the Eilenberg-Moore and Adams spectral sequences. In this talk, we will explain how to set up the spectral sequence associated to a simplicial object in an $(\infty, 1)$-category, in a model-independent manner. We will also show how the differentials and filtration of the spectral sequence can be described in terms of the combinatorics of the ambient $(\infty, 1)$-category.

Joint work with D. Blanc.

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**APURVA NAKADE**, University of Western Ontario
[Friday December 4 / vendredi 4 décembre, 13:30]
*Discrete Chern-Simons via 2-group bundles on elliptic curves*

Freed-Quinn define a model for 2+1 Chern-Simons theory with a finite gauge group $G$ by constructing a particular line bundle $\mathcal{L}$ on the moduli space of flat principal $G$ bundles over a genus $g$ surface $X$. In this talk, I will explain their construction and then show that $\mathcal{L}$ is naturally a 2-group bundle over $X$, where a 2-group can be thought of as a categorified version of a group with a weaker notion of associativity. Our results provide a concrete example of a mathematical physics phenomenon that can be most naturally described using higher categorical language. This talk is based on joint work with D. Berwick-Evans, E. Cliff, L. Murray, and E. Phillips.

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**KATE POIRIER**, City University of New York - NYCCT
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Polyhedra for V-infinity algebras, string topology, and moduli spaces*

Where associahedra are polyhedra that organize operations and relations in an $A_\infty$ algebra, assocoipahedra are polyhedra that organize operations and relations in a $V_\infty$ algebra, a homotopy version of an associative algebra that has a compatible co-inner product. Assocoipahedra appear in the study of spaces of string topology operations—both on the chains or homology of the loop space of a closed, oriented manifold (the topological side) and on the Hochschild cochains or cohomology of a $V_\infty$ algebra (the algebraic side). We describe the role assocoipahedra play on both sides and present progress on a conjecture relating these spaces of operations to the moduli space of Riemann surfaces.

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**DORETTE PRONK**, Dalhousie University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Three approaches toward orbifold mapping objects*

We consider orbispaces as proper étale groupoids (also called *orbigroupoids*) in the category of locally compact, paracompact Hausdorff spaces. When defined this way, two groupoids represent equivalent orbispaces precisely when they are Morita equivalent. So we consider the bicategory of fractions with respect to Morita equivalences. For orbispaces $G$ and $H$ we can then consider the mapping groupoid $\mathbf{OMap}(G, H)$ of generalized maps and equivalences classes of 2-cell diagrams. The question

I want to address is how to define a topology on these mapping groupoids to obtain mapping objects for this bicategory. I will approach this question from three different directions:

1. When the orbifold G is compact, we can define a topology on $\mathbf{OMap}(G, H)$ so that

$$\mathbf{Orbispaces}(K \times G, H) \simeq \mathbf{Orbispaces}(K, \mathbf{OMap}(G, H)).$$

2. For any pair of orbigroupoids $G$, $H$ we can define a topology on $\mathbf{OMap}(G, H)$ so that $\mathbf{Orbispaces}$ has the structure of an enriched bicategory.

3. There is a fibration structure on the category of orbigroupoids with groupoid homomorphisms as defined in [Pronk-Warren]. (This can be derived from work by Colman and Costoya.) This implies that when G and H are stack groupoids, we may restrict ourselves to groupoid homomorphisms and their usual 2-cells.

In this talk I will discuss the relationships between the topologies obtained in these ways. This is joint work with Laura Scull and Hellen Colman.

[Pronk-Warren] Dorette A. Pronk, Michael A. Warren, Bicategorical fibration structures and stacks, Theory and Applications of Categories, Vol. 29, 2014, No. 29, pp 836-873.

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**LUIS SCOCCOLA**, Michigan State University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Homotopy coherence in applied topology*

A persistent object consists of a diagram indexed by the poset of real numbers. The interleaving distance is a natural way of comparing persistent objects, and is used to state and prove that certain algorithms in applied topology are stable to perturbations of the input dataset. For persistent objects of a model category there exist several ways of weakening the interleaving distance in order to make it homotopy-invariant, and comparing these choices requires solving rectification problems that can be approached using tools from homotopy theory. I will discuss positive and negative rectification results recently obtained in joint work with Edoardo Lanari.

**Org: Marcin Sabok** (McGill) and/et **Anush Tserunyan** (Mcgill/UIUC)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

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|---|---|
| 13:00 - 13:30 | Jan Hubicka (Charles University), *Big Ramsey degrees of the homogeneous universal partial order* (p. 144) |
| 13:30 - 14:00 | Colin Jahel (Lyon), *Actions of automorphism groups of Fraïssé limits on the space of linear orderings.* (p. 144) |
| 14:00 - 14:30 | Dakota Ihli (UIUC), *What generic automorphisms of the random poset look like* (p. 144) |
| 14:30 - 15:00 | Andy Zucker (UCSD), *Big Ramsey degrees via coding trees* (p. 148) |
| 15:30 - 16:00 | Matt Bowen (McGill), *Monochromatic products and sums in* $\mathbb{N}$ (p. 142) |
| 16:00 - 16:30 | Jamal Kawach (Toronto), *Fraïssé and Ramsey properties of Fréchet spaces* (p. 145) |

### Saturday December 5 — samedi 5 décembre

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|---|---|
| 14:00 - 14:30 | Deirdre Haskell (McMaster) (p. 144) |
| 14:30 - 15:00 | Taboka Chalebgwa (McMaster), *A remark on certain Schanuel $n$-tuples for the $j$-function.* (p. 142) |
| 15:00 - 15:30 | Claude Laflamme (Calgary), *How many siblings do you have ?* (p. 145) |
| 15:30 - 16:00 | William Chan (CMU), *Definable Combinatorics of the First Uncountable Cardinal* (p. 143) |
| 16:00 - 16:30 | Saeed Ghasemi (Czech Academy of Sciences), *Strongly self-absorbing C*-algebras and Fraïssé limits* (p. 143) |
| 16:30 - 17:00 | Pavlos Motakis (York), *Coarse Universality* (p. 146) |

### Sunday December 6 — dimanche 6 décembre

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| 14:00 - 14:30 | Antonina Kolokolova (Memorial) (p. 145) |
| 14:30 - 15:00 | Dino Rossegger (Waterloo), *Degree spectra of analytic complete equivalence relations* (p. 146) |
| 15:00 - 15:30 | Bradd Hart (McMaster), *Undecidability and embedding problems in continuous logic* (p. 144) |
| 15:30 - 16:00 | Ronnie Chen (UIUC), *A universal characterization of standard Borel spaces* (p. 143) |
| 16:00 - 16:30 | Michael Wolman (Caltech), *Probabilistic Programming Semantics for Name Generation* (p. 147) |
| 16:30 - 17:00 | Chris Kapulkin (Western Ontario), *Canonicity for Homotopy Type Theory* (p. 145) |

### Monday December 7 — lundi 7 décembre

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| 14:00 - 14:30 | Tomasz Ciesla (Lancaster), *On lifting invariant probability measures* (p. 143) |
| 14:30 - 15:00 | Forte Shinko (Caltech), *Lifts of Borel actions on quotient spaces* (p. 146) |
| 15:00 - 15:30 | Jenna Zomback (UIUC), *A backward ergodic theorem and its forward implications* (p. 148) |
| 15:30 - 16:00 | Spencer Unger (Toronto), *Embeddings and factor maps between $\mathbb{Z}^d$ actions* (p. 147) |
| 16:00 - 16:30 | Riley Thornton (UCLA), *Factor of i.i.d. processes and Cayley diagrams* (p. 147) |
| 16:30 - 17:00 | Konrad Wrobel (Texas A&M), *Cost of inner amenable equivalence relations* (p. 148) |

### Tuesday December 8 — mardi 8 décembre

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| 11:00 - 11:30 | Noe de Rancourt (Vienna), *Intersection-smooth equivalence relations* (p. 143) |
| 11:30 - 12:00 | Zoltán Vidnyánszky (Caltech), *Bases for Borel graphs of large chromatic number: injective case* (p. 147) |
| 12:00 - 12:30 | Aristotelis Panagiotopoulos (Munster), *Dynamical obstructions to classification by (co)homology and other TSI-group invariants.* (p. 146) |
| 13:00 - 13:30 | Felix Weilacher (CMU), *Descriptive Chromatic Numbers of Locally Finite and Everywhere Two Ended Graphs* (p. 147) |

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|---|---|
| 13:30 - 14:00 | Shaun Allison (CMU), *Polish groups with the pinned property* (p. 142) |
| 14:00 - 14:30 | Assaf Shani (Harvard), *Classification by sequences of countable sets of reals* (p. 146) |
| 14:30 - 15:00 | Filippo Calderoni (UIC), *Descriptive set theory: order and classification* (p. 142) |

## Abstracts/Résumés

**SHAUN ALLISON**, Carnegie Mellon University
[Tuesday December 8 / mardi 8 décembre, 13:30]
*Polish groups with the pinned property*

Given an analytic equivalence relation $E$ on a Polish space $X$ with all classes Borel, one can define a "virtual $E$-class" to be a infinity-Borel code which becomes a Borel code for an $E$-class in any generic extension in which it becomes hereditarily countable. For example, the virtual $=^+$-classes correspond to the (possibly uncountable) sets of reals. Then $E$ is considered "pinned" iff every virtual $E$-class is realized in the ground model. A Polish group $G$ has the "pinned property" iff for every Polish $G$-space $X$, the induced orbit equivalence relation $E_X^G$ is pinned. We give an overview of results of Hjorth and Larson-Zapletal, as well as some original work, towards the goal of giving an algebraic characterization of the Polish groups with the pinned property in different models of set theory, such as the Solovay model.

**MATT BOWEN**, McGill
[Friday December 4 / vendredi 4 décembre, 15:30]
*Monochromatic products and sums in* $\mathbb{N}$

An old question of Hindman asks if every finite coloring of $\mathbb{N}$ contains monochromatic sets of the form $\{x, y, xy, x+y\}$. Although this remains open, there have been several recent advances in the field of non-linear Ramsey theory, including Moreira's proof that any finite coloring of $\mathbb{N}$ contains monochromatic sets of the form $\{x, xy, x+y\}$. In this talk I will discuss some refinements of this result, including a proof of the 2-color case of Hindman's question and a common extension of Moreira's theorem and Rado's theorem on linear Ramsey families.

**FILIPPO CALDERONI**, UIC
[Tuesday December 8 / mardi 8 décembre, 14:30]
*Descriptive set theory: order and classification*

We shall discuss recent applications of descriptive set theory to ordered groups. First we shall analyze various examples of orderable groups whose Borel space of left-invariant orders, modulo the conjugacy relation, is not standard. Most notably, the conjugacy relation on the space of left-invariant orders of $\mathbb{F}_2$ is a universal countable Borel equivalence relation. Next we shall investigate the complexity of the isomorphism relation on countable ordered Archimedean groups from the viewpoint of Borel reducibility. Time permitting, we shall discuss anti-classification results that prevent classifying ordered Archimedean groups by countable subsets of reals. This includes joint work with A. Clay and with D. Marker, L. Motto Ros, and A. Shani.

**TABOKA CHALEBGWA**, McMaster University
[Saturday December 5 / samedi 5 décembre, 14:30]
*A remark on certain Schanuel $n$-tuples for the $j$-function.*

The famous conjecture of Schanuel states that given any $n$ complex numbers $\alpha_1, \ldots, \alpha_n$ that are $\mathbb{Q}$-linearly independent, the transcendence degree of the field extension $\mathbb{Q}(\alpha_1, \ldots, \alpha_n, e^{\alpha_1}, \ldots, e^{\alpha_n})$ is at least $n$ over $\mathbb{Q}$. A rather curious result of K

Senthil Kumar states that for any $\mathbb{Q}$-linearly independent tuple $\alpha_1, \ldots, \alpha_n$, there exits uncountably many $c \in \mathbb{C}$ such that the transcendence degree of the field extension $\mathbb{Q}(c\alpha_1, \ldots, c\alpha_n, e^{c\alpha_1}, \ldots, e^{c\alpha_n})$ is at least $n$ over $\mathbb{Q}$. In this talk we will explore a method for obtaining a modular ($j$-function) analogue of this result.

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**WILLIAM CHAN**, Carnegie Mellon University
[Saturday December 5 / samedi 5 décembre, 15:30]
*Definable Combinatorics of the First Uncountable Cardinal*

Under the axiom of determinacy, the first uncountable cardinal $\omega_1$ has the strong partition property which implies that for each $\epsilon \leq \omega_1$, the $\epsilon$-length partition filter, $\mu_\epsilon$, is a countably complete ultrafilter. For $1 \leq n < \omega$, $\omega_{n+1}$ is the ultrapower of $\omega_1$ by $\mu_n$ and these ultrapower representations are important for combinatorics below $\omega_\omega$. Goldberg asked what is the ordertype of the ultrapower of $\omega_1$ by all the other partition measures $\mu_\epsilon$ when $\omega \leq \epsilon \leq \omega_1$. This talk will discuss progress on this question and other applications to combinatorics of determinacy. This will include club uniformization principles, continuity properties of functions on sequence of countable ordinals, and cardinality computations under determinacy. This is joint work with Stephen Jackson and Nam Trang.

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**RONNIE CHEN**, University of Illinois at Urbana-Champaign
[Sunday December 6 / dimanche 6 décembre, 15:30]
*A universal characterization of standard Borel spaces*

Standard Borel spaces are widely used in descriptive set theory as a basic model of "definable set", admitting many familiar "countable first-order" set operations such as countable products, countable disjoint unions, etc. We give a category-theoretic justification for the canonicity of the category of standard Borel spaces, by showing that it is the free category admitting some of the aforementioned operations subject to some simple compatibility conditions (e.g., products distribute over disjoint unions). In this talk, we will discuss the precise formulation of this result, its connection with the theory of $\kappa$-complete Boolean algebras, and its proof using methods from categorical logic.

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**TOMASZ CIESLA**, Lancaster University
[Monday December 7 / lundi 7 décembre, 14:00]
*On lifting invariant probability measures*

I'll discuss the following question posed by Feliks Przytycki. Let $X$ be a Polish space with a Borel probability measure $\mu$. Let $T\colon X \to X$ be a pmp map. Let $Y$ be a Polish space and $S\colon Y \to Y$ a continuous map. Suppose that $p\colon Y \to X$ is a Borel surjection such that $p \circ S = T \circ p$. Does $\mu$ lift to an $S$-invariant Borel probability measure $\nu$ on $Y$?

It turns out that if the sets $p^{-1}(x)$ are compact for all $x \in X$ then an $S$-invariant lift of $\mu$ exists. A similar result is true in a more general setting when an amenable semigroup acts on $X$ and $Y$ by pmp maps and continuous maps, respectively, and the actions commute with $p$. On the other hand, for non-amenable semigroups the result does not hold in general.

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**NOE DE RANCOURT**, University of Vienna
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Intersection-smooth equivalence relations*

This talk is based on a joint work in progress with Benjamin Miller and Zoltán Vidnyánszky. We introduce the notion of intersection reduction, a generalization of the usual notion of Borel reduction between equivalence relations on Polish spaces. Our main result is a generalization of Kechris–Louveau's $\mathbb{E}_1$-dichotomy to the class of so-called *intersection-smooth* equivalence relations, that is, the class of all equivalence relations that are intersection-reducible to the equality on $\mathbb{R}$. This class contains, in particular, all countable unions of essentially countable equivalence relations, as well as $\mathbb{E}_1$. Consequences and connected results will also be presented.

**SAEED GHASEMI**, Institute of Mathematics of the Czech Academy of Sciences
[Saturday December 5 / samedi 5 décembre, 16:00]
*Strongly self-absorbing C*-algebras and Fraïssé limits*

A unital separable C*-algebra (other than the C*-algebra of all complex numbers) is strongly self-absorbing if it is isomorphic to its (minimal) tensor product with itself, in a "strong" sense. Strongly self-absorbing C*-algebras play a crucial role in Elliott's classification program of separable nuclear C*-algebras by K-theoretic data. Among them, the Jiang- Su algebra $\mathcal{Z}$ has a special place and, to this date, the classification of separable, simple, unital, nuclear C*-algebras that tensorially absorb $\mathcal{Z}$ and satisfy the UCT has been the most remarkable achievement of the classification program. In their original paper from 1999, Jiang and Su already proved that $\mathcal{Z}$ is strongly self-absorbing. However, their proof uses heavy results and machinery from the classification, such as KK-theory. I will outline an easier proof of the fact that $\mathcal{Z}$ is strongly self-absorbing which does not depend on any classification results, via establishing a general connection between the strongly self-absorbing C*-algebras and the "Fraïssé limits" of categories of C*-algebras that are sufficiently closed under tensor products. It was previously known that $\mathcal{Z}$ can be realized as the Fraïssé limit of the category of its building blocks and unital trace-preserving embeddings.

**BRADD HART**, McMaster University
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Undecidability and embedding problems in continuous logic*

In their recent work, MIP*=RE, Ji et al use quantum complexity theory to resolve the Connes embedding problem. Together with Isaac Goldbring, we realized that this also showed that the universal theory of certain $\mathrm{II}_1$ factors (particular von Neumann algebras) had undecidable continuous universal theories. There was a certain Gödelian aspect to the proof which I will highlight in this talk. This technique applies to other embedding problems and I will give some examples.

**DEIRDRE HASKELL**, McMaster
[Saturday December 5 / samedi 5 décembre, 14:00]

**JAN HUBICKA**, Department of Applied mathematics
[Friday December 4 / vendredi 4 décembre, 13:00]
*Big Ramsey degrees of the homogeneous universal partial order*

We apply the Carlson-Simpson theorem to show that the homogeneous universal partial order are finite. This new construction has several other applications ; in particular, it gives the first direct proof of a theorem by Dobrinen on big Ramsey degrees of the universal homogeneous triangle-free graph. We also discuss the generalization to the triangle constrained strong amalgamation classes in binary language satisfying certain completion property and if time allows discuss actual big Ramsey degrees which is a joint project with Balko, Chodounsky, Dobrinen, Konecny, Nesetril, Vena, and Zucker.

**DAKOTA IHLI**, University of Illinois at Urbana-Champaign
[Friday December 4 / vendredi 4 décembre, 14:00]
*What generic automorphisms of the random poset look like*

The Fraïssé limit of the class of finite posets, also called the random poset, admits generic automorphisms — that is, its automorphism group admits a comeagre conjugacy class. This result, due to D. Kuske and J. Truss, was proven without explicitly describing the automorphisms in question. Here we give a new, concrete description of the generic automorphisms, and we discuss the tools-and-tricks involved.

**COLIN JAHEL**, Université Claude Bernard Lyon 1
[Friday December 4 / vendredi 4 décembre, 13:30]
*Actions of automorphism groups of Fraïssé limits on the space of linear orderings.*

In 2005, Kechris, Pestov and Todorcevic exhibited a correspondence between combinatorial properties of structures and dynamical properties of their automorphism groups. In 2012, Angel, Kechris and Lyons used this correspondence to show the unique ergodicity of all the actions of some groups. In this talk, I will give an overview of the aforementioned results and discuss recent work generalizing results of Angel, Kechris and Lyons.

**CHRIS KAPULKIN**, University of Western Ontario
[Sunday December 6 / dimanche 6 décembre, 16:30]
*Canonicity for Homotopy Type Theory*

I will outline a proof, joint with Sattler, of Voevodsky's conjecture asserting that univalent type theory has the (homotopy) canonicity property. The proof is based on Artin's gluing, adapted to models of dependent type theory by Shulman and homotopical inverse diagram models of homotopy type theory, developed jointly with Lumsdaine.

**JAMAL KAWACH**, University of Toronto
[Friday December 4 / vendredi 4 décembre, 16:00]
*Fraïssé and Ramsey properties of Fréchet spaces*

A topological group $G$ is *extremely amenable* if every continuous action of $G$ on a compact Hausdorff space has a common fixed point. In 2005, Kechris, Pestov and Todorčević showed that Fraïssé theory provides a useful link between extreme amenability and Ramsey theory. In this talk we will survey some recent Fraïssé-theoretic developments in the context of Fréchet spaces, which we view as topological vector spaces equipped with a compatible sequence of semi-norms. We will define an approximate Ramsey property of finite-dimensional Fréchet spaces, and we will see how this property is related to the extreme amenability of the automorphism groups of approximately ultrahomogeneous Fréchet spaces.

This is joint work in progress with Jordi López-Abad.

**ANTONINA KOLOKOLOVA**, Memorial
[Sunday December 6 / dimanche 6 décembre, 14:00]

**CLAUDE LAFLAMME**, University of Calgary
[Saturday December 5 / samedi 5 décembre, 15:00]
*How many siblings do you have ?*

Two structures are *siblings*, or *equimorphic*, if each embeds in the other. The famous Cantor-Bernstein-Schroeder Theorem states that, in a language with pure equality, equimorphic structures (sets) are isomorphic. This is the case for various other structures, but in the general equimorphic structures need not to be isomorphic.

The main objective of this program is to understand these equimorphic structures, with a first step being simply to count siblings (up to isomorphy).

Bonato and Tardif conjectured [06] that any tree having a non-isomorphic sibling must have infinitely many such siblings (up to isomorhism). Thomassé proposed a related conjecture [ 00], that any countable relational structures with at most countably many relations must have either one, $\aleph_0$, or $2^{\aleph_0}$ siblings (up to isomorhism).

We will briefly review progress made on those conjectures and present recent joint results on $\aleph_0$-categorical structures.

Both conjectures remain open.

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**PAVLOS MOTAKIS**, York University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Coarse Universality*

The Bourgain index is a tool that can be used to show that if a separable Banach space contains isomorphic copies of all members of a class $C$ then it must contain isomorphic copies of all separable Banach spaces. This can be applied, e.g., to the class $R$ of separable reflexive spaces. Notably, the embedding of each member of $R$ does not witness the universality of $X$. We investigate a natural coarse analogue of this index which can be used, e.g., to show that a separable metric space that contains coarse copies of all members in certain "small" classes of metric spaces $C$ then $X$ contains a coarse copy of $c_0$ and thus of all separable metric spaces.

This is joint work with F. Baudier, G. Lancien, and Th. Schlumprecht.

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**ARISTOTELIS PANAGIOTOPOULOS**, WWU
[Tuesday December 8 / mardi 8 décembre, 12:00]
*Dynamical obstructions to classification by (co)homology and other TSI-group invariants.*

One of the leading questions in many mathematical research programs is whether a certain classification problem admits a "satisfactory" solution. Hjorth's theory of turbulence provides conditions under which such a classification problem cannot be solved using only isomorphism types of countable structures as invariants. In the same spirit, we will introduce "unbalancedness": a new dynamical obstruction to classification by orbits of a Polish group which admits a two-side invariant metric (TSI). We will illustrate how "unbalancedness" can be used for showing that a classification problem cannot be solved by classical homology and cohomology invariants, and we will apply these ideas to attain anti-classification results for the isomorphism problem of Hermitian line bundles.

This is joint work with Shaun Allison.

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**DINO ROSSEGGER**, University of Waterloo
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Degree spectra of analytic complete equivalence relations*

We present new results on the complexity of the classification problem of countable structures and their computational complexity. We show that the elementary bi-embeddability relation on the class of graphs is analytic complete under Borel reducibility by giving a reduction from the bi-embeddability relation on graphs. We then compare the degree spectra with respect to these equivalence relations. The degree spectrum of a countable structure with respect to an equivalence relation $E$ is the set of Turing degrees of structures $E$ equivalent to it. We show that the degree spectra of structures with respect to bi-embeddability and elementary bi-embeddability are related: Every bi-embeddability spectrum of a graph is the set of jumps of Turing degrees in the elementary bi-embeddability spectrum of a graph.

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**ASSAF SHANI**, Harvard University
[Tuesday December 8 / mardi 8 décembre, 14:00]
*Classification by sequences of countable sets of reals*

We study Borel equivalence relations which can be completely classified by countable sequences of "definably countable" sets of reals. We define an equivalence relation which is arguably maximal with this property, and study it in comparison to other known Borel equivalence relations.

**FORTE SHINKO**, Caltech
[Monday December 7 / lundi 7 décembre, 14:30]
*Lifts of Borel actions on quotient spaces*

Given a countable Borel equivalence relation $E$ and a countable group $G$, we study the problem of when a Borel action of $G$ on $X/E$ can be lifted to a Borel action of $G$ on $X$. This is joint work with Joshua Frisch and Alexander Kechris.

**RILEY THORNTON**, UCLA
[Monday December 7 / lundi 7 décembre, 16:00]
*Factor of i.i.d. processes and Cayley diagrams*

Let $G$ be a Cayley graph for a countable group $\Gamma$. This talk will look at when $\Gamma$-f.i.i.d. solutions (or approximate solutions) to local labelling problems on $G$ lift to $aut(G)$-f.i.i.d. solutions. In particular we'll show that this lifting is always possible when $G$ admits an $aut(G)$-f.i.i.d. (approximate) Cayley diagram and establish some results on which graphs admit such diagrams.

**SPENCER UNGER**, University of Toronto
[Monday December 7 / lundi 7 décembre, 15:30]
*Embeddings and factor maps between $\mathbb{Z}^d$ actions*

We present several results on the existence of Borel embeddings and factor maps into natural spaces of colorings, tilings and Hamilton paths of the Cayley graph of $\mathbb{Z}^d$. This is joint work with Nishant Chandgotia.

**ZOLTÁN VIDNYÁNSZKY**, California Institute of Technology
[Tuesday December 8 / mardi 8 décembre, 11:30]
*Bases for Borel graphs of large chromatic number: injective case*

The Kechris-Solecki-Todorcevic dichotomy states that there is a single element basis for Borel graphs with uncountable Borel chromatic number ordered by Borel homomorphisms. Recently, an analogous theorem has been found for Borel graphs with Borel chromatic number at least 3. We discuss what happens in the above cases when the Borel homomorphisms are required to be injective.

**FELIX WEILACHER**, Carnegie Mellon University
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Descriptive Chromatic Numbers of Locally Finite and Everywhere Two Ended Graphs*

We construct Borel graphs which settle or advance several questions in descriptive graph combinatorics. The theme of these questions is "What can the discrete structure of a Borel graph tell us about its descriptive combinatorics?". Specific instances we may discuss include "What bounds does the (discrete) chromatic number place on the Baire measurable chromatic number?", the analogous question in the Borel probability measure setting, and "What does the Cayley graph of a group tell us about its Bernoulli shift?".

**MICHAEL WOLMAN**, Caltech
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Probabilistic Programming Semantics for Name Generation*

In this talk we present a probabilistic model for name generation. Specifically, we interpret the nu-calculus, a simply-typed lambda-calculus with name generation, in the category of quasi-Borel spaces, an extension of the category of standard Borel

spaces supporting both measure theory and higher-order programming. We prove that this model is fully abstract at first-order types. This is joint work with Marcin Sabok, Sam Staton and Dario Stein.

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**KONRAD WROBEL**, Texas A&M University
[Monday December 7 / lundi 7 décembre, 16:30]
*Cost of inner amenable equivalence relations*

Cost is a $[1, \infty)$-valued measure-isomorphism invariant of equivalence relations defined by Gilbert Levitt and heavily studied by Damien Gaboriau. For a large class of equivalence relations, including aperiodic amenable, the cost is 1. Yoshikata Kida and Robin Tucker-Drob recently defined the notion of an inner amenable equivalence relation as an analog of inner amenability in the setting of groups. We show inner amenable equivalence relations also have cost 1. This is joint work with Robin Tucker-Drob.

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**JENNA ZOMBACK**, University of Illinois at Urbana Champaign
[Monday December 7 / lundi 7 décembre, 15:00]
*A backward ergodic theorem and its forward implications*

A pointwise ergodic theorem for a transformation $T$ on a probability space equates the global property of ergodicity of the transformation to its pointwise combinatorics. Our main result is a backward (in the direction of $T^{-1}$) ergodic theorem for countable-to-one probability measure preserving (pmp) transformations $T$. We discuss examples of such transformations, including the shift map on Markov chains, which yields a new (forward) pointwise ergodic theorem for pmp actions of finitely generated countable groups. This is joint work with Anush Tserunyan.

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**ANDY ZUCKER**, UC San Diego
[Friday December 4 / vendredi 4 décembre, 14:30]
*Big Ramsey degrees via coding trees*

Recently, Dobrinen has shown that for every k, the class of k-clique free graphs has finite big Ramsey degrees. In this talk, I will discuss a generalization and simplification of this result which works for almost any binary free amalgamation class in a finite language. Time permitting, I will discuss joint work in progress with Balko, Chodounsky, Dobrinen, Hubicka, Konecny, and Vena which characterizes the exact big Ramsey degrees for these classes.

# Mathematical biology / Biomathématiques

**Org: Claire Guerrier** (Université Côte d'Azur) and/et **Anmar Khadra** (McGill)

## Schedule/Horaire

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| 13:20 - 13:40 | Grant Lythe (University of Leeds), *How many TCR clonotypes does a body maintain ?* (p. 153) |
| 13:40 - 14:00 | Bard Ermentrout (University of Pittsburgh), *A model for the the inflammatory response to SARS-CoV-2 in the upper- and lower-respiratory tracts.* (p. 151) |
| 14:00 - 14:20 | Sam Jamaleddine (McGill University), *Investigating the effects of T cell avidity distributions on acute vs. chronic viral infection dynamics* (p. 153) |
| 14:20 - 14:40 | Jürgen Reingruber (Institut de Biologie École Normale Supérieure), *Monitoring and predicting the Covid-19 epidemic and its implications for hospitals* (p. 156) |
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| 14:40 - 15:00 | Eric Foxall (University of British Columbia), *Bifurcation theory of well-mixed stochastic population models* (p. 151) |
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| 14:20 - 14:40 | Anmar Khadra (McGill University), *Excitable media in fish keratocytes model: Canard explosion, traveling waves and beyond* (p. 153) |
| 14:40 - 15:00 | Thomas Hillen (University of Alberta), *Non-local Models for Cellular Adhesion* (p. 152) |
| 15:00 - 15:20 | Khoren Ponsin (McGill University), *Mathematical Modeling of Cellular Phagocytosis During Embryogenesis of the Urogenital System* (p. 155) |
| 15:20 - 15:40 | Lisanne Rens (TU Delft), *Computational models for feedback between cell shape, cell signaling and extracellular matrix* (p. 156) |
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## Abstracts/Résumés

**BECCA ASQUITH**, Imperial College London
[Friday December 4 / vendredi 4 décembre, 14:40]

**JACQUES BÉLAIR**, Université de Montréal
[Saturday December 5 / samedi 5 décembre, 14:20]
*Waning immunity in a two-strain disease model*

Motivated by the interactions between two strains of the virus causing Dengue Fever, we consider a model essentially taking the form of two mutually coupled SIRS models, with general density function for the duration of stay in each of the compartments, leading to a system of nonlinear functional-differential equations. We consider the stability of equilibria, detect Hopf bifurcations and investigate the influence of the distribution of the density function on these stability properties.

**IGOR BELYKH**, Georgia State University
[Tuesday December 8 / mardi 8 décembre, 14:40]
*When repulsive coupling promotes synchronization of bursting neurons*

Synchrony has been broadly observed in pathological brain states, especially during epilepsy and Parkinson's tremors. The neuronal mechanisms that generate such abnormal synchronous states are far from being fully understood. In this talk, we discuss the emergence of synchronization in networks of bursting neurons as highly non-trivial, synergistic effects when (i) the addition of pairwise repulsive inhibition to excitatory networks can promote in-phase synchronization and (ii) combined electrical and inhibitory coupling can induce synchronization even though each coupling alone promotes an antiphase rhythm. In particular, we reveal the underlying mechanism, which uses a balance between hidden properties of electrical and inhibitory coupling to act together to synchronize neuronal bursting. We show that this balance is controlled by the duty cycle of the

self-coupled system which governs the synchronized bursting rhythm. Our studies of neuronal synchronization form a basis for understanding the counterintuitive dynamics of bursting networks, which may yield meaningful insight into the phenomenon of pathological synchrony in epileptic networks. Our results suggest that promoting normally repulsive inhibition in an attempt to prevent seizures can have an unintended effect of inducing pathological synchrony.

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**KHANH DAO DUC**, University of British Columbia
[Monday December 7 / lundi 7 décembre, 14:40]
*A study of stochastic dynamics of mRNA translation and their impact across biological scales*

The translation of mRNA into protein is a fundamental cellular process, mediated by the flow of ribosomes. As these dynamics can be locally regulated by many molecular mechanisms, analytical tools are needed to find the determinants of translation speed. I will present analytical and computational methods that we recently developed to study translation across different scales, using a wide array of structural, sequencing, and imaging data. These methods importantly rely on a stochastic interacting particle model that generalizes the totally asymmetric simple exclusion process (TASEP). We analytically studied this process to determine its phase diagram and find the key parameters that govern translation efficiency. In the context of recent advances in deep sequencing, we also used the model to infer translation rates for a large set of genes in yeast, and analyzed the contribution of traffic jams, codon specificity, and other biophysical parameters. These results more recently guided our studies of the molecular structure of the ribosome (obtained from cryoEM) and translation kinetics observed in vitro using lysate systems. Overall, these completing approaches emphasize the major role played by the ribosome in gene expression, at both molecular and population levels.

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**BARD ERMENTROUT**, University of Pittsburgh
[Friday December 4 / vendredi 4 décembre, 13:40]
*A model for the the inflammatory response to SARS-CoV-2 in the upper- and lower-respiratory tracts.*

We create a two-compartment model of the upper and lower respiratory tract in order to model the progression of a viral disease such as SARS-CoV-2. The model includes viral replication, tissue damage, tissue healing, and an immune component. The immune component includes markers for inflammation as well as pro- and anti-inflammatory cytokines. We fit the parameters of the model to recent data on rhesus monkeys. We then characterize the dynamics of the model in cases where the outcomes are (i) clearance and return to health, (ii) inability to clear the virus, (iii) clearance, but high damage incurred by the inflammatory response. In the latter two cases, we examine how the timing of anti-viral or anti-inflammatory drugs impacts the outcomes. This work is joint with Ericka Mochan (Carlow University), TJ Sego (Indiana), Emmaline Rial and Lauren Gaona.

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**SAEED FARJAMI**, University of Surrey
[Tuesday December 8 / mardi 8 décembre, 14:20]
*Non-sequential Spike Adding in Cerebellar Stellate Cells*

Cerebellar Stellate Cells are spontaneously spiking. Recently, our colleagues have recorded bursting activities in these cells by applying pharmacological agents known for blocking certain ion currents. Such activities are usually modelled in the form of systems with different time scales. When the slow variables are treated as parameters, the fast subsystem can provide good insights into the dynamics of the full model. Using slow-fast analysis, we explain the underlying mechanisms responsible for generating types of bursting emerging in the model. Also, a bifurcation analysis of the full model reveals the effect of different doses of the pharmacological agents on the system dynamics. Moreover, our investigations show that the number of spikes in an active phase of bursting changes when parameters of the system fluctuate. However, in contrast to former studies, adding new spikes does not happen sequentially. In this talk, we will discuss such phenomena and try to shed light on their underlying dynamics.

This is joint work with Ryan Alexander, Derek Bowie and Anmar Khadra.

**ERIC FOXALL**, UBC Okanagan
[Saturday December 5 / samedi 5 décembre, 14:40]
*Bifurcation theory of well-mixed stochastic population models*

The bifurcation theory of ordinary differential equations (ODEs), and its application to deterministic population models, are by now well established. In this article, we begin to develop a complementary theory for well-mixed stochastic population models, with the goal of understanding the scale, in both time and population density, of fluctuations near bifurcation points of the underlying deterministic system. To do so we study the ODE and SDE limits that arise in the vicinity of bifurcation points and discover that they can be neatly classified in a bifurcation diagram that complements and enhances the deterministic theory. We focus on one-dimensional bifurcations, although the general approach is extensible to higher dimensions.

**PAUL FRANCOIS**, McGill University
[Saturday December 5 / samedi 5 décembre, 15:00]
*Information in cytokine dynamics : robotic mapping and machine learning*

An immune response is by essence a collective computation. Starting with the initial activations of few T cells, a complex dance of immune actors self-organize over long time scales. Understanding how and why immune cells communicate with one another to perform this response could be key to a better understanding of personalized medecine and immunotherapy. In collaboration with Gregoire Altan-Bonnet (NIH), we have developped a pipeline to study, decode and model cytokine communications between T cells. I will show how simple machine learning allows to project the complex immune response into a 2D latent space, where immune parameters can be simple deconvolved. Remarkably, this suggests a simple model of collective communication and computation, highly reproducible and universal. I will show how our approach can be used to predict quality of unknown antigen, and how it can potentially help to better estimate success of immunotherapy.

**SIMON GIREL**, Université Côte-d'Azur
[Saturday December 5 / samedi 5 décembre, 14:00]
*Mathematical modeling of the CD8 T-cells immune response*

Infection of an organism by a pathogen triggers the activation of the CD8 T-cells and the initiation of the immune response. The result is a complex program of proliferation and differentiation of the CD8 T-cells, controlled by the evolution of their molecular content. I will introduce two mathematical models of the CD8 T-cell response. The first one is presented as an impulsive differential equation by which we study the effect of unequal molecular partitioning at cell division on the regulation of molecular heterogeneity. The second one is an agent-based-model that couples the description of a discrete population of CD8 T-cells and that of their molecular content. This model can reproduce the different typical phases of the CD8 T-cell response at both the cellular and the molecular scales. These two studies support the hypothesis that the cell dynamics observed *in vivo* is a consequence of the molecular heterogeneity structuring the CD8 T-cell population.

**THOMAS HILLEN**, University of Alberta
[Sunday December 6 / dimanche 6 décembre, 14:40]
*Non-local Models for Cellular Adhesion*

Cellular adhesion is one of the most important interaction forces between cells and other tissue components. In 2006, Armstrong, Painter and Sherratt introduced a non-local PDE model for cellular adhesion, which was able to describe known experimental results on cell sorting and cancer growth. Since then, this model has been the focus of applications and analysis. The analysis becomes challenging through non-local cell-cell interaction and interactions with boundaries. In this talk I will present theoretical results of the adhesion model, such as a random walk derivation, biologically realistic boundary conditions, pattern formation and results on local and global existence of solutions. (joint work with A. Buttenschoen).

**DAVID HOLCMAN**, Institut de Biologie École Normale Supérieure
[Tuesday December 8 / mardi 8 décembre, 13:20]

**NATHANAEL HOZÉ**, Institut Pasteur
[Saturday December 5 / samedi 5 décembre, 15:20]

**SAM JAMALEDDINE**, McGill University
[Friday December 4 / vendredi 4 décembre, 14:00]
*Investigating the effects of T cell avidity distributions on acute vs. chronic viral infection dynamics*

The generation of lymphocyte receptor diversity is a key feature of adaptive immunity. In addition to somatic recombination, diversification of the T cell repertoire is significantly enhanced by terminal deoxynucleotidyl transferase, or TdT. However, TdT-knockout studies have shown that lack of TdT does not abrogate T cell immunity in response to acute stimulation by bacterial or viral antigen, and so the specific advantage that this added TdT-dependent variability brings forth remains unclear. We propose that TdT may alter properties of the binding-avidity distribution of protective T cells, and that lack of TdT can impair the immune response against a chronic viral pathogen. In this work, we study the response of a population of T cells that together confer a continuum of T-cell avidities. By constructing and analyzing a system of integro-differential equations, we can not only consider the temporal evolution of key population sizes (namely effector T-cell levels and viral loads), but also track the evolution and infer the role of the distribution of T cell avidities over time. We observe that TdT could offer an advantage over TdT-deficient T cells in a chronic viral context, by either decreasing the average binding avidity, or broadening the range of observable T cells avidities.

**ANMAR KHADRA**, McGill University
[Sunday December 6 / dimanche 6 décembre, 14:20]
*Excitable media in fish keratocytes model: Canard explosion, traveling waves and beyond*

A partial differential equation (PDE) model of a self-organizing lamellipodium in crawling keratocytes has been previously developed to understand the three spatiotemporal patterns of activity observed in such cells, namely, stalling, waving and smooth motility. The model consisted of three key variables: the density of barbed actin filaments, newly formed FAs called nascent adhesions (NAs) and VASP, an anti-capping protein that gets sequestered by NAs during maturation. Using parameter sweeping, the distinct regimes of behaviour associated with the three activity patterns were identified. By converted the PDE model into an ODE model, we successfully examined the excitability properties of this system and determined all of its patterns of activity. Our results revealed that there are two additional regimes not previously identified: bistability and type IV excitability (generated by three steady states and their manifolds). We found that these regimes are also present in the PDE model. Applying slow-fast analysis on the ODE model showed that it exhibits a canard explosion through a folded-saddle and that rough motility seen in keratocytes is likely due to noise-dependent motility governed by dynamics near the interface of bistability and type IV excitability. The two parameter bifurcation suggested that the increase in the proportion of rough motion is due to a shift in activity towards the bistable and type IV excitable regimes induced by a decrease in NA maturation rate. In this talk, I will provide a summary of these findings.

**GRANT LYTHE**, University of Leeds
[Friday December 4 / vendredi 4 décembre, 13:20]
*How many TCR clonotypes does a body maintain ?*

There are approximately 400000000000 naive CD4 T cells in your body, about the same as the number of stars in our galaxy. On the other hand, the number of cells of one TCR clonotype is a small integer that increases or decreases by one cell at a time,

when cells divide or die. New clonotypes are released from the thymus and compete with other clonotypes in the periphery for specific and non-specific resources. Mean clonal sizes can therefore be calculated from mean clonal lifetimes. For example, if the ratio of thymic production to peripheral division is four percent, then the number of distinct T-cell clonotypes in the human body is about nine percent of the total number of (naive CD4) T cells. In mice, most TCR clonotypes may consist of just one or two T cells.

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**LAURENT MACKAY**, McGill University
[Monday December 7 / lundi 7 décembre, 14:00]
*Feedback onto cellular polarization from paxillin, implications for migrating cells.*

Cellular polarization plays a critical during cellular differentiation, development, and cellular migration through the establishment of a long-lived cell-front and cell-rear. Although mechanisms of polarization vary across cells types, some common biochemical players have emerged, namely the RhoGTPases Rac and Rho. The low diffusion coefficient of the active form of these molecules combined with their mutual inhibitory interaction dynamics have led to a prototypical pattern formation system that can polarizes cell through a non-Turing pattern formation mechanism termed wave-pinning. We investigate the effects of paxillin, a master regulator of adhesion dynamics, on the Rac-Rho system through a serine phosphorylation-dependent positive feedback loop that amplifies Rac activation. We find that paxillin feedback onto the Rac-Rho system produces cells that (i) self-polarize in the absence of any input signal (i.e., paxllin feedback causes a Turing instability) and (ii) become arrested due to the development of multiple protrusive regions. The former effect is a positive finding, while the latter outcome is likely an artefact of the model. In order to minimize the effects of this artefact to produce cells that can both self-polarize and migrate for extended periods of time, we revisit some of model's parameter values and use lessons from previous models of polarization. After some simple modifcations to the model, our simulations behave very much like these previous models while being significantly simpler yet biochemically detailed. Thus this work yields insights into the biochemical acitivties of paxillin as well as general feedback patterns necessary for effective cellular migration.

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**BRIAN MERCHANT**, University of British Columbia
[Monday December 7 / lundi 7 décembre, 15:00]
*Using a Rho GTPase based model of cell polarization to explain group advantage in chemotaxis*

We model a migrating cell as a 2D elastic polygon, with Rho GTPase biochemistry simulated on the vertices. This biochemistry enables a model cell to polarize and migrate. Intercellular interactions between cells can emerge by allowing them to modulate each others' polarization. In particular, we recapitulate two intercellular interactions observed in neural crest cells (NCCs): 1) contact inhibition of locomotion (CIL), whereby upon making contact, cells re-polarize in order to break contact and disperse, and 2) co-attraction (COA), whereby cells attract each other at a distance. We had previously confirmed a hypothesis that model NCC clusters enjoy enhanced directional motility, compared to a single cell, due to suppression of random protrusions through CIL and COA interactions between cluster cells. Now, we investigate whether this same increase in a cluster's directional motility could also explain the ability of a cluster of NCCs to respond to a chemoattractant gradient too weak for a single cell to interpret.

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**LAWRENCE OPREA**, McGill University
[Tuesday December 8 / mardi 8 décembre, 13:40]
*Simulation and analysis of white matter in a variably hypomyelinated transgenic mouse model*

Demyelination, which causes severe reductions in the quality of action potential transmission, is important in the study of diseases such as multiple sclerosis. Recently, a series of transgenic mouse lines were developed with variable levels of myelin basic protein (mbp) mRNA. Applying semi-automated image segmentation to electron micrographs from these mice, we were able to extract information on myelin thickness, g ratio, myelin volume fraction, and geometric properties from tens of thousands of cells. Additionally, we built an axon packing algorithm to produce simulated 2D and 3D renderings of tracts with varying myelination. Results show clear nonlinear relationships between mbp levels and myelination of axons. These additionally vary

across spinal cord regions and age. Compensatory mechanisms that mitigate the effects of low myelination, such as increased cell size and number, appear to occur once a demyelination threshold is reached. These data naturally lead to models investigating the energetics and electrophysiological effects of demyelination in development and maturation.

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**FERNANDO PERUANI**, CY Cergy Paris Université
[Friday December 4 / vendredi 4 décembre, 13:00]
*A mathematical approach to bacterial infections: models for bacterial exploration and infection*

Gastrointestinal infections occur by both, motile and non-motile pathogenic bacteria. Whether there exists a correlation between bacterial motility and bacterial virulence remains a key open question. Combining mathematical models and in vitro bacterial experiments, we will analyze how pathogenic bacteria explore the bottom surface of a cell chamber and infect the human colonic epithelial cells sitting on it. The study quantifies and explains the role of bacterial motility in the infection process.

References: Perez-Ipiña et al., Nature Physics 15, 610-615 (2019), and Otte et al., to appear (2020)

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**CHARLES S. PESKIN**, New York University
[Tuesday December 8 / mardi 8 décembre, 14:00]
*Interaction of Facilitation and Depression in Synaptic Transmission*

We use experimental data to construct a simple model of stochastic vesicle release that includes facilitation, and we apply that model to study the interaction of facilitation and depression in synaptic transmission. Depending on parameters and on the rate of arrival of action potentials, we find that the model synapse can process signals in a variety of ways, and these will be discussed both from a linear, frequency-analysis viewpoint that requires consideration of small-amplitude modulation of a regular spike train, and also from a nonlinear perspective in which large-amplitude steplike changes in the rate of arrival of action potentials are considered. (Joint work with Calvin Zhang-Molina, University of Arizona.)

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**KHOREN PONSIN**, McGill University
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Mathematical Modeling of Cellular Phagocytosis During Embryogenesis of the Urogenital System*

During embryonic development of the urogenital system in mice, apoptosis plays a crucial role in removing a temporal structure called the Common Nephric Duct (CND), a necessary step to connect the ureter to the bladder epithelium. Experimental data suggest that apoptotic cell removal generates pulling forces necessary for tissue rearrangement. Efferocytosis by epithelial cells was observed during CND elimination. In this process, epithelial cells programmed to die are engulfed and subsequently phagocytosed by neighboring cells. This entire process involves a stationary distribution within the five different stages of phagocytosis and an apoptotic gradient along the CND. In this study, we used mathematical modeling approaches to analyze the spatiotemporal dynamics of this system and quantified not only the dwell time in each stage but also the flux of cells along the CND. We developed a Markov model of cellular engulfment and efferocytosis and coupled it to the transport equation to quantify dwell times and the flux of cells. The model was then solved and analyzed analytically. It revealed that cell death and processing increase along the CND towards the bladder. Model outcomes also matched biological observations and allowed us to quantify the temporal changes in the number of cells in each apoptotic stage. This apoptotic cell clearance machinery described in the model is probably the first example known so far in which its role was found to be absolutely necessary for tissue morphogenesis during normal development. This work thus provides important insights into spatiotemporal dynamics of cellular rearrangement in the CND.

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**STEPHANIE PORTET**, University of Manitoba
[Sunday December 6 / dimanche 6 décembre, 15:40]
*Intracellular transport driven by antagonistic motor proteins*

Intermediate filaments are long elastic fibers that are transported in cells along microtubules by antagonistic motor proteins. How elastic fibers are efficiently transported by antagonistic motors is not well understood and is difficult to measure with current experimental techniques. Adapting the tug-of-war paradigm for vesicle-like cargos, a mathematical model is developed to describe the motion of an elastic fiber punctually bound to antagonistic motors [1]. Combining dynamical simulations and qualitative analysis, the asymptotic behavior of the model, which defines the mode of transport of fibers, is studied ; the effects of initial conditions, reflecting the intracellular context, and model parameters and functionals, describing motors and fiber properties are characterized.

Work in collaboration with J. Dallon (BYU, Provo, Utah, USA), C. Leduc and S. Etienne-Manneville (Institut Pasteur, Paris, France)

[1] Portet, S., Leduc, C., Etienne-Manneville, S., Dallon, J. Deciphering the transport of elastic filaments by antagonistic motor proteins. Phys. Rev. E. 99: 042414 (2019).

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**JÜRGEN REINGRUBER**, Ecole Normale Superieure
[Friday December 4 / vendredi 4 décembre, 14:20]
*Monitoring and predicting the Covid-19 epidemic and its implications for hospitals*

The world and France are strongly impacted by the SARS-COV-2 epidemic. Finding appropriate measures that effectively contain the epidemic without putting severe pressure on social and economic life is a major challenge for predictive approaches. We developed an modeling framework to monitor and predict the spread of the epidemic together with its impact on the health care system. The current implementation accounts for interactions between five age-stratified population groups, and predicts disease progression and hospitalization status using eight different categories such as infected, hospitalized, occupancy of intensive care units, deceased, recovered from hospitalization and more. We use a variety of public health care data for France to calibrate the model and to predict the implications for hospitals.

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**LISANNE RENS**, Delft University of Technology
[Sunday December 6 / dimanche 6 décembre, 15:20]
*Computational models for feedback between cell shape, cell signaling and extracellular matrix*

Cell shape changes and cell migration in mammalian cells are regulated by many signaling proteins. Cells also interact with a meshwork of protein fibers, called the extracellular matrix (ECM), that affects signaling proteins that regulate cell motility, Rac and Rho. The feedback between Rac-Rho-ECM affeects invasiveness of melanoma cancer cells. In our models, we expand on a previous 2-compartment model that describes Rac-Rho mutual inhibition, self-activation, the effect of each protein on the amount of contact with the ECM, and ECM activation of Rho. We study the full spatial dynamics in 1D and in static 2D domains, demonstrating oscillations and static/dynamic waves. These results give insight into how distinct types of cell migration emerge. By simulating the set of PDEs in a fully deformable 2D cell using a Cellular Potts model, we predict how spatially distributed signaling is coupled to cell motility. Predicted cell shapes and behavior resemble experimental observations. This full 2D model reveals how ECM anisotropy, cell stiffness, and other cell parameters affect cell migration, leading to experimentally testable predictions. Our computational models suggests insights into how the invasiveness of melanoma cells is regulated.

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**JOHN RINZEL**, New York University
[Tuesday December 8 / mardi 8 décembre, 13:00]
*A neuronal model for learning to keep a rhythmic beat.*

When listening to music, we typically lock onto and move to a beat. Behavioral studies on such synchronization (Repp 2005) abound, yet the neural mechanisms remain poorly understood. Beat perception and generation involves time estimation and plasticity for a neural circuit that can adapt and learn a rhythm. In the case of music, the range of beat frequency includes 1-6 Hz. Some models of beat perception hypothesize that the brain contains an array of self-sustaining entrainable oscillators, which resonate when forced with periodic stimuli, i.e. musical rhythms (Large et al. 2010). In contrast, our approach, in the

simplest case, assumes a single beat generator neuron (BG) which can change its intrinsic frequency and phase to match that of an external rhythm, say a metronome. Our model implements an error correction scheme and includes counting of naturally occurring gamma frequency cycles to estimate time intervals. The model quickly learns new rhythms, within a few cycles as found in human behavior. When the stimulus is removed the BG continues to produce the learned rhythm in accordance with a synchronization continuation task.

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**MARC ROUSSEL**, University of Lethbridge
[Monday December 7 / lundi 7 décembre, 14:20]
*Dynamics-preserving model reduction using bipartite-graph representations of biochemical systems*

At a fundamental level, biochemical systems can be represented as sets of elementary reactions. These mechanistic descriptions can in turn be represented as bipartite graphs, with one vertex type representing chemical species, and the other chemical reactions. Specially constructed subsets of the bipartite graph known as fragments have a one-to-one correspondence with terms in the characteristic equation arising in stability analysis, whether for ODEs representing a well-mixed system, or for reaction-diffusion PDEs. Accordingly, there is a connection between the structure of the bipartite graph and stability. Specifically, critical fragments, those corresponding to terms in the characteristic equation with negative coefficients, are necessary to allow for Andronov-Hopf, saddle-node, or Turing bifurcations. Because biochemical networks are typically very large, it is often desirable to simplify the corresponding models. This talk will explore an idea for using the bipartite-graph representation of a biochemical network to reduce a biochemical model while preserving its dynamics, by carrying out graph transformations that preserve critical fragments.

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**ARTHUR SHERMAN**, National Institutes of Health
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Clinical Insights from a Diabetes Progression Model*

Insulin is the chief hormone that regulates glucose homeostasis, preserving glucose for use by the brain in fasting conditions but sharing glucose with other tissues, such as muscle, after meals. This orderly cycle of fuel usage is disrupted in obesity, which renders tissues resistant to the effects of insulin and leads to chronic hyperglycemia, a condition known as type 2 diabetes. A salient characteristic of diabetes is its relentless progressive nature, which is almost impossible to reverse once the disease is established and difficult to reverse in the pre-diabetes stage when glucose is elevated but below the diagnostic threshold. A puzzling feature is that people with pre-diabetes or in the early stages of T2D have abnormally high plasma insulin concentrations, and insulin rises before glucose does. We show that these characteristics of diabetes are explained by a mathematical model in which the onset of T2D is represented by the crossing of a threshold. From a clinical point of view, the near irreversibility of diabetes once the threshold is crossed highlights the need for identifying people at risk early. We will present examples of how the model has provided insights for improving diabetes screening and treatment.

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**JOHANNES TEXTOR**, Radboud University Medical Center
[Saturday December 5 / samedi 5 décembre, 15:40]
*A tipping point in cancer-immune dynamics leads to divergent immunotherapy responses and hampers biomarker discovery*

Predicting the effects of immunotherapy treatments on cancer patients remains a challenge. Efforts to overcome these challenges focus mainly on the discovery of new biomarkers. Owing to the complexity of cancers and their tumor microenvironment, only a limited number of candidate biomarkers eventually enters clinical practice, despite advances in cellular and molecular approaches. We used an ordinary differential equation model to simulate the fundamental mechanisms that dictate tumor-immune dynamics and investigated its implications on responses to immune checkpoint inhibition (ICI) and patient survival. By simulation of biomarker discovery trials, we extracted fundamental principles underlying the success rates of biomarker discovery programs. Our model predicts a tipping point – a sharp state transition between immune control and immune evasion – that induces a strongly non-linear relationship between patient survival and both immunological and tumor-related parameters. In patients close to the tipping point, ICI therapy may lead to long-lasting survival benefits, whereas patients far from the tipping point may

fail to benefit from these potent treatments. Our findings imply that (1) the apparent conundrum that ICI induces substantial benefits in some patients yet completely fails in others could be, to a large extent, explained by the presence of a tipping point ; (2) predictive biomarkers for immunotherapy should ideally combine both immunological and tumor-related markers, as the distance of a patient's status from the tipping point cannot be reliably determined from solely one of these. The notion of a tipping point in cancer-immune dynamics could help to optimize strategies in biomarker discovery.

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**JUSTIN TZOU**, Macquarie University
[Monday December 7 / lundi 7 décembre, 15:20]
*Localized patterns and narrow escape problems in more general geometries*

The main focus of this talk will be on a method for analyzing localized spot patterns on general surfaces. Past analytic frameworks have been restricted to analyses on flat and spherical surfaces ; we discuss a new addition to the analytic framework that allows us to obtain results on more general (and perhaps more realistic) surfaces. We also discuss briefly recent results obtained for the narrow escape problem inside an arbitrary bounded three-dimensional domain with a small target on the boundary. Methods used for these problems may provide a way forward for understanding how cell geometry impacts processes such as cell polarization.

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**ROMAIN VELTZ**, INRIA
[Tuesday December 8 / mardi 8 décembre, 15:00]
*Mean field study of stochastic spiking neural networks*

In this work, we study the dynamics of a network of stochastic spiking neurons akin to the "generalized linear model". This network is a generalization of the one introduced in [DeMasi et al. 2014]. It allows to capture most intrinsic neuronal spiking, like bursting for example, while being quite easy to investigate compared to the Hodgkin-Huxley model. Two sets of results will be provided. On the theory side, the mean field will be derived and the stability of its invariant measure(s) will be investigated. On the numerical side, simulations of the PDE and of the finite network (on GPU) will be compared close to the bifurcations of the system. More precisely, I will present some recent results concerning the quasi-synchronisation of the neurons as function of the different parameters of the network (adaptation variable, synaptic strength...).

# Nonlinear PDEs and kinetic problems / ÉDP non linéaires et problèmes cinétiques

**Org: Slim Ibrahim** (Victoria) and/et **Weiran Sun** (SFU)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:30 - 14:00 | Ricardo Alonso (Texas A&M University at Qatar, Qatar), *Brief Intro to Dissipative Particle Systems and the role of self-similarity* (p. 159) |
| 14:00 - 14:30 | Gong Chen (Fields Institute and University of Toronto, Canada) (p. 160) |
| 14:30 - 15:00 | Zheng Chen (University of Massachusetts Dartmouth, US), *Multiscale Convergence Properties for Spectral Approximation of a Model Kinetic Equation* (p. 160) |
| 15:30 - 16:00 | Dayton Preissl (University of Victoria, Canada), *The Hot, Magnetized Relativistic Maxwell Vlasov System* (p. 161) |
| 19:00 - 19:30 | Hiroaki Kikuchi (Tsuda University, Japan), *Existence of a ground state and blowup problem for a class of nonlinear Schrödinger equations* (p. 161) |
| 19:30 - 20:00 | Takafumi Akahori (Shizuoka University, Japan), *Uniqueness of ground states for combined power-type nonlinear scalar field equations* (p. 159) |
| 20:00 - 20:30 | Kai Koike (Kyoto University, Japan), *Refined pointwise estimates for the solutions to a system of a 1D viscous compressible fluid and a moving point mass* (p. 161) |
| 20:30 - 21:00 | Tong Yang (City University of Hong Kong, Hong Kong), *Some recent progress on the Boltzmann equation without angular cutoff* (p. 162) |
| 21:00 - 21:30 | I-Kun Chen (National Taiwan University, Taiwan) (p. 160) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 19:00 - 19:30 | Quyuan Lin (Texas A&M, US), *The Inviscid Primitive Equations and the Effect of Rotation* (p. 161) |
| 19:30 - 20:00 | Ikkei Shimizu (Kyoto University, Japan), *Local well-posedness for the Landau-Lifshitz equation with helicity term* (p. 162) |
| 20:00 - 20:30 | Yanxia Deng (Sun Yat-sen University), *Global existence and singularity of the Hill's type lunar problem* (p. 160) |
| 20:30 - 21:00 | Yakine Bahri (University of Victoria, Canada) (p. 160) |
| 21:00 - 21:30 | Razvan Fetecau (Simon Fraser University, Canada), *Aggregation with intrinsic interactions on Riemannian manifolds* (p. 160) |
| 21:30 - 22:00 | Shugo Yasuda (University of Hyogo, Japan), *Numerical analysis of the instability and aggregation in a kinetic transport equation with internal state* (p. 162) |

## Abstracts/Résumés

**TAKAFUMI AKAHORI**, Shizuoka university
[Friday December 4 / vendredi 4 décembre, 19:30]
*Uniqueness of ground states for combined power-type nonlinear scalar field equations*

We consider the uniqueness of ground states for combined power-type nonlinear scalar field equations with the Sobolev critical exponent and large frequency parameter. For five and higher dimensions, the uniqueness of the ground states had been proved. In this talk, I give a uniqueness result for three and four dimensions. This study is motivated and inspired by that by Coles and Gustafson (Publ.Res.Inst.Math.Sci.56 (2020), pp.647-699).

**RICARDO ALONSO**, Texas A&M Qatar
[Friday December 4 / vendredi 4 décembre, 13:30]
*Brief Intro to Dissipative Particle Systems and the role of self-similarity*

This talk is a brief introduction to Dissipative Particle Systems. The presentation evolves around 3 relevant examples: granular gases, alignment and annihilation processes. The notion of self-similarly is discussed and then connected to the analysis and simulation of such systems. Recent results and perspectives will be commented along the way.

**YAKINE BAHRI**, University of Victoria, Canada
[Saturday December 5 / samedi 5 décembre, 20:30]

**GONG CHEN**, Fields Institute and University of Toronto, Canada
[Friday December 4 / vendredi 4 décembre, 14:00]

**I-KUN CHEN**, National Taiwan University, Taiwan
[Friday December 4 / vendredi 4 décembre, 21:00]

**ZHENG CHEN**, University of Massachusetts Dartmouth
[Friday December 4 / vendredi 4 décembre, 14:30]
*Multiscale Convergence Properties for Spectral Approximation of a Model Kinetic Equation*

We prove rigorous convergence properties for a semi-discrete, moment-based approximation of a model kinetic equation in one dimension. This approximation is equivalent to a standard spectral method in the velocity variable of the kinetic distribution and, as such, is accompanied by standard algebraic estimates of the form $N^{-q}$, where $N$ is the number of modes and $q$ depends on the regularity of the solution. However, in the multiscale setting, we show that the error estimate can be expressed in terms of the scaling parameter $\epsilon$, which measures the ratio of the mean-free-path to the characteristic domain length. In particular, we show that the error in the spectral approximation is $\mathcal{O}(\epsilon^{N+1})$. More surprisingly, for isotropic initial conditions, the coefficients of the expansion satisfy super convergence properties. In particular, the error of the $l^{th}$ coefficient of the expansion scales like $\mathcal{O}(\epsilon^{2N})$ when $l = 0$ and $\mathcal{O}(\epsilon^{2N+2-l})$ for all $1 \leq l \leq N$. This result is significant, because the low-order coefficients correspond to physically relevant quantities of the underlying system. All the above estimates involve constants depending on $N$, the time $t$, and the initial condition. We investigate specifically the dependence on $N$, in order to assess whether increasing $N$ actually yields an additional factor of $\epsilon$ in the error. Numerical tests will also be presented to support the theoretical results.

**YANXIA DENG**, Sun Yat-sen University
[Saturday December 5 / samedi 5 décembre, 20:00]
*Global existence and singularity of the Hill's type lunar problem*

In a joint work with Slim Ibrahim, we used the idea of ground states in nonlinear dispersive equations (e.g. Klein-Gordon and Schrödinger equations) to characterize solutions in the N-body problem with strong force under some energy constraints. In this talk, I will explore this method to a restricted 3-body problem (Hill's type lunar problem), and talk about the dynamics of the solutions below, at, and (slightly) above the ground state energy threshold.

**RAZVAN FETECAU**, Simon Fraser University
[Saturday December 5 / samedi 5 décembre, 21:00]
*Aggregation with intrinsic interactions on Riemannian manifolds*

We consider a model for collective behaviour with intrinsic interactions on Riemannian manifolds. We establish the well-posedness of measure solutions, defined via optimal mass transport, on several specific manifolds (sphere, hypercylinder, rotation group SO(3)), and investigate the mean-field particle approximation. We study the long-time behaviour of solutions, where the primary goal is to establish sufficient conditions for a consensus state to form asymptotically. The analytical results are illustrated with numerical experiments that exhibit various asymptotic patterns.

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**HIROAKI KIKUCHI**, Tsuda University
[Friday December 4 / vendredi 4 décembre, 19:00]
*Existence of a ground state and blowup problem for a class of nonlinear Schrödinger equations*

In this talk, we study the existence of the ground state and blowup problem for a class of nonlinear Schrödinger equations involving the mass and energy critical exponents. To show that a ground state exists, we solve a minimization problem related to the virial identity, so that we need to compare the minimization value to the best constant of the Gagliardo-Nirenberg inequality because our nonlinearities contain the mass critical nonlinearity. Once we obtain the ground state, we can introduce a subset $\mathcal{A}_{\omega,-}$ of $H^1(\mathbb{R}^d)$ for each $\omega > 0$ as in Berestycki and Cazenave (1981). Then, it turn out that any radial solution starting from $\mathcal{A}_{\omega,-}$ blows up in a finite time. This talk is based on a joint work with Minami Watanabe (Tsuda University).

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**KAI KOIKE**, Kyoto University
[Friday December 4 / vendredi 4 décembre, 20:00]
*Refined pointwise estimates for the solutions to a system of a 1D viscous compressible fluid and a moving point mass*

The long-time behavior of a system of a one-dimensional barotropic viscous compressible fluid and a moving point mass is investigated. In a previous work, I showed that the velocity $V(t)$ of the point mass satisfies a power-law decay estimate $V(t) = O(t^{-3/2})$. This time, I give a necessary and sufficient condition for a corresponding lower bound $|V(t)| \geq C^{-1}(t+1)^{-3/2}$ $(t \gg 1)$ to hold (preprint: https://arxiv.org/abs/2010.06578). This is proved as a corollary to refined pointwise estimates for the fluid variables.

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**QUYUAN LIN**, Texas A&M University
[Saturday December 5 / samedi 5 décembre, 19:00]
*The Inviscid Primitive Equations and the Effect of Rotation*

Large scale dynamics of the oceans and the atmosphere is governed by the primitive equations (PEs). It is well-known that the three-dimensional viscous primitive equations are globally well-posed in Sobolev spaces. In this talk, I will discuss the ill-posedness in Sobolev spaces, the local well-posedness in the space of analytic functions, and the finite-time blowup of solutions to the three-dimensional inviscid PEs with rotation (Coriolis force). Eventually, I will also show, in the case of "well-prepared" analytic initial data, the regularizing effect of the Coriolis force by providing a lower bound for the life-span of the solutions which grows toward infinity with the rotation rate. The latter is achieved by a delicate analysis of a simple limit resonant system whose solution approximate the corresponding solution of the 3D inviscid PEs with the same initial data.

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**DAYTON PREISSL**, University of Victoria
[Friday December 4 / vendredi 4 décembre, 15:30]
*The Hot, Magnetized Relativistic Maxwell Vlasov System*

Fusion energy is at the threshold of becoming one of the most green and sustainable energy sources in the world. This energy is creating by heating an ionized gas (plasma) to extreme temperatures in order to allow high energy particle collisions to occur. This leads to an exothermic fusion reaction releasing immense energy to be harvested. One major hurdle, is the plasma is highly pressurizes and must be contained within a reactor. A solution to this issue is applying a strong magnetic field which traps the particles from escaping radially outwards from the confinement chamber. Such a system can be modeled mathematically by the

Hot, Magnetized, Relativistic Vlasov Maxwell (HMRVM) system. A small physically pertinent parameter $\epsilon$, with $0 < \epsilon \ll 1$, related to the inverse of a gyrofrequency, governs the strength of a spatially inhomogeneous applied magnetic field given by the function $x \mapsto \epsilon^{-1}\mathbf{B}_e(x)$. Stationary (equilibrium) solutions to this system are well understood, but it is not clear how perturbations from equilibrium could lead to destabilization of the plasma (the plasma explodes releasing uncontrollable energy). It has been recently in shown that, in the case of *neutral*, *cold*, and *dilute* plasmas (like in the Earth's magnetosphere), smooth solutions corresponding to perturbations of equilibria exist on a uniform time interval $[0, T]$, with $0 < T$ independent of $\epsilon$. In this talk we further extend these results to hot plasmas for well prepared initial data.

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**IKKEI SHIMIZU**, Kyoto University
[Saturday December 5 / samedi 5 décembre, 19:30]
*Local well-posedness for the Landau-Lifshitz equation with helicity term*

We consider the initial value problem for the Landau-Lifshitz equation with helicity term (chiral interaction term), which arises from the Dzyaloshinskii-Moriya interaction. We show that it is locally well-posed in $\vec{k} + H^s$ for $s > 2$ with $\vec{k} = {}^t(0, 0, 1)$. The key idea is to reduce the problem to a system of semi-linear Schrödinger equations, called modified Schrödinger map equation. The problem here is that the helicity term appears as quadratic derivative nonlinearities, which is known to be difficult to treat as perturbation of the free evolution. To overcome that, we consider them as magnetic terms, then apply the energy method by introducing the differential operator associated with magnetic potentials.

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**TONG YANG**, City University of Hong Kong
[Friday December 4 / vendredi 4 décembre, 20:30]
*Some recent progress on the Boltzmann equation without angular cutoff*

In this talk, after reviewing the work on global well-posedness of the Boltzmann equation without angular cutoff with algebraic decay tails, we will present a recent work on the global weighted $L^\infty$-solutions to the Boltzmann equation without angular cutoff in the regime close to equilibrium. A De Giorgi type argument, well developed for diffusion equations, is crafted in this kinetic context with the help of the averaging lemma. More specifically, we use a strong averaging lemma to obtain suitable $L^p$ estimates for level-set functions. These estimates are crucial for constructing an appropriate energy functional to carry out the De Giorgi argument. Then we extend local solutions to global by using the spectral gap of the linearized Boltzmann operator with the convergence to the equilibrium state obtained as a byproduct. This result fill in the gap of well-posedness theory for the Boltzmann equation without angular cutoff in the $L^\infty$ framework. The talk is based on the joint works with Ricardo Alonso, Yoshinori Morimoto and Weiran Sun.

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**SHUGO YASUDA**, University of Hyogo
[Saturday December 5 / samedi 5 décembre, 21:30]
*Numerical analysis of the instability and aggregation in a kinetic transport equation with internal state*

Collective motion of chemotactic bacteria, such as E. Coli, stems from, at individual level, continuous reorientations by runs and tumbles. It has been established that the length of run is decided by a stiff response to the external chemical cue via the intracellular signal transduction pathway. This study numerically investigates the self-organized aggregation of chemotactic bacteria based on a kinetic transport equation with internal state coupled with a reaction-diffusion equation of chemical cues. We put the focus on the effect of the adaptation time in the intracellular dynamics on the self-organized aggregation both at the macroscopic and microscopic levels. We found that the aggregation profile is highly affected by the adaptation time. Especially, we uncovered a non-monotonic behavior of the peak aggregation density with respect to the adaptation time. This indicates that there exists an optimal adaptation time to perform a strong aggregation behavior. Remarkably, this non-monotonic behavior is observed only at the kinetic level when the adaptation time is moderately large compared to the tumbling frequency, but cannot be described at the continuum level, i.e., the Keller-Segel model, which is obtained by the asymptotic analysis of the kinetic model. We also discover a plateau-like aggregation profile when the adaptation time is very large. We illustrate the formation of the plateau-type aggregation by a microscopic characterization.

# Operator algebras (semi)groups, and dynamics / Algèbres d'opérateur, (semi)groupes et dynamiques

Org: **Chris Bruce** (Queen Mary University of London) and/et **Marcelo Laca** (Victoria)

## Schedule/Horaire

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 9:00 - 9:30 | Karen Strung (Czech Academy of Sciences), *Constructions in minimal amenable dynamics and applications to classification of C*-algerbas.* (p. 166) |
| 9:30 - 10:00 | Kristin Courtney (University of Münster), *C*-structure on images of completely positive order zero maps* (p. 164) |
| 10:00 - 10:30 | Jamie Gabe (University of Southern Denmark), *Classification of embeddings* (p. 165) |
| 10:30 - 11:00 | Aaron Tikuisis (University of Ottawa), *Classification of embeddings II* (p. 167) |

### Monday December 7 — lundi 7 décembre

| | |
|---|---|
| 9:00 - 9:30 | Takuya Takeishi (Kyoto Institute of Technology), *Partition functions as C*-dynamical invariants and actions of congruence monoids* (p. 167) |
| 9:30 - 10:00 | Xin Li (University of Glasgow), *K-theory for semigroup C*-algebras and partial crossed products* (p. 166) |
| 10:00 - 10:30 | Nadia Larsen (University of Oslo), *Equilibrium states on C*-algebras of right lcm monoids* (p. 165) |
| 10:30 - 11:00 | Camila Fabre Sehnem (Victoria University of Wellington), *Nuclearity for partial crossed products by exact discrete groups* (p. 166) |
| 14:00 - 14:30 | Matthew Kennedy (University of Waterloo), *Amenability, proximality and higher order syndeticity* (p. 165) |
| 14:30 - 15:00 | Dilian Yang (University of Windsor), *Zappa-Szép Actions of Groups on Product Systems* (p. 168) |
| 15:00 - 15:30 | Elizabeth Gillaspy (University of Montana), *Homotopy of product systems, and K-theory for higher-rank graphs* (p. 165) |
| 15:30 - 16:00 | Anna Duwenig (University of Wollongong), *Cartan subalgebras for non-principal twisted groupoid C*-algebras* (p. 164) |
| 16:00 - 16:30 | Ben Hayes (University of Virginia), *A random matrix approach to the Peterson-Thom conjecture* (p. 165) |
| 16:30 - 17:00 | Tyrone Crisp (University of Maine), *An imprimitivity theorem for Hilbert modules* (p. 164) |

### Tuesday December 8 — mardi 8 décembre

| | |
|---|---|
| 9:00 - 9:30 | Dan Ursu (University of Waterloo), *Characterizing traces on crossed products of noncommutative C*-algebras* (p. 167) |
| 9:30 - 10:00 | Hung-Chang Liao (University of Ottawa), *Almost finiteness, comparison, and tracial Z-stability* (p. 166) |
| 10:00 - 10:30 | Maria Grazia Viola (Lakehead University), *Regularities properties of Cuntz-Pimsner algebras associated to C*-correspondences over commutative C*-algebras* (p. 167) |
| 10:30 - 11:00 | Johannes Christensen (KU Leuven), *A new approach to describing KMS states on $C^*$-algebras.* (p. 163) |
| 11:00 - 11:30 | Kari Eifler (Texas A&M University), *Non-local games and quantum metric spaces* (p. 164) |
| 11:30 - 12:00 | Boyu Li (University of Victoria), *The Zappa-Szép product of a Fell bundle by a groupoid* (p. 166) |

## Abstracts/Résumés

**JOHANNES CHRISTENSEN**, KU Leuven
[Tuesday December 8 / mardi 8 décembre, 10:30]
*A new approach to describing KMS states on $C^*$-algebras.*

Studying KMS states for $C^*$-dynamical systems is a popular theme in the Operator Algebra community in these years. This is in part motivated by the natural interpretation of KMS states in models in physics and in part because KMS states is a powerful tool for building bridges between seemingly unrelated areas of mathematics and uncovering interesting structural properties of $C^*$-dynamical systems.

In this talk I will present a new approach to describing KMS states for $C^*$-dynamical systems that admit a certain kind of nicely behaved subalgebra of the fixed-point algebra. I will then explain how this description of KMS states provides a new interpretation of a celebrated theorem by Sergey Neshveyev, and how it relates to recent results of Ursu on traces on crossed products.

The results I will present in this talk is joint work with Klaus Thomsen.

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**KRISTIN COURTNEY**, WWU Muenster
[Saturday December 5 / samedi 5 décembre, 9:30]
*C*-structure on images of completely positive order zero maps*

A completely positive (cp) map is called order zero when it preserves orthogonality. Such maps enjoy a rich structure, which has made them a key component of completely positive approximations of nuclear C*-algebras. Motivated by generalized inductive limits arising from such cp approximations, we consider the structure of the image of a cp order zero map. It turns out that there are a few key properties of a self-adjoint subspace of a C*-algebra that characterize when it is the image of a cp order zero map and, moreover, allow us to build a C*-structure on that subspace. This is joint work with Wilhelm Winter.

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**TYRONE CRISP**, University of Maine
[Monday December 7 / lundi 7 décembre, 16:30]
*An imprimitivity theorem for Hilbert modules*

Mackey's imprimitivity theorem identifies those unitary representations of a group $G$ that are induced from a representation of a subgroup $H$: the induced representations are precisely those that carry a compatible representation of the $C^*$-algebra $C_0(G/H)$. Rieffel later put this result into the broader context of induced representations of $C^*$-algebras: induced representations can in general be characterised by the existence of a compatible representation of an auxiliary $C^*$-algebra.

In this talk I shall discuss the related problem of recognising induced Hilbert $C^*$-modules. I shall explain why the natural auxiliary object entering into the characterisation of induced modules is a kind of $C^*$-coalgebra, rather than a $C^*$-algebra ; and I will describe two examples in which these somewhat abstract co-algebraic objects can be put into a more familiar $C^*$-algebraic form.

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**ANNA DUWENIG**, University of Wollongong
[Monday December 7 / lundi 7 décembre, 15:30]
*Cartan subalgebras for non-principal twisted groupoid C*-algebras*

The reduced C*-algebra of a topologically principal twisted groupoid has a canonical Cartan subalgebra: functions on its unit space. The remarkable Weyl construction, due to Renault, asserts the converse: If a C*-algebra A admits a Cartan subalgebra, there exists such a groupoid whose C*-algebra is isomorphic to A in a Cartan-preserving way. In this talk, I will present on joint work with Gillaspy, Norton, Reznikoff, and Wright, in which we identified subgroupoids of (not necessarily topologically principal) groupoids that give rise to Cartan subalgebras. If time permits, I will further give an explicit description of the associated Weyl groupoid and twist, which is based on further joint work with Gillaspy and Norton.

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**KARI EIFLER**, Texas A&M University
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Non-local games and quantum metric spaces*

We will look at quantum metric spaces, which are a non-commutative analogue of finite metric spaces. Banica has defined the quantum symmetry group of a finite metric space, and I will talk about how to capture Banica's definition using the Weaver-Kupperberg framework of quantum metric spaces. I will also connect this extension to the theory of non-local games.

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**JAMIE GABE**, University of Southern Denmark
[Saturday December 5 / samedi 5 décembre, 10:00]
*Classification of embeddings*

I will survey some recent developments in the classification theory of simple, nuclear $C^*$-algebras with an emphasis on a new approach to the main classification theorem. The proof goes through classification of embeddings of $C^*$-algebras. This is joint work with José Carrión, Chris Schafhauser, Aaron Tikuisis, and Stuart White.

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**ELIZABETH GILLASPY**, University of Montana
[Monday December 7 / lundi 7 décembre, 15:00]
*Homotopy of product systems, and K-theory for higher-rank graphs*

One can model the $C^*$-algebra of a higher-rank graph ($k$-graph) via a product system, which is a higher-dimensional version of a $C^*$-correspondence. Just as for the Cuntz–Pimsner algebra associated to a $C^*$-correspondence, there is a 6-term exact sequence for the $K$-theory of the Cuntz–Nica–Pimsner algebra of a product system. This talk will present joint work with J. Fletcher and A. Sims, in which we establish the compatibility of this 6-term exact sequence with the new notion of a homotopy of product systems, and discuss the applications to higher-rank graphs. Our results imply that certain questions about the $K$-theory of $k$-graph $C^*$-algebras reduce to questions about the path-connectedness of certain spaces of matrices.

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**BEN HAYES**, University of Virginia
[Monday December 7 / lundi 7 décembre, 16:00]
*A random matrix approach to the Peterson-Thom conjecture*

The Peterson-Thom conjecture asserts that any diffuse, amenable subalgebra of a free group factor is contained in a unique maximal amenable subalgebra. This conjecture is motivated by related results in Popa's deformation/rigidity theory and Peterson-Thom's results on $L^2$-Betti numbers. We present an approach to this conjecture in terms of so-called strong convergence of random matrices by formulating a conjecture which is a natural generalization of the Haagerup-Thorbjornsen theorem whose validity would imply the Peterson-Thom conjecture. This random matrix conjecture is related to recent work of Collins-Guionnet-Parraud. This talk will be accessible to $C^*$-algebraists. I promise.

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**MATTHEW KENNEDY**, University of Waterloo
[Monday December 7 / lundi 7 décembre, 14:00]
*Amenability, proximality and higher order syndeticity*

I will present new descriptions of some universal flows associated to a discrete group, obtained using what we view as a kind of "topological Furstenberg correspondence." The descriptions are algebraic and relatively concrete, involving subsets of the group satisfying a higher order notion of syndeticity. We utilize them to establish new necessary and sufficient conditions for strong amenability and amenability. Furthermore, utilizing similar techniques, we obtain a characterization of "dense orbit sets," answering a question of Glasner, Tsankov, Weiss and Zucker. Throughout the talk, I will discuss connections to operator algebras.

This is joint work with Sven Raum and Guy Salomon.

**NADIA LARSEN**, University of Oslo, Norway
[Monday December 7 / lundi 7 décembre, 10:00]
*Equilibrium states on C*-algebras of right lcm monoids*

Left cancellative monoids with right lcm's (least common multiples) for every pair of elements with a common right multiple cover a variety of examples, such as Zappa-Szep products from self-similar actions of groups, and several classes of semidirect products. The C*-algebras of such monoids that display a generalised scale, namely a particular type of monoid homomorphism into the multiplicative natural numbers, admit a characterisation of all their equilibrium states. I will present some of the key ideas in this characterisation. The talk is based on a joint work with Nathan Brownlowe, Jacqui Ramagge and Nicolai Stammeier.

**BOYU LI**, University of Victoria
[Tuesday December 8 / mardi 8 décembre, 11:30]
*The Zappa-Szép product of a Fell bundle by a groupoid*

In group theory, the Zappa-Szép product generalizes the semi-direct product. As the semi-direct product is related to the crossed product of operator algebras, we seek to define a Zappa-Szép product analogue. First, we define the notion of the compatible groupoid action on a Fell bundle, which allows us to define the Zappa-Szép product of a Fell bundle by a groupoid. We show that this product is a Fell bundle over the Zappa-Szép product of the underlying groupoids. We then show that the representation of the Zappa-Szép product Fell bundle is related to the notion of covariant representations. Finally, we briefly discuss some basic properties of its C*-algebra. This is a joint work with Anna Duwenig.

**XIN LI**, University of Glasgow
[Monday December 7 / lundi 7 décembre, 9:30]
*K-theory for semigroup C*-algebras and partial crossed products*

We present a K-theory formula for a class of inverse semigroup C*-algebras. As a special case, we discuss C*-algebras generated by left regular representations of semigroups, and illustrate the main theorem and its applications with concrete examples.

**HUNG-CHANG LIAO**, University of Ottawa
[Tuesday December 8 / mardi 8 décembre, 9:30]
*Almost finiteness, comparison, and tracial Z-stability*

Inspired by Kerr's work on topological dynamics, we define tracial Z-stability for sub-C*-algebras. We will discuss how it is related to dynamical properties such as almost finiteness and comparison. The talk is based on a joint work with Aaron Tikuisis.

**CAMILA FABRE SEHNEM**, Victoria University of Wellington
[Monday December 7 / lundi 7 décembre, 10:30]
*Nuclearity for partial crossed products by exact discrete groups*

Important classes of C*-algebras can be described as partial crossed products. Even though a partial action of a discrete group on a C*-algebra is in an appropriate sense always equivalent to a global action, the commutativity of the underlying C*-algebra may be lost under this correspondence. I will talk about a joint work with A. Buss and D. Ferraro, in which we generalise a result by Matsumura for ordinary actions by showing that the partial crossed product of a commutative C*-algebra by an exact discrete group is nuclear whenever the full and reduced partial crossed products coincide. We apply our results to show that the reduced semigroup C*-algebra $\mathrm{C}^*_\lambda(P)$ of a submonoid of an exact discrete group is nuclear if the left regular representation on $\ell^2(P)$ is an isomorphism between the full and reduced C*-algebras.

**KAREN STRUNG**, Institute of Mathematics, Czech Academy of Sciences
[Saturday December 5 / samedi 5 décembre, 9:00]
*Constructions in minimal amenable dynamics and applications to classification of C*-algerbas.*

What abelian groups can arise as the $K$-theory of $\mathrm{C}^*$-algebras arising from minimal dynamical systems ? In joint work with Robin Deeley and Ian Putnam, we completely characterize the $K$-theory of the crossed product of a space $X$ with finitely generated $K$-theory by an action of the integers and show that crossed products by a minimal homeomorphisms exhaust the range of these possible $K$-theories. We also investigate the $K$-theory and the Elliott invariants of orbit-breaking algebras. We show that given arbitrary countable abelian groups $G_0$ and $G_1$ and any Choquet simplex $\Delta$ with finitely many extreme points, we can find a minimal orbit-breaking relation such that the associated $\mathrm{C}^*$-algebra has $K$-theory given by this pair of groups and tracial state space affinely homeomorphic to $\Delta$. These results have important applications to the Elliott classification program for $\mathrm{C}^*$-algebras. In particular, we make a step towards determining the range of the Elliott invariant of the $\mathrm{C}^*$-algebras associated to étale equivalence relations.

**TAKUYA TAKEISHI**, Kyoto Institute of Technology
[Monday December 7 / lundi 7 décembre, 9:00]
*Partition functions as C*-dynamical invariants and actions of congruence monoids*

C*-algebras of $ax+b$-semigroups of congruence monoids $C^*_\lambda(R \rtimes R_{\mathrm{m},\Gamma})$ are introduced by C. Bruce, which behaves similarly to the C*-algebras examined by Cuntz–Deninger–Laca. Both kinds of algebras have canonical time evolutions, and have similar phase transition phenomena. In this talk, we determine the partition functions and associated representations of $(C^*_\lambda(R \rtimes R_{\mathrm{m},\Gamma}), \sigma)$, inspired by the construction of the representations of Cuntz–Deninger–Laca. As a consequence, we recover several number theoretic invariants from those C*-dynamical sysmtems. In the case of $(C^*_\lambda(R \rtimes R^\times), \sigma)$, we in fact obtain slightly different partition functions from those suggested in the work of Cuntz–Deninger–Laca. This is a joint work with C. Bruce and M. Laca.

**AARON TIKUISIS**, University of Ottawa
[Saturday December 5 / samedi 5 décembre, 10:30]
*Classification of embeddings II*

In a sequel to Jamie's talk, I will further discuss recent developments in the classification of nuclear simple C*-algebras and full embeddings. This is joint work with José Carrión, Jamie Gabe, Chris Schafhauser, and Stuart White.

**DAN URSU**, University of Waterloo
[Tuesday December 8 / mardi 8 décembre, 9:00]
*Characterizing traces on crossed products of noncommutative C*-algebras*

Given a discrete group $G$ acting on a unital C*-algebra $A$, a crossed product is a C*-algebra containing a copy of $G$ (as unitaries) and $A$, where the action of $G$ on $A$ is now inner. This comes in two main flavours - the universal crossed product $A \rtimes G$ and the reduced crossed product $A \rtimes_r G$.

We give complete descriptions of the tracial states on both the universal and reduced crossed products. In particular, we also answer the question of when the tracial states are in canonical bijection with the $G$-invariant tracial states on $A$. This generalizes the unique trace property for discrete groups. The analysis simplifies greatly in various cases, such as in the case of FC groups, more so for abelian groups, and even more so in the case of $G = \mathbb{Z}$. In other cases, we obtain previously known results, for example when $A = C(X)$.

**MARIA GRAZIA VIOLA**, Lakehead University
[Tuesday December 8 / mardi 8 décembre, 10:00]
*Regularities properties of Cuntz-Pimsner algebras associated to C*-correspondences over commutative C*-algebras*

We discuss the structural properties of Cuntz-Pimsner algebras arising from full, minimal, non-periodic, and finitely generated projective C*-correspondence over commutative C*-algebras. A large class of examples is obtained considering the set $\Gamma(V, \alpha)$ of continuous sections of a complex vector bundle on a compact metric space $X$, where left multiplication is given by a twist by a minimal homeomorphism $\alpha\colon X \to X$.

Cuntz-Pimsner algebras are generalization of both Cuntz-Krieger algebras and crossed products by the integers. In the case of crossed products by minimal homeomorphisms, the orbit breaking subagebra, defined by I. Putnam, is a large subalgebra in the sense of N. C. Phillips. We show that the Cuntz-Pismner algebra $\mathcal{O}(\Gamma(V, \alpha))$ also contains a large subalgebras, at least for a large class of C*-correspondences. We will discuss some properties that $\mathcal{O}(\Gamma(V, \alpha))$ and/or its large subalgebra have, focusing on properties needed for classification by the Elliott invariant.

This is joint work with M. S. Adamo, D. Archey, M. Forough, M. Georgescu, J. A Jeong, and K. Strung.

**DILIAN YANG**, University of Windsor
[Monday December 7 / lundi 7 décembre, 14:30]
*Zappa-Szép Actions of Groups on Product Systems*

Let $G$ be a group and $X$ be a product system over a semigroup $P$. Suppose $G$ has a left action on $P$ and $P$ has a right action on $G$, so that one can form a Zappa-Szép product $P \bowtie G$. We define a *Zappa-Szép action* of $G$ on $X$, roughly speaking, to be a collection of functions on $X$, which is compatible with both actions from $P \bowtie G$. For a given Zappa-Szép action of $G$ on $X$, we construct a new product system $X \bowtie G$ over $P \bowtie G$, which is called the Zappa-Szép product of $X$ by $G$. Then we associate $X \bowtie G$ some universal C*-algebras, and show some Hao-Ng type isomorphisms. A special case of interest is when the action is homogenous.

This is ongoing joint work with Boyu Li.

# Optimal Transport and Applications / Transport Optimal et Applications

Org: **Jun Kitagawa** (Michigan State) and/et **Abbas Momeni** (Carleton)

## Schedule/Horaire

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Robert McCann (University of Toronto), *Inscribed radius bounds for lower Ricci bounded metric measure spaces with mean convex boundary* (p. 171) |
| 14:30 - 15:00 | Luigi De Pascale (Università di Pisa), *The relaxation of the Coulomb multi-marginal optimal transport cost and applications* (p. 170) |
| 15:00 - 15:30 | Tongseok Lim (Purdue University), *Geometry of interaction energy minimizers* (p. 171) |
| 15:30 - 16:00 | Yash Jhaveri (Columbia University), *On the (in)stability of the identity map in optimal transportation* (p. 171) |
| 16:00 - 16:30 | Young-heon Kim (University of British Columbia), *Optimal transport for dendritic structures* (p. 171) |
| 16:30 - 17:00 | Seonghyeon Jeong (Michigan State University), *Equivalence of the synthetic MTW conditions* (p. 170) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Alfred Galichon (New York University), *Equilibrium transport with entropic regularization* (p. 170) |
| 14:30 - 15:00 | Shuangjian Zhang (École normale supérieure, Paris), *Wasserstein Control of Mirror Langevin Monte Carlo* (p. 172) |
| 15:00 - 15:30 | Adrian Tudorascu (West Virginia University), *ON THE CONVEXITY CONDITION FOR THE SEMI-GEOSTROPHIC SYSTEM* (p. 171) |
| 15:30 - 16:00 | Farhan Abedin (Michigan State University), *Exponential Convergence of Parabolic Optimal Transport on Bounded Domains* (p. 169) |
| 16:00 - 16:30 | Katy Craig (University of California, Santa Barbara), *A blob method for spatially inhomogeneous degenerate diffusion and applications to sampling and two layer neural networks.* (p. 170) |
| 16:30 - 17:00 | René Cabrera (University of Massachusetts Amherst), *The Monge-Kantorovich Optimal Transportation of Mass Problem on Rectifiable Continuous Paths* (p. 169) |

## Abstracts/Résumés

**FARHAN ABEDIN**, Michigan State University
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Exponential Convergence of Parabolic Optimal Transport on Bounded Domains*

I will speak about joint work with Jun Kitagawa on the asymptotic behavior of solutions to a parabolic version of the optimal mass transport problem. Our main result is an exponential rate of convergence for solutions of the evolution equation to the stationary solution of the optimal transport problem. The key ingredient we use is a global differential Harnack inequality for a special class of functions that solve the linearized problem. I will discuss the proof of this differential Harnack inequality in the case of domains with boundary, and show how it implies the desired exponential convergence result.

**RENÉ CABRERA**, University of Massachusetts Amherst
[Sunday December 6 / dimanche 6 décembre, 16:30]
*The Monge-Kantorovich Optimal Transportation of Mass Problem on Rectifiable Continuous Paths*

The Monge-Kantorovich problem (MKP) is the study of transferring mass from an initial location to a final location in the most efficient way possible. Essentially, in the classical MKP we are a priori transferring mass along straight lines. But suppose

that we now want to transfer mass along paths. In this talk, we present the MKP along paths and show that minimizers exist using a coercivity property. We consider maps $\Gamma(x,t) := (\gamma(x))(t)$ defined on the space of paths such that $\Gamma(x,0) = x$ and $\Gamma(x,1) = T(x)$, where $T$ pushes forward $\mu_0$ to $\mu_1$—probability measures on $\overline{B}_R(0)$. Then for given transference plan on the space of paths, $\pi_\Gamma = \Gamma_\sharp \mu_0$, MKP takes the form $\int c(\gamma)\, d\pi(\gamma) = \int c(\Gamma)\, d\mu_0$. When the cost is $c(\gamma) := \int_0^1 \frac{1}{2}|\dot\gamma|^2$, perturbations and optimality conditions of $\Gamma$ show $\pi_\Gamma$ concentrates on constant speed geodesics. Then we untrivialize the problem on paths by adding congestion with interaction term: $\mathcal{E}(\pi) := \int c(\gamma) d\pi(\gamma) + \int\int\int_0^1 u(|\gamma(t) - \sigma(t)|)\, dt d\pi(\gamma) d\pi(\sigma)$ between paths $\sigma$'s, keeping $\gamma$ fixed, with different endpoints. Here we require $u$ to satisfying a Lipschitz condition. The methods that we used to prove existence of minimizers for MKP on paths apply equally well to this new formulation. Formally, the minimizers of $\mathcal{E}(\pi)$ are solutions of $-\partial_{tt}\Gamma(x,t) + \int u'(|\Gamma(x,t) - \Gamma(y,t)|) \frac{\Gamma(x,t)-\Gamma(y,t)}{|\Gamma(x,t)-\Gamma(y,t)|}\, d\mu_0(y) = 0$.

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**KATY CRAIG**, University of California, Santa Barbara
[Sunday December 6 / dimanche 6 décembre, 16:00]
*A blob method for spatially inhomogeneous degenerate diffusion and applications to sampling and two layer neural networks.*

Given a desired target distribution on Euclidean space and an initial guess of that distribution, composed of finitely many samples from Euclidean space, what is the best way to move the locations of the samples so that they more accurately represent the desired distribution? A classical solution to this problem is to allow the samples to evolve according to Langevin dynamics, the stochastic particle method for approximating solutions of the Fokker-Planck equation. In today's talk, I will introduce an alternative deterministic particle method for approximating solutions of a spatially inhomogeneous porous medium equation. This method corresponds exactly to the mean-field dynamics of training a two layer neural network for a radial basis function activation function. We prove that, as the number of samples increases and the variance of the radial basis function goes to zero, the particle method converges to a bounded entropy solution of the porous medium equation. As a consequence, we both obtain a novel method for sampling probability distributions as well as insight into the dynamics of training two layer neural networks in the mean field regime, including conditions on which the limiting energy is strongly convex. This is joint work with Karthik Elamvazhuthi (UCLA), Matt Haberland (Cal Poly), and Olga Turanova (Michigan State).

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**LUIGI DE PASCALE**, University of Firenze
[Saturday December 5 / samedi 5 décembre, 14:30]
*The relaxation of the Coulomb multi-marginal optimal transport cost and applications*

Multi-marginal optimal transport costs are relevant for several applications. In particular the Coulomb repulsive cost play a role in certain energies in quantum mechanics. Some times, these energies don't allow to obtain compactness in the space of probability measures and then one needs to define, in a physically meaningful way, the transport cost for a sub-probability measure. After describing briefly the motivations, I will introduce the problem and two formula for the relaxed cost. If time allows I'll address the dual problem for the relaxed functional too. (From joints works with Guy Bouchitté, Giuseppe Buttazzo and Thierry Champion).

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**ALFRED GALICHON**, New York University
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Equilibrium transport with entropic regularization*

In this talk, I will introduce and motivate the equilibrium transport problem, which is a generalization of the optimal transport problem, and I will focus on its entropic regularization. I will show the existence and uniqueness of a solution to a generalization of the Schrodinger-Bernstein system, and I will provide an algorithm to compute it. Based on joint work with Eugene Choo, Charles Liang, and Simon Weber.

**SEONGHYEON JEONG**, Michigan State University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Equivalence of the synthetic MTW conditions*

I will present about the synthetic MTW conditions, Loerper's condition introduced by G. Loeper in 09 and QQconv introduced by N. Guillen and J. Kitagawa in 15. I will show that the two synthetic MTW conditions are equivalent when the regularity of the cost function is weaker than $C^3$.

**YASH JHAVERI**, Columbia University
[Saturday December 5 / samedi 5 décembre, 15:30]
*On the (in)stability of the identity map in optimal transportation*

In the optimal transport problem, it is well-known that the geometry of the target domain plays a crucial role in the regularity of the optimal transport. In the quadratic cost case, for instance, Caffarelli showed that having a convex target domain is essential in guaranteeing the optimal transport's continuity. In this talk, we shall explore how, quantitatively, important convexity is in producing continuous optimal transports.

**YOUNG-HEON KIM**, The University of British Columbia
[Saturday December 5 / samedi 5 décembre, 16:00]
*Optimal transport for dendritic structures*

Optimal transport gives an effective way to make geometric averages of different shapes, by giving a metric barycentre of a distribution over the space of probability measures. This metric barycentre is called the Wasserstein barycentre. We will discuss how this notion can be applied to studying dendritic structures, such as plant roots. Based on joint work with Brendan Pass (U. Alberta) and David Schneider (U. Saskatchewan).

**TONGSEOK LIM**, Purdue University
[Saturday December 5 / samedi 5 décembre, 15:00]
*Geometry of interaction energy minimizers*

An interaction energy is a quadratic function defined on a domain of probability measures. We study geometry and uniqueness of interaction energy minimizers on $\mathbb{R}^n$, $\mathbb{S}^n$, or $\mathbb{RP}^n$. This talk is based on a sequence of joint works with Robert J. McCann.

**ROBERT MCCANN**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 14:00]
*Inscribed radius bounds for lower Ricci bounded metric measure spaces with mean convex boundary*

Consider an essentially nonbranching metric measure space with the measure contraction property of Ohta and Sturm. We prove a sharp upper bound on the inscribed radius of any subset whose boundary has a suitably signed lower bound on its generalized mean curvature. This provides a nonsmooth analog of results dating back to Kasue (1983) and subsequent authors. We prove a stability statement concerning such bounds and — in the Riemannian curvature-dimension (RCD) setting — characterize the cases of equality. This represents joint work with Annegret Burtscher, Christian Ketterer and Eric Woolgar.

**ADRIAN TUDORASCU**, West Virginia University
[Sunday December 6 / dimanche 6 décembre, 15:00]
*ON THE CONVEXITY CONDITION FOR THE SEMI-GEOSTROPHIC SYSTEM*

We argue that conservative distributional solutions to the Semi-Geostrophic system in a rigid domain are in some well-defined sense critical points of a time-shifted energy functional involving measure-preserving rearrangements of the absolute density and momentum, which arise as one-parameter flow maps of continuously differentiable, compactly supported divergence free vector fields. We also show that the convexity requirement on the modified pressure potentials arises naturally if these critical points are local minimizers of said energy functional for any admissible vector field.

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**SHUANGJIAN ZHANG**, CNRS, ENS Paris
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Wasserstein Control of Mirror Langevin Monte Carlo*

Discretized Langevin diffusions are efficient Monte Carlo methods for sampling from high dimensional target densities that are log-Lipschitz-smooth and (strongly) log-concave. In particular, the Euclidean Langevin Monte Carlo sampling algorithm has received much attention lately, leading to a detailed understanding of its non-asymptotic convergence properties and of the role that smoothness and log-concavity play in the convergence rate. Distributions that do not possess these regularity properties can be addressed by considering a Riemannian Langevin diffusion with a metric capturing the local geometry of the log-density. However, the Monte Carlo algorithms derived from discretizations of such Riemannian Langevin diffusions are notoriously difficult to analyze.

In this talk, we consider Langevin diffusions on a Hessian-type manifold and study a discretization that is closely related to the mirror-descent scheme. We establish for the first time a non-asymptotic upper-bound on the sampling error of the resulting Hessian Riemannian Langevin Monte Carlo algorithm. This bound is measured according to a Wasserstein distance induced by a Riemannian metric ground cost capturing the squared Hessian structure and closely related to a self-concordance-like condition. The upper-bound implies, for instance, that the iterates contract toward a Wasserstein ball around the target density whose radius is made explicit. Our theory recovers existing Euclidean results and can cope with a wide variety of Hessian metrics related to highly non-flat geometries. This talk represents joint work with Gabriel Peyré, Jalal Fadili, and Marcelo Pereyra.

# Optimization and Data Science / Optimisation et Science des Données

Org: **Michael Friedlander** (University of British Columbia), **Abraham P Punnen** (Simon Fraser University) and/et **Mohamed Tawhid** (Thompson Rivers University)

## Schedule/Horaire

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Montaz Ali (University of the Witwatersrand), *Convex Formulation for Planted Quasi-Clique Recovery* (p. 173) |
| 14:30 - 15:00 | Courtney Paquette (McGill University), *Halting Time is Predictable for Large Models: A Universality Property and Average-case Analysis* (p. 176) |
| 15:00 - 15:30 | Zhaosong Lu (University of Minnesota), *First-Order Augmented Lagrangian Methods for Convex Conic Programming* (p. 176) |
| 15:30 - 16:00 | Yankai Cao (UBC), *A Global Optimization Algorithm for Clustering Problems* (p. 174) |
| 16:00 - 16:30 | Ibrahim Numanagić (University of Victoria), *Optimization in Pharmacogenomics* (p. 176) |
| 16:30 - 17:00 | Jabed Tomal and Jan Ciborowski (Thompson River University, University of Calgary), *Detection of environmental thresholds by assessing discontinuities in slopes and variances via a Bayesian regression model* (p. 177) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Paula Fermín Cueto (University of Edinburgh), *Machine learning and statistical methods for characterising and predicting capacity degradation of Li-ion cells* (p. 174) |
| 14:30 - 15:00 | Gonçalo dos Reis (University of Edinburgh), *State of Health for the capacity and internal resistance of Li-ion cells: A machine learning approach with knees and elbows* (p. 175) |
| 15:00 - 15:30 | Lukasz Golab (University of Waterloo), *Explanation Tables* (p. 175) |
| 15:30 - 16:00 | Mark Schmidt (UBC), *Faster Algorithms for Deep Learning ?* (p. 177) |
| 16:00 - 16:30 | Tamon Stephen (SFU), *Minimal Cuts Set and Computing with Monotone Boolean Functions* (p. 177) |
| 16:30 - 17:00 | Xuekui Zhang (University of Victoria), *The Optimal Design of Clinical Trials with Potential Biomarker Effects, A Novel Computational Approach* (p. 178) |

### Monday December 7 — lundi 7 décembre

| | |
|---|---|
| 14:00 - 14:30 | Abdelmonem Ibrhaim (Alzahr University), *Binary whale optimization algorithm for feature selection* (p. 176) |
| 14:30 - 15:00 | Aleksandr Aravkin (University of Washington), *A Robust Risk Score for Evaluating Evidence in Global Health* (p. 174) |
| 15:00 - 15:30 | Warren Hare (UBC), *Imaginary Derivative Free Optimization* (p. 175) |
| 15:30 - 16:00 | Xiaoping Shi (Thompson River University), *Graph-based change-point test* (p. 177) |
| 16:00 - 16:30 | Thomas Humphries (University of Washington Bothell), *Unrolled iterative algorithm for CT image reconstruction with learned penalty term* (p. 175) |
| 16:30 - 17:00 | Monica Gabriela Cojocaru (University of Guelph) (p. 174) |

## Abstracts/Résumés

**MONTAZ ALI**, Witwatersrand University
[Saturday December 5 / samedi 5 décembre, 14:00]
*Convex Formulation for Planted Quasi-Clique Recovery*

In this talk, we consider the planted quasi-clique or $\gamma$-clique problem. This problem is an extension of the well known planted clique problem which is NP-hard. The maximum quasi-clique problem is applicable in community detection, information retrieval and biology. We propose a convex formulation using nuclear norm minimization for planted quasi-clique recovery. We carry out numerical experiments using our convex formulation and the existing mixed integer programming formulations. Results show that the convex formulation performs better than the mixed integer formulations when $\gamma$ is greater than a particular threshold.

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**ALEKSANDR ARAVKIN**, University of Washington (Institute for Health Metrics and Evaluation)
[Monday December 7 / lundi 7 décembre, 14:30]
*A Robust Risk Score for Evaluating Evidence in Global Health*

How strong is the relationship between (red meat, alcohol) and heart disease ? (Sugar sweetened beverages, BMI) and diabetes ? (Smoking, air pollution) and lung cancer ? Each of these risk-outcome pairs has been the subject of numerous large studies. With results in hand, can we rate the evidence, and compare these risks to guide policy, and initiate further studies ?

We present a new methodology to answer these questions. The methodology comprises modeling between-study disagreement, capturing nonlinear dose-response relationships, detecting outliers, and accounting for nonlinear observation mechanisms inherent in how studies report results. It is now used to analyze more than 470 risk-outcome pairs in the Global Burden of Disease study, conducted by IHME and collaborators. We present the main model, highlight the role of optimization, and include recent results for select risk-outcome pairs of interest.

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**YANKAI CAO**, University of British Columbia
[Saturday December 5 / samedi 5 décembre, 15:30]
*A Global Optimization Algorithm for Clustering Problems*

We present a reduced-space spatial branch and bound strategy for two-stage stochastic nonlinear programs. At each node, a lower bound is constructed by relaxing the non-anticipativity constraints, and an upper bound is constructed by fixing the first-stage variables. Both lower and upper bounds can be computed by solving individual scenario subproblems. Another key property is that we only need to perform branching on the first-stage variables to guarantee convergence.

We also extend this algorithm to address clustering problems (a class of unsupervised learning). Preliminary numerical results have demonstrated that our algorithm is able to solve problems with hundreds of samples to global optimality within a reasonable amount of time, while state-of-the-art global solvers can only deal with tens of samples. Moreover, global optimization can significantly improve performance on several datasets compared with local optimal algorithms, such as k-means.

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**MONICA GABRIELA COJOCARU**, University of Guelph
[Monday December 7 / lundi 7 décembre, 16:30]

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**PAULA FERMÍN CUETO**, University of Edinburgh
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Machine learning and statistical methods for characterising and predicting capacity degradation of Li-ion cells*

In automotive applications, Li-ion cells are typically considered to have reached their end-of-life when they are down to 80% of their initial capacity. However, the degradation of these cells typically displays a "knee" pattern: the capacity degrades at a slow rate up to a so-called "knee-point", after which it degrades very rapidly until its end-of-life. This knee-point therefore gives a more advanced warning of the cell's degradation than the end-of-life. Nevertheless, the industry does not have a standard definition or identification method for this crucial metric.

In this talk, we present robust statistical methods to identify two different knee-points in capacity degradation data of Li-ion cells. Following this identification step, we show how machine learning algorithms can be employed to successfully predict the occurrence of these knee-points from the first few discharge cycles of a cell's life. We rely on feature engineering to overcome the challenge of working with a very small, yet high-dimensional data set and we quantify the uncertainty of the predictions to build trust in our models.

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**GONÇALO DOS REIS**, University of Edinburgh
[Sunday December 6 / dimanche 6 décembre, 14:30]
*State of Health for the capacity and internal resistance of Li-ion cells: A machine learning approach with knees and elbows*

Degradation of lithium-ion cells with respect to increases of internal resistance (IR) has negative implications for rapid charging times and thermal management of cell in electric vehicles and energy storage applications. Despite this, IR and associated IR State of Health have received much less attention than the State of Health with respect to capacity degradation in Li-ion research. We address this by building on recent developments on "knee" identification for capacity degradation curves. We propose the concepts of "elbow-point" and "elbow-onset" for IR degradation curves, and create an identification algorithm for these variables.

We use machine learning Neural Network techniques to build independent capacity and IR predictor models achieving a MAPE of 0.4% and 1.6%, respectively. We then use the IR model to synthesize internal resistance data to complete the dataset from Attia et al 2020 for which no IR data was logged.

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**LUKASZ GOLAB**, University of Waterloo
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Explanation Tables*

I will present a solution to the following data summarization problem: given a dataset with multiple categorical features and a binary outcome, construct a summary that offers an interpretable explanation of the factors affecting the outcome in terms of the feature value combinations. We refer to such a summary as an explanation table, which is a disjunction of overlapping patterns over the features, where each pattern specifies a conjunction of attribute=value conditions. We give an efficient and effective greedy algorithm to construct explanation tables that uses sampling to prune the space of candidate patterns. This is joint work with Parag Agrawal, Kareem El Gebaly, Guoyao Feng, Flip Korn, Divesh Srivastava and Michael Vollmer.

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**WARREN HARE**, University of British Columbia
[Monday December 7 / lundi 7 décembre, 15:00]
*Imaginary Derivative Free Optimization*

Consider the problem of minimizing an objective function that is provided by a blackbox. Suppose that, while the optimization problem seeks a real-valued solution, the blackbox is capable of accepting complex-valued input and returning complex-valued output. We explore using complex-variables in a model-based derivative-free optimization method. We begin by discussion how to construct such model and then present the results of some numerical experiments. Results suggest that the quality of a model-based DFO algorithm is (i) highly impacted by the number of function evaluations required to create the models and (ii) also impacted by the accuracy of the created models, but to a lesser degree.

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**THOMAS HUMPHRIES**, University of Washington Bothell
[Monday December 7 / lundi 7 décembre, 16:00]
*Unrolled iterative algorithm for CT image reconstruction with learned penalty term*

In the last three to four years there has been an explosion of interest in using deep learning techniques to address challenging problems in computed tomography (CT) image reconstruction, such as low-dose, sparse-view, and limited angle imaging. A

wide variety of approaches have been proposed, including using deep neural networks (DNN) as pre- or post-processing steps, using neural networks to encode prior information within existing iterative reconstruction algorithms, or learning to solve the inverse problem altogether.

We present a CT reconstruction approach which unrolls a standard iterative algorithm and trains it end-to-end as a DNN. The DNN consists of fixed layers, corresponding to the basic iterative algorithm, as well as trainable layers, which have the effect of perturbing the solution between iterations. The trainable layers can be viewed as replacing the negative gradient of an unknown penalty function or regularizer, which can vary with the iteration number. In numerical experiments, we test the approach on sparse-view and limited-angle CT problems, and study the effect of network architecture on the effectiveness of the algorithm. The proposed method provides significant improvement over the basic iterative algorithm, as well as total variation minimization approach. Joint work with Yiran Jia, Noah McMichael, Pedro Mokarzel, and Dong Si (UW Bothell).

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**ABDELMONEM IBRHAIM**, Mathematics Department, Faculty of Science, Al-Azhar University, Egypt
[Monday December 7 / lundi 7 décembre, 14:00]
*Binary whale optimization algorithm for feature selection*

The principle of any approach for solving feature selection problem is to find a subset of the original features. Since finding a minimal subset of the features is an NP-hard problem, it is necessary to develop and propose practical and efficient heuristic algorithms. The whale optimization algorithm is a recently developed nature-inspired meta-heuristic optimization algorithm that imitates the hunting behavior of humpback whales to solve continuous optimization problems. In this paper, we propose a novel binary whale optimization algorithm (BWOA) to solve the feature selection problem. BWOA is especially desirable and appealing for feature selection problem whenever there is no heuristic information that can lead the search to the optimal minimal subset. Nonetheless, whales can find the best features as they hunt the prey. Rough set theory (RST) is one of the effective algorithms for feature selection. We use RST with BWOA as the first experiment, and in the second experiment, we use a wrapper approach with three different classifiers for feature selection. Also, we verify the performance and the effectiveness of the proposed algorithm by performing our experiments using 32 datasets from the UCI machine learning repository and comparing the proposed algorithm with some powerful existing algorithms in the literature. The results show that the proposed algorithm can provide an efficient tool to find a minimal subset of the original features.

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**ZHAOSONG LU**, University of Minnesota
[Saturday December 5 / samedi 5 décembre, 15:00]
*First-Order Augmented Lagrangian Methods for Convex Conic Programming*

In this talk, we propose some first-order augmented Lagrangian (AL) methods for solving a class of convex conic programming with adaptive update on penalty parameters and inexactness associated with the AL subproblems. We establish their first-order oracle complexity for finding an approximate Karush–Kuhn–Tucker (KKT) point. To our best knowledge, our complexity is the lowest one among all existing first-order AL methods for finding an approximate KKT point.

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**IBRAHIM NUMANAGIĆ**, University of Victoria
[Saturday December 5 / samedi 5 décembre, 16:00]
*Optimization in Pharmacogenomics*

High-throughput sequencing provides the means to determine the allelic decomposition— the exact sequence content of all gene copies present in the sample— for any gene of interest. When applied to pharmaceutical genes, such decomposition can be used to inform the drug treatment and dosage decisions. However, many clinically and functionally important genes are highly polymorphic and have undergone structural alterations, and as such present a significant challenge for the existing genotyping methods. Here we present a combinatorial optimization framework based on integer linear programming that is able to efficiently solve this problem for various pharmacogenes, including those with structural alterations. We also show how to adapt these linear programs for the emerging long-range barcoded sequencing datasets.

**COURTNEY PAQUETTE**, McGill University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Halting Time is Predictable for Large Models: A Universality Property and Average-case Analysis*

Average-case analysis computes the complexity of an algorithm averaged over all possible inputs. Compared to worst-case analysis, it is more representative of the typical behavior of an algorithm, but remains largely unexplored in optimization. One difficulty is that the analysis can depend on the probability distribution of the inputs to the model. However, we show that almost all instances of high-dimensional data are indistinguishable to first-order algorithms. Particularly for a class of large-scale problems, which includes random least squares and one-hidden neural networks with random weights, the halting time is independent of the probability distribution. With this barrier for average-case analysis removed, we provide the first explicit average-case convergence rates showing a tighter complexity not captured by traditional worst-case analysis. Finally, numerical simulations suggest this universality property holds in greater generality. Joint work with Elliot Paquette, Fabian Pedregosa, and Bart van Merriënboer

**MARK SCHMIDT**, University of British Columbia
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Faster Algorithms for Deep Learning ?*

The last 10 years have seen a revolution in stochastic gradient methods, with variance-reduced methods like SAG/SVRG provably achieving faster convergence rates than all previous methods. These methods give dramatic speedups in a variety of applications, but have had virtually no impact to the practice of training deep models. We hypothesize that this is due to the over-parameterized nature of modern deep learning models, where the models are so powerful that they could fit every training example with zero error (at least theoretically). Such over-parameterization nullifies the benefits of variance-reduced methods, because in some sense it leads to "easier" optimization problems. In this work, we present algorithms specifically designed for over-parameterized models. This leads to methods that provably achieve Nesterov acceleration, methods that automatically tune the step-size as they learn, and methods that achieve superlinear convergence with second-order information.

**XIAOPING SHI**, Thompson Rivers University
[Monday December 7 / lundi 7 décembre, 15:30]
*Graph-based change-point test*

Modeling high-dimensional time series is necessary in many fields such as neuroscience, signal processing, network evolution, text analysis, and image analysis. Such a time series may contain unknown multiple change-points. For example, the time of cell divisions can be accessed using an automatic embryo monitoring system by a time-lapse observation. When a cell divides at some time point, the distribution of pixel values in the corresponding frame will change, and hence the detection of cell divisions can be formulated as a multiple change-point problem. In this talk, we introduce a powerful change-point test in terms of the shortest Hamiltonian path (SHP).

**TAMON STEPHEN**, Simon Fraser University
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Minimal Cuts Set and Computing with Monotone Boolean Functions*

We consider methods of generating Minimal Cut Sets in computational biology. This leads us to monotone Boolean functions, which can be used model phenomena in a variety of large data applications. Computing with monotone Boolean functions is an interesting and worthwhile mathematical challenge. We briefly introduce some of the techniques and issues involved.

**JABED TOMAL AND JAN CIBOROWSKI**, Thompson Rivers University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Detection of environmental thresholds by assessing discontinuities in slopes and variances via a Bayesian regression model*

Co-author: Jan J.H. Ciborowski, Professor, Biological Sciences, University of Calgary

Abstract: An ecological threshold occurs at a point along an environmental stress gradient at which there is a discontinuous change in the conditional distribution of a biological response. Traditionally, ecological thresholds are estimated from the discontinuities in the central tendency (e.g., slope) using a piecewise linear regression model (PLRM). However, thresholds can also be manifested as changes in the range of natural variation (e.g., conditional variance) for a given level of the environmental stress. In this paper, we defined a Bayesian PLRM by incorporating experts' knowledge about the relationships between the biological response relative to environmental stress represented via prior distributions. The posterior distributions of the thresholds are obtained by combining the information in the data with experts' prior knowledge, and optimized via Gibbs sampling and the Metropolis algorithm. We applied our method to two datasets relating an index of the health of marsh-nesting bird communities to habitat alteration (areal extent of land development adjacent to wetlands) within the Detroit River Area of Concern. Our preliminary analysis identified two potential thresholds - one manifested via the change in slope and the other observed from increased variance across the environmental stress gradient.

**XUEKUI ZHANG**, University of Victoria
[Sunday December 6 / dimanche 6 décembre, 16:30]
*The Optimal Design of Clinical Trials with Potential Biomarker Effects, A Novel Computational Approach*

As a future trend of healthcare, personalized medicine tailors medical treatments to individual patients. It requires to identify a subset of patients with the best response to treatment. The subset can be defined by a biomarker (e.g. expression of a gene) and its cutoff value. Topics on subset identification have received massive attention. There are over 2 million hits by keyword searches on Google Scholar. However, designing clinical trials that utilize the discovered uncertain subsets/biomarkers is not trivial and rarely discussed in the literature. This leads to a gap between research results and real-world drug development.

To fill in this gap, we formulate the problem of clinical trial design into an optimization problem involving high-dimensional integration, and propose a novel computational solution based on Monte-Carlo and smoothing methods. Our method utilizes the modern techniques of General-Purpose computing on Graphics Processing Units for large-scale parallel computing. Compared to a published method in three-dimensional problems, our approach is more accurate and 133 times faster. This advantage increases when dimensionality increases. Our method is scalable to higher-dimensional problems since the precision bound of our estimated study power is a finite number not affected by dimensionality.

# Probability in Number Theory / Applications des Probabilités en Théorie des Nombres

Org: **Louis-Pierre Arguin** and/et **Andrew Granville** (Université de Montréal)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:30 | Dimitris Koukoulopoulos (Montréal), *How concentrated can the divisors of a typical integer be ?* (p. 181) |
| 13:30 - 14:00 | Emma Bailey (CUNY), *Random matrices and $L$-functions: moments of moments, branching, and log-correlation* (p. 179) |
| 14:00 - 14:30 | Suresh Eswarathasan (Dalhousie), *Counting tangencies of nodal domains* (p. 181) |
| 14:30 - 15:00 | Sacha Mangerel (CRM), *Arrangements of Consecutive Values of Real Multiplicative Functions* (p. 182) |
| 15:30 - 16:00 | Francesco Cellarosi (Queens), *Rational Horocycle lifts and the tails of Quadratic Weyl sums* (p. 180) |
| 16:00 - 16:30 | Aled Walker (CRM & Cambridge), *Triple correlations of dilates squares modulo 1* (p. 183) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Adam Harper (Warwick), *Large fluctuations of random multiplicative functions* (p. 181) |
| 14:30 - 15:00 | Claire Burrin (CRM), *Higher moment formulas for discrete lattice orbits in the plane* (p. 180) |
| 15:00 - 15:30 | Youness Lamzouri (Lorraine), *Zeros of linear combinations of $L$-functions near the critical line* (p. 182) |
| 15:30 - 16:00 | Vesselin Dimitrov (Toronto) (p. 181) |
| 16:00 - 16:30 | Asif Zaman (Toronto), *Low moments of random power series* (p. 183) |
| 16:30 - 17:00 | Brad Rodgers (Queens), *The distribution of sums of two squares in short intervals* (p. 183) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:30 - 15:00 | Michel Pain (NYU), *Extrema of branching random walks and log-correlated fields* (p. 183) |
| 15:00 - 15:30 | Paul Bourgade (NYU), *The Fyodorov-Hiary-Keating Conjecture* (p. 180) |
| 15:30 - 16:00 | Maksym Radziwill (Caltech) (p. 183) |
| 16:00 - 16:30 | Yu-Ru Liu (Waterloo), *Number of Prime Factors with a Given Multiplicity* (p. 182) |
| 16:30 - 17:00 | Karl Dilcher (Dalhousie), *General Convolution Identities for Bernoulli and Euler Polynomials* (p. 180) |

### Monday December 7 — lundi 7 décembre

| | |
|---|---|
| 14:00 - 14:30 | Winston Heap (Max Planck), *Random multiplicative functions and a model for the Riemann zeta function* (p. 181) |
| 14:30 - 15:00 | Frédéric Ouimet (Caltech) (p. 183) |
| 15:00 - 15:30 | Cameron Stewart (Waterloo), *Counting solvable S-unit equations* (p. 183) |
| 15:30 - 16:00 | Richard Gottesman (Queens) (p. 181) |
| 16:00 - 16:30 | Jean-Marie de Koninck (Laval), *Consecutive integers divisible by a power of their largest prime factor* (p. 180) |
| 16:30 - 17:00 | Ram Murty (Queens), *An "all-purpose" Erdos-Kac theorem* (p. 182) |

## Abstracts/Résumés

**EMMA BAILEY**, University of Bristol
[Friday December 4 / vendredi 4 décembre, 13:30]
*Random matrices and $L$-functions: moments of moments, branching, and log-correlation*

Recently there has been a great deal of interest in understanding the moments of partition functions of logarithmically correlated processes. Particular examples of note are the logarithm of the zeta function over short intervals, the logarithm of characteristic polynomials of unitary matrices, and random walks on binary trees. In this talk I will present results for the moments of partition functions of such processes. This analysis also leads to conjectures for other families of primitive $L$-functions. This is joint work with Jon Keating and Theo Assiotis.

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**PAUL BOURGADE**, Courant Institute, New York University
[Sunday December 6 / dimanche 6 décembre, 15:00]
*The Fyodorov-Hiary-Keating Conjecture*

By analogy with conjectures for random matrices, Fyodorov-Hiary-Keating proposed precise asymptotics for the maximum of the Riemann zeta function in a typical short interval on the critical line. I will explain a recent proof of the upper bound part of their prediction. This is joint work with Louis-Pierre Arguin and Maksym Radziwill.

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**CLAIRE BURRIN**, ETH Zurich
[Saturday December 5 / samedi 5 décembre, 14:30]
*Higher moment formulas for discrete lattice orbits in the plane*

We consider discrete sets in the plane arising from the linear action of a lattice in $\mathrm{SL}_2(\mathbb{R})$. The set of primitive integers vectors (i.e., where the coordinates are coprime) is one such example. In a very different direction, the set of holonomy vectors of saddle connections on a square-tiled surface provides another example. How are such discrete planar sets distributed in the plane ? I will report on on-going work with Samantha Fairchild.

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**FRANCESCO CELLAROSI**, Queen's University
[Friday December 4 / vendredi 4 décembre, 15:30]
*Rational Horocycle lifts and the tails of Quadratic Weyl sums*

Equidistribution of horocycles on hyperbolic surfaces has been used to dynamically answer several probabilistic questions about number-theoretical objects. In this talk we focus on horocycle lifts, i.e. curves on higher-dimensional manifolds whose projection to the hyperbolic surface is a classical horocycle, and their behaviour under the action of the geodesic flow. It is known that when such horocycle lifts are 'generic', then their push forward via the geodesic flow becomes equidistributed in the ambient manifold. We consider certain 'non-generic' (i.e. rational) horocycle lifts, in which case the equidistribution takes place on a sub-manifold. We then use this fact to study the tail distribution of quadratic Weyl sums when one of their arguments is random and the other is rational. In this case we obtain random variables with heavy tails, all of which only possess moments of order less than 4. Depending on the rational argument, we establish the exact tail decay, which can be described with the help of the Dedekind $\psi$-function. Joint work with Tariq Osman.

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**JEAN-MARIE DE KONINCK**, Université Laval
[Monday December 7 / lundi 7 décembre, 16:00]
*Consecutive integers divisible by a power of their largest prime factor*

Given integers $k \geq 2$ and $\ell \geq 2$, the Chinese Remainder Theorem guarantees the existence of $k$ consecutive integers divisible respectively by preassigned prime powers $p_j^\ell$, $j = 1, \ldots, k$. However, there is no guarantee that the respective largest prime factors of the resulting $k$ consecutive integers will be precisely the chosen $p_j$'s. How can we make it so ? Using elementary, analytic and probabilistic approaches, we shed some light and raise many questions regarding this difficult problem. This is joint work with Matthieu Moineau.

**KARL DILCHER**, Dalhousie University
[Sunday December 6 / dimanche 6 décembre, 16:30]
*General Convolution Identities for Bernoulli and Euler Polynomials*

Using identities for difference operators and tools from probability theory, very general convolution identities of order $k \geq 2$ can be obtained for Bernoulli and Euler polynomials. This is achieved by applying an elementary result on uniformly distributed random variables. The resulting identities depend on $k$ positive real parameters and I show, in particular, that the well-known identities of Miki and Matiyasevich for Bernoulli numbers are special cases of the same general formula.If time allows, I will present an explicit formula for the polynomial part of a restricted partition function, using similar methods. (Joint work with Christophe Vignat).

**VESSELIN DIMITROV**, Toronto
[Saturday December 5 / samedi 5 décembre, 15:30]

**SURESH ESWARATHASAN**, Dalhousie University
[Friday December 4 / vendredi 4 décembre, 14:00]
*Counting tangencies of nodal domains*

Fix a smooth vector field $V$, with finitely many zeroes, on a compact surface $(\mathcal{M}, g)$ without boundary. We give results on the distribution of the number of tangencies to $V$ of the nodal components of random band-limited functions. In the high-energy limit, the distributions obey a universal deterministic law, independent of the surface $\mathcal{M}$ and the vector field $V$. Applications towards arithmetic random waves on the flat torus will be discussed. This is joint work with I. Wigman (King's College London).

**RICHARD GOTTESMAN**, Queens
[Monday December 7 / lundi 7 décembre, 15:30]

**ADAM HARPER**, University of Warwick
[Saturday December 5 / samedi 5 décembre, 14:00]
*Large fluctuations of random multiplicative functions*

Random multiplicative functions $f(n)$ are a well studied random model for deterministic multiplicative functions like Dirichlet characters or the Mobius function. Arguably the first question ever studied about them, by Wintner in 1944, was to obtain almost sure bounds for the largest fluctuations of their partial sums $\sum_{n \leq x} f(n)$, seeking to emulate the classical Law of the Iterated Logarithm for independent random variables. It remains an open question to sharply determine the size of these fluctuations, and in this talk I will describe a new result in that direction.

**WINSTON HEAP**, Max Planck Institute for Mathematics
[Monday December 7 / lundi 7 décembre, 14:00]
*Random multiplicative functions and a model for the Riemann zeta function*

We look at a weighted sum of random multiplicative functions and view this as a model for the Riemann zeta function. We investigate various aspects including its high moments, distribution and maxima.

**DIMITRIS KOUKOULOPOULOS**, Université de Montréal
[Friday December 4 / vendredi 4 décembre, 13:00]
*How concentrated can the divisors of a typical integer be ?*

The Delta function measures the concentration of the sequence of divisors of an integer. Specifically, given an integer $n$, we write $\Delta(n)$ for the maximum over $y$ of the number of divisors of $n$ lying in the dyadic interval $[y, 2y]$. It was introduced by Hooley in 1979 because of its connections to various problems in Diophantine equations and approximation. In 1984, Maier and Tenenbaum proved that $\Delta(n) > 1$ for almost all integers $n$, thus settling a 1948 conjecture due to Erdős. In subsequent work, they proved that $(\log\log n)^{c+o(1)} \leq \Delta(n) \leq (\log\log n)^{\log 2+o(1)}$, where $c = (\log 2)/\log(\frac{1-1/\log 27}{1-1/\log 3}) \approx 0.33827$ for almost all integers $n$. In addition, they conjectured that $\Delta(n) = (\log\log n)^{c+o(1)}$ for almost all $n$. In this talk, I will present joint work with Kevin Ford and Ben Green that disproves the Maier-Tenenbaum conjecture by replacing the constant $c$ in the lower bound by another constant $c' = 0.35332277\ldots$ that we believe is optimal. We also prove analogous results about permutations and polynomials over finite fields by reducing all three cases to an archetypal probabilistic model.

**YOUNESS LAMZOURI**, Université de Lorraine
[Saturday December 5 / samedi 5 décembre, 15:00]
*Zeros of linear combinations of $L$-functions near the critical line*

In this talk I will present a recent joint work with Yoonbok Lee, where we investigate the number of zeros of linear combinations of $L$-functions in the vicinity of the critical line. More precisely, we let $L_1, \ldots, L_J$ be distinct primitive $L$-functions belonging to a large class (which conjecturally contains all $L$-functions arising from automorphic representations on $\mathrm{GL}(n)$) and $b_1, \ldots, b_J$ be real numbers. Our main result is an asymptotic formula for the number of zeros of $F(s) = \sum_{j\leq J} b_j L_j(s)$ in the region $\mathrm{Re}(s) \geq 1/2 + 1/G(T)$ and $\mathrm{Im}(s) \in [T, 2T]$, uniformly in the range $\log\log T \leq G(T) \leq (\log T)^{\nu}$, where $\nu \asymp 1/J$. This establishes a generalization of a conjecture of Hejhal in this range.

**YU-RU LIU**, University of Waterloo
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Number of Prime Factors with a Given Multiplicity*

In this talk, we study a variation of the $\omega$ function. More precisely, given the positive integer $k$, let $\omega_k(n)$ denote the number of distinct prime factors of $n$ which occur with multiplicity $k$. We will prove that $\omega_1(n)$ has the normal order $\log\log n$, while $\omega_k(n)$ does not have normal order. This is joint work with Ertan Elma.

**SACHA MANGEREL**, Centre de Recherche Mathématiques
[Friday December 4 / vendredi 4 décembre, 14:30]
*Arrangements of Consecutive Values of Real Multiplicative Functions*

We will discuss the following problem: given a multiplicative function $f : \mathbb{N} \to \mathbb{R}$ and a $k$-tuple of "admissible", distinct non-negative integer shifts $a_1, \ldots, a_k$, what is the probability that a given $n \in \mathbb{N}$ satisfies $f(n+a_1) \leq \cdots \leq f(n+a_k)$ ? Randomness heuristics suggest that such a pattern occur with probability $1/k!$ for a "generic" function $f$. Under certain assumptions on $f$ we will give both conditional and unconditional results in this direction for a large collection of examples, in particular the Ramanujan $\tau$ function as well as sequences of Fourier coefficients of many non-CM, arithmetically normalized Hecke eigencusp forms with trivial nebentypus.

**RAM MURTY**, Queen's University
[Monday December 7 / lundi 7 décembre, 16:30]
*An "all-purpose" Erdos-Kac theorem*

We will discuss a general axiomatic formulation that allows for the derivation of Erdos-Kac type theorems in a wide range of contexts. In particular, we will apply it to derive Erdos-Kac type theorems for the number of prime factors of sums of Fourier coefficients of Hecke eigenforms. This is joint work with Kumar Murty and Sudhir Pujahari.

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**FRÉDÉRIC OUIMET**, Caltech
[Monday December 7 / lundi 7 décembre, 14:30]

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**MICHEL PAIN**, Courant Institute (NYU)
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Extrema of branching random walks and log-correlated fields*

In this talk, I will discuss in an introductory manner the study of extrema of branching random walks and its application to the wider class of log-correlated fields, which includes the logarithm of the Riemann zeta function on short intervals of the critical line and the logarithm of the characteristic polynomial of random matrices. Moreover, I will present some recent results that fit into this general picture.

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**MAKSYM RADZIWILL**, Caltech
[Sunday December 6 / dimanche 6 décembre, 15:30]

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**BRAD RODGERS**, Queen's University
[Saturday December 5 / samedi 5 décembre, 16:30]
*The distribution of sums of two squares in short intervals*

In this talk I will discuss the distribution in short intervals of integers representable as sums of two squares. For sufficiently short intervals this distribution is (conjecturally) governed by a Poisson distribution, but I will explain why one should expect in intervals which are just a little longer a connection to what are known as z-measures. These were first investigated in the context of harmonic analysis on the infinite symmetric group and I hope to also give a short introduction to them. Results can be proved in a function field setting. This is joint work with Ofir Gorodetsky.

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**CAMERON STEWART**, University of Waterloo
[Monday December 7 / lundi 7 décembre, 15:00]
*Counting solvable S-unit equations*

We shall discuss joint work with I. Shparlinski concerning upper bounds on the number of finite sets S of primes below a given bound for which various 2 variable S-unit equations have a solution.

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**ALED WALKER**, Centre de Recherches Mathématiques
[Friday December 4 / vendredi 4 décembre, 16:00]
*Triple correlations of dilates squares modulo 1*

Twenty years ago, Rudnick-Sarnak-Zaharescu made a deep conjecture about the gap distribution of $\alpha n^2$ modulo $1$. They posited that this distribution should be poissonian, provided some generic conditions on the diophantine approximation of the dilate $\alpha$ were satisfied. In this talk I will give a summary of the previous work around this conjecture, and describe a recent result which extends the threshold for the triple correlations beyond the trivial range. This is joint work with Niclas Technau.

**ASIF ZAMAN**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 16:00]
*Low moments of random power series*

Harper recently proved that the low moments of partial sums of random multiplicative functions exhibit better-than-squareroot cancellation, as conjectured by Helson. This breakthrough result was surprising and its proof is a serious technical feat. Together with Soundararajan, we establish a closely related result for low moments of certain random power series. Our proof possesses the same key principles and phenomena as Harper's but our idealized setting affords several simplifications to the arguments. I will discuss the setup and share some of the key simplifications.

# Recent Advances in Harmonic and Complex Analysis / Développements récents en analyses harmonique et complexe

**Org: Ilia Binder** (Toronto), **Damir Kinzebulatov** (Université Laval) and/et **Javad Mashreghi** (Université Laval)

## Schedule/Horaire

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Paul Gauthier (Université de Montréal), *Asymptotic first boundary value problem for holomorphic functions of several complex variables* (p. 186) |
| 14:30 - 15:00 | Galia Dafni (Concordia University), *Extension domains for bmo* (p. 186) |
| 15:00 - 15:30 | Ryan Gibara (Université Laval), *Boundedness and continuity of rearrangements on spaces defined by mean oscillation* (p. 187) |
| 15:30 - 16:00 | Adi Glucksam (University of Toronto), *Computability of harmonic measures* (p. 187) |
| 16:00 - 16:30 | Malik Younsi (University of Hawaii), *Holomorphic motions, capacity and conformal welding* (p. 190) |
| 16:30 - 17:00 | Alexander Brudnyi (University of Calgary), *On nonlinear Runge approximation problems* (p. 186) |
| 17:00 - 17:30 | Ludovick Bouthat (Université Laval), *The norm of an infinite L-matrix* (p. 185) |
| 17:30 - 18:00 | Wenbo Li (University of Toronto), *Conformal dimension and minimality of stochastic objects* (p. 187) |
| 18:00 - 18:30 | Frédéric Morneau-Guérin (Université TÉLUQ), *La $*$-stabilité de l'espace pondéré des suites de carré sommable sur la somme directe de groupes abéliens finis* (p. 187) |

### Monday December 7 — lundi 7 décembre

| | |
|---|---|
| 14:00 - 14:30 | Thomas Ransford (Université Laval), *A Gleason-Kahane-Żelazko theorem for reproducing kernel Hilbert spaces.* (p. 188) |
| 14:30 - 15:00 | Almaz Butaev (University of Calgary), *On geometric preduals of jet spaces on subsets of $\mathbb{R}^n$* (p. 186) |
| 15:00 - 15:30 | Pierre-Olivier Parisé (Université Laval), *Cesàro summability of Taylor series in weighted Dirichlet spaces* (p. 188) |
| 15:30 - 16:00 | Larissa Richards (University of Toronto), *On the rate of convergence of discrete interfaces to SLE.* (p. 188) |
| 16:00 - 16:30 | Ignacio Uriarte-Tuero (Michigan State University), *Two weight norm inequalities for singular integrals in $\mathbb{R}^n$* (p. 189) |
| 16:30 - 17:00 | William Verreault (Université Laval), *Nonlinear Oscillatory Expansions of holomorphic functions* (p. 189) |
| 17:00 - 17:30 | James Wilson (University of Vermont), *Discretization of adapted functions* (p. 189) |
| 17:30 - 18:00 | Scott Rodney (Cape Breton University), *Bounded Weak Solutions of Second Order Linear PDEs with Data in Orlicz Spaces* (p. 188) |
| 18:00 - 18:30 | Jie Xiao (Memorial University) (p. 190) |
| 18:30 - 19:00 | Javad Mashreghi (Université Laval), *Outer Functions and the Schur Class* (p. 187) |

## Abstracts/Résumés

**LUDOVICK BOUTHAT**, Université Laval

[Sunday December 6 / dimanche 6 décembre, 17:00]

*The norm of an infinite L-matrix*

We know that any linear application from $\mathbb{C}^n$ to $\mathbb{C}^n$ can be described with an $n \times n$ square matrix. The space $\ell^2$ of square-summable sequences indexed by the natural numbers is a generalization of $\mathbb{C}^n$ to infinite dimension. We find that the operators,

in the case of $\ell^2$, can be described by infinite matrices. However, not all infinite matrices gives us an operator on $\ell^2$. It is natural to wonder which infinite matrices are a representation of an operator on $\ell^2$, and what is their norm. Because of their applications in the problem of the caracterisation of the multipliers in the weighted Dirichlet spaces, we restrict ourselves to the case of infinite $L$-matrices. An infinite positive $L$-matrix is an infinite matrix which is defined by a sequence $(a_n)_{n\geq 0}$ of positive real numbers and which is of the form

$$A = \begin{pmatrix} a_0 & a_1 & a_2 & a_3 & \dots \\ a_1 & a_1 & a_2 & a_3 & \dots \\ a_2 & a_2 & a_2 & a_3 & \dots \\ a_3 & a_3 & a_3 & a_3 & \dots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{pmatrix}.$$

We will use the Schur test to find some conditions on the sequence $(a_n)_{n\geq 0}$ for $A$ to be an operator on $\ell^2$ and to find an upper bound on the $\ell^2$ norm of $A$. Moreover, we will use these tools to find the exact norm of a particular set of $L$-matrices.

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**ALEXANDER BRUDNYI**, University of Calgary
[Sunday December 6 / dimanche 6 décembre, 16:30]
*On nonlinear Runge approximation problems*

We present interpolation and approximation results for bounded holomorphic maps into complex manifolds.

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**ALMAZ BUTAEV**, University of Calgary
[Monday December 7 / lundi 7 décembre, 14:30]
*On geometric preduals of jet spaces on subsets of $\mathbb{R}^n$*

For a closed set $S \subset \mathbb{R}^n$ the jet space $J_b^{k,\omega}(S)$ is the Banach space of vector functions whose components are partial derivatives of functions in $C_b^{k,\omega}(\mathbb{R}^n)$ evaluated at points of $S$ equipped with the corresponding quotient norm. The geometric predual $G_J^{k,\omega}(S)$ of $J_b^{k,\omega}(S)$ is the minimal closed subspace of the dual $\left(C_b^{k,\omega}(\mathbb{R}^n)\right)^*$ containing the evaluation functionals of all partial derivatives of order $\leq k$ at points in $S$. In this talk, we study some geometric properties of spaces $G_J^{k,\omega}(S)$ related to the classical Whitney problems. This talk is based on joint work with Alex Brudnyi.

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**GALIA DAFNI**, Concordia University
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Extension domains for bmo*

In joint work with Almaz Butaev (Calgary), we consider the problem of characterizing domains $\Omega \subset \mathbb{R}^n$ for which there exists a bounded linear extension operator from $\mathrm{bmo}(\Omega)$ to $\mathrm{bmo}(\mathbb{R}^n)$, where bmo denotes the nonhomogeneous (also called "local") space of functions of bounded mean oscillation, defined by Goldberg. The analogous problem for BMO was solved by Jones, who identified extension domains for BMO with uniform domains. He subsequently defined local versions of these domains, called $(\epsilon, \delta)$ domains, and proved extension results for Sobolev functions on such domains. We show that the condition on the domain is both necessary and sufficient for the extension of bmo functions.

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**PAUL GAUTHIER**, Université de Montréal
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Asymptotic first boundary value problem for holomorphic functions of several complex variables*

**Theorem** (with Mohammad Shirazi, McGill University).
Let $M$ be a complex manifold endowed with a distance $d$ and a regular Borel measure $\mu$, such that non-empty open sets have

positive measure. Let $U \subset M$ be an arbitrary Stein domain and $\psi \in \mathcal{M}(\partial U)$ an arbitrary Borel measurable function on the boundary $\partial U$, whose restriction to some closed subset $S \subset \partial U$ is continuous. Then, for an arbitrary regular $\sigma$-finite Borel measure $\nu$ on $\partial U$, there exists a holomorphic function $f$ on $U$, such that, for $\nu$-almost every $p \in \partial U$, and for every $p \in S$, $f(x) \to \psi(p)$, as $x \to p$ outside a set of $\mu$-density 0 at $p$ relative to $U$.

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**RYAN GIBARA**, Université Laval
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Boundedness and continuity of rearrangements on spaces defined by mean oscillation*

In joint work with Almut Burchard and Galia Dafni, we study the boundedness and continuity of rearrangement operators on the space BMO of functions of bounded mean oscillation. New bounds are obtained on the BMO-seminorm of the decreasing and the symmetric decreasing rearrangements, both of which are shown to be discontinuous as maps on BMO. The corresponding questions of boundedness and continuity for both these rearrangements on the space VMO of functions of vanishing mean oscillation is then addressed.

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**ADI GLUCKSAM**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Computability of harmonic measures*

In this talk I will present the new notion of computable harmonic approximation, and show that for an arbitrary domain, computability of the harmonic measure for a single point implies its computability for any point. Nevertheless, different points may require different algorithms, which gives rise to surprisingly natural examples of continuous functions whose values can be computed at any point but cannot be computed using same algorithm on their entire domain. I will present counter examples supporting this and study the conditions under which the harmonic measure is computable uniformly, that is by a single algorithm, and characterize them for regular domains with a computable boundary.

This talk is based on a joint work with I. Binder, C. Rojas, and M. Yampolsky.

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**WENBO LI**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 17:30]
*Conformal dimension and minimality of stochastic objects*

In this talk, we discuss the conformal dimension of some stochastic objects. The conformal dimension of a metric space is the infimum of the Hausdorff dimension of all its quasisymmetric images. We call a metric space minimal if its conformal dimension equals its Hausdorff dimension. We begin with a construction of a graph of a random function which is minimal. Inspired by this, we apply the same techniques to the study of 1-dimensional Brownian graphs. The main tool is the Fuglede modulus. This is a joint work with Ilia Binder and Hrant Hakobyan.

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**JAVAD MASHREGHI**, Laval University
[Monday December 7 / lundi 7 décembre, 18:30]
*Outer Functions and the Schur Class*

It is well known that the composition of two inner functions is an inner function. Parallel to this result, the composition of an outer function with a self map of the open unit disk is also outer. The result, while known and classic, is not that trivial. We present an approach via uniform integrability.

This is a joint work With T. Ransford.

**FRÉDÉRIC MORNEAU-GUÉRIN**, Université TÉLUQ
[Sunday December 6 / dimanche 6 décembre, 18:00]
*La $*$-stabilité de l'espace pondéré des suites de carré sommable sur la somme directe de groupes abéliens finis*

Au cours de cet exposé, nous présenterons diverses conditions que doit nécessairement satisfaire une fonction de pondération sur un groupe abélien discret afin que l'espace pondéré des suites de carré sommable définies sur ce même groupe soit stable sous le produit de convolution. Nous nous pencherons ensuite plus spécifiquement sur le cas où le groupe sous-jacent est la somme directe de groupes abéliens finis.

**PIERRE-OLIVIER PARISÉ**, Université Laval
[Monday December 7 / lundi 7 décembre, 15:00]
*Cesàro summability of Taylor series in weighted Dirichlet spaces*

A recent result of J. Mashreghi and T. Ransford has shown that, for a weighted Dirichlet space $\mathcal{D}_\omega$ where $\omega : \mathbb{D} \to (0, \infty)$ is a superharmonic function on the unit disk $\mathbb{D}$, the Cesàro means of order $1$ of the partial sums $s_n[f]$ of the Taylor expansion of a function $f \in \mathcal{D}_\omega$ converge to the function in the norm of the space. However, it is known that, for certain weights $\omega$, the partial sums themselves fail to converge. This leads us to the following question : Do the Cesàro means of order $\alpha > 0$ of $s_n[f]$ converge to $f$ in the space $\mathcal{D}_\omega$ for any superharmonic weight $\omega$ ?

In this talk, I will present the following result for the spaces $\mathcal{D}_\omega$ : If $\alpha > \frac{1}{2}$, the Cesàro means of order $\alpha$ always converge to the function $f$ in any space $\mathcal{D}_\omega$, but if $\alpha \leq \frac{1}{2}$, it breaks down for some superharmonic weight $\omega$. This result contrasts with what is known on Cesàro means of order $\alpha > 0$ in the disk algebra and the Hardy space $H^1$. (Joint work with Javad Mashreghi and Thomas Ransford).

**THOMAS RANSFORD**, Université Laval
[Monday December 7 / lundi 7 décembre, 14:00]
*A Gleason-Kahane-Żelazko theorem for reproducing kernel Hilbert spaces.*

The Gleason-Kahane-Żelazko theorem states that a linear functional on a Banach algebra that is non-zero on invertible elements is necessarily a scalar multiple of a character. In this talk I shall describe an analogue of this result for a certain class of Hilbert spaces. (Joint work with Cheng Chu, Michael Hartz and Javad Mashreghi.)

**LARISSA RICHARDS**, University of Toronto
[Monday December 7 / lundi 7 décembre, 15:30]
*On the rate of convergence of discrete interfaces to SLE.*

We will present recent developments in generating a general framework for establishing a rate of convergence of the critical interfaces of various critical lattice models to SLE. Following the work of S. Smirnov and A. Kemppainen and the work of F. Viklund, assuming a polynomial rate of convergence of the martingale observable functions we can obtain a polynomial rate of convergence provided the random curve satisfies some mild conditions. We will discuss the application of this framework to percolation, harmonic explorer, and Ising model.

**SCOTT RODNEY**, Cape Breton University
[Monday December 7 / lundi 7 décembre, 17:30]
*Bounded Weak Solutions of Second Order Linear PDEs with Data in Orlicz Spaces*

Reporting on joint work with David Cruz-Uribe (UAlabama) and S. Francis MacDonald (CBU math student). For a non-negative definite symmetric matrix valued function $Q = Q(x)$ in a bounded domain $\Omega \subset \mathbb{R}^n$ with $n \geq 3$, we consider weak

solutions of Dirichlet problems for linear equations of the form

$$(**) - \frac{1}{v}\mathrm{Div}\left(\sqrt{Q}\nabla u\right) + \mathbf{H}Ru - \frac{1}{v}S'[\mathbf{G}uv] + Fu = f - \frac{1}{v}T'[gv]$$

for $x \in \Omega$ $v - a.e.$ Here, the weight $v \in L^1(\Omega)$ satisfies $|Q(x)|_{op} \leq kv(x)$ in $\Omega$ where $k$ is a constant. $R, S, T$ are $n$-tuples of first order vectorfields with adjoints $R', S', T'$. The data functions $f, g$, coefficient functions $\mathbf{H}, \mathbf{G}, F$ and are assumed to belong to Orlicz classes associated to the Young functions

$$A(t) = t^{\sigma'}\log(e+t)^q,\ B(t) = A^2(t) \text{ respectively}$$

where $q > \sigma'$, the dual exponent of $\sigma > 1$ that describes the gain in a Sobolev inequality associated to $Q(x)$ and $v$. Under the assumption of a positivity condition on the vectorfields, we show that any non-negative weak solution $u$ of equation (**) is bounded with

$$\|u\|_{L^\infty(v;\Omega)} \leq C\left(\|u\|_{QH^1_0(\Omega)} + \|f\|_{L^A(\Omega)} + \|g\|_{L^B(\Omega)}\right)$$

where $C$ is independent of $f, g$, and $u$.

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**IGNACIO URIARTE-TUERO**, University of Toronto
[Monday December 7 / lundi 7 décembre, 16:00]
*Two weight norm inequalities for singular integrals in* $\mathbb{R}^n$

In this talk I will present the most recent advances in the problem of characterizing the two weight norm inequality for singular integrals in Euclidean space. In particular two weight local Tb theorems in n dimensions with an energy side condition. The talk will be self-contained. Mostly joint work with Grigoriadis, Paparizos, Sawyer, Shen. The talk will be self-contained.

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**WILLIAM VERREAULT**, Université Laval
[Monday December 7 / lundi 7 décembre, 16:30]
*Nonlinear Oscillatory Expansions of holomorphic functions*

In 1995, R. Coifman discovered a nonlinear analogue of Fourier series called Blaschke unwinding series. This iterative Blaschke factorisation has a wide range of practical applications, but it is not well understood. In recent years, the method has been rediscovered by T. Qian et al. and extensively studied, while Coifman and collaborators have studied other unwindings and convergence in given function spaces such as orthogonal decompositions of invariant subspaces of Hardy spaces.

We present results that explain why this Blaschke factorisation only corresponds to a specific (and the most simple) type of unwinding of holomorphic functions, and, using techniques from operator theory, we give necessary and sufficient conditions for the convergence of the unwinding series.

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**JAMES WILSON**, University of Vermont
[Monday December 7 / lundi 7 décembre, 17:00]
*Discretization of adapted functions*

We say that a family $\{\psi_\gamma\}_{\gamma\in\Gamma} \subset L^2(\mathbf{R}^d)$ is almost-orthogonal if there is a finite $R$ so that, for all finite $\mathcal{F} \subset \Gamma$ and all linear combinations $\sum_{\gamma\in\mathcal{F}} \lambda_\gamma\psi_\gamma$, where $\{\lambda_\gamma\}_{\gamma\in\mathcal{F}} \subset \mathbf{C}$,

$$\left\|\sum_{\mathcal{F}} \lambda_\gamma\psi_\gamma\right\|_2 \leq R\left(\sum_{\mathcal{F}} |\lambda_\gamma|^2\right)^{1/2}.$$

The least $R$ for which this holds is called the family's almost-orthogonality constant, denoted $\|\{\psi_\gamma\}_{\gamma\in\Gamma}\|_{AO(\Gamma)}$. The almost-orthogonality constant can be used to quantify how far a family is from having certain useful properties (orthonormality, being a frame, etc.). We show:

Theorem. Let $0 < \alpha, \tau \leq 1$. Let $\{f^{(Q)}\}_{Q\in\mathcal{D}}$ be a family of functions indexed over the dyadic cubes $\mathcal{D}$ in $\mathbf{R}^d$, satisfying: a) $\forall Q \in \mathcal{D}$, supp $f^{(Q)} \subset \overline{Q}$; b) $\forall x, x' \in \mathbf{R}^d (|f^{(Q)}(x) - f^{(Q)}(x')| \leq (|x - x'|/\ell(Q))^\alpha$, where $\ell(Q)$ is $Q$'s sidelength. For each $Q \in \mathcal{D}$ let $\mathcal{G}(Q)$ be a set of disjoint dyadic cubes $J$ such that $\ell(J) \leq \tau\ell(Q)$ and $\cup_{\mathcal{G}(Q)} J = Q$. Set

$$f^{(Q)}_{\mathcal{G}(Q)} := \sum_{J\in\mathcal{G}(Q)} f^{(Q)}_J \chi_J,$$

where $f^{(Q)}_J$ means $f^{(Q)}$'s average over $J$. There is a constant $C(\alpha, d)$, depending only on $\alpha$ and $d$, so that

$$\left\| \left\{ \frac{f^{(Q)} - f^{(Q)}_{\mathcal{G}(Q)}}{|Q|^{1/2}} \right\}_{Q\in\mathcal{D}} \right\|_{AO(\mathcal{D})} \leq C(\alpha, d)\tau^\alpha,$$

where $|Q|$ = the measure of $Q$.

What this means is that, if we apply sufficiently fine dyadic stopping times to the functions in $\{f^{(Q)}/|Q|^{1/2}\}_{Q\in\mathcal{D}}$, the resulting family $\{f^{(Q)}_{\mathcal{G}(Q)}/|Q|^{1/2}\}_{Q\in\mathcal{D}}$ is close to $\{f^{(Q)}/|Q|^{1/2}\}_{Q\in\mathcal{D}}$ in the almost-orthogonal sense. If time permits we will say a few words about a companion result (in different ways stronger and weaker) for such families when $\alpha = 1$.

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**JIE XIAO**, Memorial University
[Monday December 7 / lundi 7 décembre, 18:00]

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**MALIK YOUNSI**, University of Hawaii
[Sunday December 6 / dimanche 6 décembre, 16:00]

*Holomorphic motions, capacity and conformal welding*

The notion of a holomorphic motion was introduced by Mané, Sad and Sullivan in the 1980's, motivated by the observation that Julia sets of rational maps often move holomorphically with holomorphic variations of the parameters. In the years that followed, the study of the behavior of various set-functions under holomorphic motions became an area of significant interest. For instance, holomorphic motions played a central role in the work of Astala on distortion of Hausdorff dimension and area under quasiconformal mappings.

In this talk, I will first review the basic notions and results related to holomorphic motions, including the extended lambda lemma. I will then present some recent results on the behavior of logarithmic capacity and analytic capacity under holomorphic motions. The proofs involve different notions such as conformal welding, quadratic Julia sets and harmonic measure. This is joint work with Tom Ransford and Wen-Hui Ai.

# Spectral Methods and Singular Integral Equations / Méthodes Spectrales et Équations Intégrales Singulières

Org: Richard Slevinsky (Manitoba)

## Schedule/Horaire

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Matthew Colbrook (Cambridge University), *A Mathieu function boundary spectral method for acoustic scattering* (p. 191) |
| 14:30 - 15:00 | Travis Askham (NJIT), *Fast multipole methods for continuous charge distributions* (p. 191) |
| 15:00 - 15:30 | Dan Fortunato (Harvard University), *The ultraspherical spectral element method* (p. 192) |
| 15:30 - 16:00 | Andrew Horning (Cornell University), *Twice is enough for dangerous eigenvalues* (p. 192) |
| 16:00 - 16:30 | Jim Bremer (UC Davis), *A fast algorithm for simulating scattering from a radially symmetric potential* (p. 191) |
| 16:30 - 17:00 | Nilima Nigam (Simon Fraser University), *Steklov eigenfunctions: how and why to compute them* (p. 193) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Timon Gutleb (Imperial College London), *Computing Equilibrium Measures with Power Law Kernels* (p. 192) |
| 14:30 - 15:00 | Sheehan Olver (Imperial College London), *Sparse spectral methods for singular integral and fractional differential equations* (p. 193) |
| 15:00 - 15:30 | Manas Rachh (Flatiron Institute), *Towards automatically adaptive solvers for Maxwell's equations in three dimensions* (p. 193) |
| 15:30 - 16:00 | Richard Mikael Slevinsky (University of Manitoba), *Fast associated classical orthogonal polynomial transforms* (p. 193) |
| 16:00 - 16:30 | Alex Townsend (Cornell University), *Computing the spectra of differential operators* (p. 194) |
| 16:30 - 17:00 | Tom Trogdon (University of Washington), *On arbitrary-precision enabled inverse scattering for the 1-dimensional Schrödinger operator* (p. 194) |

## Abstracts/Résumés

**TRAVIS ASKHAM**, New Jersey Institute of Technology
[Saturday December 5 / samedi 5 décembre, 14:30]
*Fast multipole methods for continuous charge distributions*

Applications with continuous charge distributions or continuously varying material properties require the calculation of so-called volume integrals involving the Green's function of the governing PDE. These integrals can be both singular and nearly singular and thus require special quadrature. We present a method for generating such quadrature rules that is efficient enough to be done on-the-fly. We also discuss how these quadrature rules are incorporated in a fast multipole method and demonstrate some applications of the scheme to optical scattering problems.

**JIM BREMER**, University of California, Davis
[Saturday December 5 / samedi 5 décembre, 16:00]
*A fast algorithm for simulating scattering from a radially symmetric potential*

Standard solvers for the variable coefficient Helmholtz equation in two spatial dimensions have running times which grow at least as fast as $\mathcal{O}\left(k^2\right)$ in the wavenumber k of the problem. I will describe an algorithm which only applies in the very special case in which the coefficient is radially symmetric, but whose running time is $\mathcal{O}(k\ log(k))$.

**MATTHEW COLBROOK**, University of Cambridge
[Saturday December 5 / samedi 5 décembre, 14:00]
*A Mathieu function boundary spectral method for acoustic scattering*

Many problems in fluid dynamics and acoustics are modelled by singular integral equations with complicated boundary conditions (BCs). This talk considers 2D Helmholtz scattering off (multiple finite) plates, with a focus on BCs ranging from linear models of variable elasticity (fourth-order ODEs), impedance and porosity, to non-linear inertial corrections. A boundary spectral collocation method using Mathieu functions is developed to solve these systems. The method is accurate and flexible for a wide range of frequencies and different BCs, and can robustly compute expansions in tens of thousands of Mathieu functions. As well as discussing numerical analysis aspects, I will demonstrate applications to acoustic black holes, reduction of aerofoil-turbulence interaction noise, and the importance of non-linear corrections for accurately predicting the noise generated by metal foam-like materials. More generally, a goal of this talk is to demonstrate that modern spectral methods can be used in a simple and effective manner for contemporary problems of acoustic scattering, with pointers to ongoing problems.

[1] Colbrook, M.J., Kisil, A.V. "A Mathieu function boundary spectral method for scattering by multiple variable poro-elastic plates, with applications to metamaterials and acoustics." Proceedings of the Royal Society A (2020)

[2] Ayton, L.J., Colbrook, M.J., Geyer, T.F., Paruchuri, C., Sarradj, E. "Reducing aerofoil-turbulence interaction noise through chordwise-varying porosity." JFM (2020)

[3] Colbrook, M.J., Priddin, M.J. "Fast and spectrally accurate numerical methods for perforated screens." IMA Journal of Applied Mathematics (2020)

[4] Colbrook, M.J., Ayton, L.J. "Do we need non-linear corrections? On the boundary Forchheimer equation in acoustic scattering." Submitted

**DAN FORTUNATO**, Flatiron Institute
[Saturday December 5 / samedi 5 décembre, 15:00]
*The ultraspherical spectral element method*

We introduce a novel spectral element method based on the ultraspherical spectral method and the hierarchical Poincaré–Steklov scheme for solving second-order linear partial differential equations on polygonal domains with unstructured quadrilateral or triangular meshes. Properties of the ultraspherical spectral method lead to almost banded linear systems, allowing the element method to be competitive in the high-polynomial regime ($p > 5$). The hierarchical Poincaré–Steklov scheme enables precomputed solution operators to be reused, allowing for fast elliptic solves in implicit and semi-implicit time-steppers. The resulting spectral element method achieves an overall computational complexity of $\mathcal{O}(p^4/h^3)$ for mesh size $h$ and polynomial order $p$, enabling $hp$-adaptivity to be efficiently performed. We develop an open-source software system, ultraSEM, for flexible, user-friendly spectral element computations in MATLAB. Joint work with Alex Townsend (Cornell University) and Nicholas Hale (Stellenbosch University).

**TIMON GUTLEB**, Imperial College London
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Computing Equilibrium Measures with Power Law Kernels*

Equilibrium measure problems naturally appear in the mathematical description of particle swarms in which particle behavior may be modeled via attractive and repulsive forces, for example ensemble movements in bird flocks, cellular scale organisms and classical particle interactions. Analytic solutions to equilibrium measure problems with power law kernels $K(x) = \frac{|x|^\alpha}{\alpha} - \frac{|x|^\beta}{\beta}$ exist for certain parameter choices but little is known about the behavior of solutions in high non-integer power cases, where discrete particle simulations predict interesting gap formation phenomena as the repulsive power increases. We introduce a banded sparse spectral method for such problems utilizing recurrence relationships in weighted ultraspherical polynomial bases. Numerical experiments agree with known analytic results as well as independent particle swarm simulations. Our method can be used to study solution behavior, uniqueness of solutions and the above-mentioned gap forming phenomenon.

**ANDREW HORNING**, Cornell University
[Saturday December 5 / samedi 5 décembre, 15:30]
*Twice is enough for dangerous eigenvalues*

A popular class of methods for large-scale eigenvalue problems use Cauchy's integral formulas to compute eigenvalues of a large matrix in a target region. We analyze the stability of these methods in the singular limit, i.e., as eigenvalues of the matrix approach the contour. Remarkably, contour-integral eigensolvers that incorporate subspace iterations are stable: the "dangerous eigenvalues" near the contour contribute large round-off errors in the first iteration, but are self-correcting in later iterations. For matrices with orthogonal eigenvectors (e.g., real-symmetric or complex Hermitian), two iterations is enough to reduce round-off errors to the order of the unit-round off. In contrast, contour-integral eigensolvers that construct Krylov subspaces typically fail to converge to unit round-off accuracy when an eigenvalue is close to the contour. However, we suggest a simple new restart strategy that recovers full precision in the target eigenpairs after two iterations.

**NILIMA NIGAM**, Simon Fraser University
[Saturday December 5 / samedi 5 décembre, 16:30]
*Steklov eigenfunctions: how and why to compute them*

In this talk we present a fast and accurate discretization strategy for computing the Steklov eigenpairs of the Laplacian. We'll also present recent result on the use of this method for three distinct problems: the spectral asymptotics of the Steklov eigenvalues on regular polygons, spectral optimization, and the solution of Robin problems.

**SHEEHAN OLVER**, Imperial College
[Sunday December 6 / dimanche 6 décembre, 14:30]
*Sparse spectral methods for singular integral and fractional differential equations*

The ultraspherical spectral method originated as an approach for generate sparse, almost banded discretisations for ordinary differential equations. It was subsequently generalised to partial differential equations on simple geometries, singular integral equations with logarithmic kernels, and fractional differential equations. In this talk we review these developments and discuss new generalisations to power-law kernels.

Contains joint work with Timon Gutleb, Mikael Slevinsky and Alex Townsend.

**MANAS RACHH**, Flatiron Institute
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Towards automatically adaptive solvers for Maxwell's equations in three dimensions*

The numerical simulation of Maxwell's equations plays a critical role in chip and antenna design, radar cross section determination, biomedical imaging, wireless communications, and the development of new meta-materials and better waveguides to name a few. In order to enable design by simulation for problems arising in these applications, automatically adaptive solvers which resolve the complexity of the geometry and the input data play a critical role. In two dimensions, this has been made possible through the development of high-order integral equation based solvers which rely on well-conditioned integral representations, efficient quadrature formulas, and coupling to fast multipole methods. However, much is still to desired of these solvers in three dimensions (both in terms of their efficiency and accuracy), particularly in the context of enabling automatic adaptivity in complex geometries. In this talk, I will present an efficient high-order solver for solving Maxwell's equations in complex three dimensional geometries with focus on the efficient quadrature methods for computing singular integrals.

**RICHARD MIKAEL SLEVINSKY**, University of Manitoba
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Fast associated classical orthogonal polynomial transforms*

We discuss a fast approximate solution to the associated classical – classical orthogonal polynomial connection problem. We first show that associated classical orthogonal polynomials are solutions to a fourth-order quadratic eigenvalue problem with polynomial coefficients such that the differential operator is degree-preserving. Upon linearization, the discretization of this quadratic eigenvalue problem is block upper-triangular and banded. After a perfect shuffle, we extend a divide-and-conquer approach to the upper-triangular and banded generalized eigenvalue problem to the blocked case, which may be accelerated by one of a few different algorithms. Associated orthogonal polynomials arise from iterated Stieltjes transforms of orthogonal polynomials; hence, fast approximate conversion to classical cases combined with fast discrete sine and cosine transforms provides a modular mechanism for synthesis of singular integral transforms of classical orthogonal polynomial expansions.

**ALEX TOWNSEND**, Cornell University
[Sunday December 6 / dimanche 6 décembre, 16:00]
*Computing the spectra of differential operators*

Spectral methods for solving differential eigenproblems usually follow the "discretize-then-solve" paradigm. Discretize first, and then solve the matrix eigenproblem. The discretize-then-solve paradigm can be tricky for differential eigenproblems as the spectrum of matrix discretizations may not converge to the spectrum of the differential operator. Moreover, it is impossible to fully capture the continuous part of the spectrum with a finite-sized matrix eigenproblem. In this talk, we will discuss an alternative "solve-then-discretize" paradigm for differential eigenproblems. To compute the discrete spectrum, we will discuss a continuous analogue of FEAST by approximating the action of the resolvent operator. For the continuous spectra, we will use a Cauchy-like integral to calculate a smoothed version of the so-called spectral measure. This is joint work with Matthew Colbrook and Andrew Horning.

**TOM TROGDON**, University of Washington
[Sunday December 6 / dimanche 6 décembre, 16:30]
*On arbitrary-precision enabled inverse scattering for the 1-dimensional Schrödinger operator*

There is renewed interest in singularity dynamics of integrable systems in the complex $x$-plane. This was originally studied by Kruskal, Kruskal and Thickstun, and Bona and Weissler and more recently by Weideman and Ankiewicz, Clarkson and Akhmediev. One approach to study this is to perform numerical analytic continuation of the solution for real $x$. This motivates us to study methods to approximate solutions of the Korteweg-de Vries equation with high precision. As a first step, we consider the small time evaluation of a very special class of solutions by solving Riemann–Hilbert problems (i.e., singular integral equations) with arbitrary precision.

Org: **Octav Cornea** and/et **Egor Shelukhin** (Université de Montréal)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 13:00 - 13:40 | Zhang Jun (Montreal), *Quantitative Lagrangian embeddings* (p. 196) |
| 14:10 - 14:50 | Marcelo Atallah (Montreal), *Hamiltonian no-torsion* (p. 195) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:40 | Ilia Kirillov (Toronto), *Classification of coadjoint orbits for symplectomorphism groups of surfaces with boundary* (p. 196) |
| 15:00 - 15:40 | Jeremy Lane (McMaster), *Canonical bases, toric degenerations, and collective integrable systems* (p. 197) |
| 16:00 - 16:40 | Jordan Payette (Montreal), *Mean value inequalities for the Poisson bracket invariant* (p. 197) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:40 | Francisco Torres de Lizaur (Toronto), *Knots and links in Beltrami fields* (p. 196) |
| 15:00 - 15:40 | Dominique Rathel-Fournier (Montreal), *Unobstructed Lagrangian cobordism groups of surfaces* (p. 197) |
| 16:00 - 16:40 | Jean-Philippe Chassé (Montreal), *The impact of metric constraints on the behavior of shadow metrics* (p. 196) |

### Tuesday December 8 — mardi 8 décembre

| | |
|---|---|
| 11:00 - 11:40 | Xiudi Tang (Toronto), *Symplectic ray removal* (p. 198) |
| 11:50 - 12:30 | Lara Suarez Lopez (Bochum), *On the rigidity of Legendrian cobordisms* (p. 197) |
| 13:10 - 13:50 | Qun Wang (Toronto), *Choreographies in the N-Vortex Problem* (p. 198) |
| 14:10 - 14:50 | Shira Tanny (Tel Aviv), *The Poisson bracket invariant: elementary and hard approaches.* (p. 198) |
| 15:30 - 16:10 | Pranav Chakravarthy (Western Ontario), *Homotopy type of equivariant symplectomorphisms of rational ruled surfaces.* (p. 195) |
| 16:20 - 17:00 | Cheng Yang (Toronto), *Symplectic reduction and perturbation theory* (p. 198) |

## Abstracts/Résumés

**MARCELO ATALLAH**, Université de Montréal
[Friday December 4 / vendredi 4 décembre, 14:10]
*Hamiltonian no-torsion*

Abstract: In 2002 Polterovich notably showed that Hamiltonian diffeomorphisms of finite order, which we call Hamiltonian torsion, must be trivial on closed symplectically aspherical manifolds. We study the existence of Hamiltonian torsion and its metric rigidity properties in more general situations. First, we extend Polterovich's result to closed symplectically Calabi-Yau and closed negative monotone manifolds. Second, going beyond topological constraints, we describe how Hamiltonian torsion is related to the existence of pseudo-holomorphic spheres and answer a close variant of Problem 24 from the introductory monograph of McDuff-Salamon. Finally, we prove an analogue of Newman's 1931 theorem for Hofer's metric and Viterbo's spectral metric on the Hamiltonian group of monotone symplecitc manifolds: a sufficiently small ball around the identity contains no torsion. During the talk, I shall discuss the results above and some of the key ingredients of their proofs. This talk is based on joint work with Egor Shelukhin.

**PRANAV CHAKRAVARTHY**, University of Western Ontario
[Tuesday December 8 / mardi 8 décembre, 15:30]
*Homotopy type of equivariant symplectomorphisms of rational ruled surfaces.*

Darboux's theorem states that "all symplectic manifolds locally look alike". Consequently, there are no local invariants in symplectic geometry, and one must look for global invariants to probe symplectic manifolds. Such invariants can be obtained by investigating the homotopy type of mapping spaces related to the symplectic structure. In this talk, we compute the homotopy type of the group of equivariant symplectomorphisms of $S^2 \times S^2$ and $\mathbb{C}P^2$ blown up once under the presence of hamiltonian $S^1$ or finite cyclic group actions.

**JEAN-PHILIPPE CHASSÉ**, Université de Montréal
[Sunday December 6 / dimanche 6 décembre, 16:00]
*The impact of metric constraints on the behavior of shadow metrics*

Since its introduction by Hofer, the eponymous norm on the group of Hamiltonian diffeomorphisms has been of great importance in symplectic topology. In particular, the Hofer norm induces a metric on the Hamiltonian orbit of a Lagrangian submanifold, as proved by Chekanov. However, this gives no way to significantly compare Lagrangian submanifolds which are not Hamiltonian diffeomorphic, let alone those which do not have the same homotopy type. This is one of the reasons why the so-called shadow metrics — or more generally the weighted fragmentation pseudometrics — introduced by Biran, Cornea and Shelukhin, are a very interesting and promising object of study.

After a brief explainer on shadow metrics, I will present a conjecture of Cornea on how they are related to the set-theoretic Hausdorff distance when one looks at a subspace of Lagrangian submanifolds respecting certain metric constraints. I will then present a proof of the conjecture in certain cases based on Groman and Solomon's reverse isoperimetric inequality. If time permits, I will explain how this result extends to other weighted fragmentation pseudometrics.

**FRANCISCO TORRES DE LIZAUR**, University of Toronto
[Sunday December 6 / dimanche 6 décembre, 14:00]
*Knots and links in Beltrami fields*

Beltrami fields on a 3-dimensional compact manifold are eigenfields of the curl operator. They describe a stationary ideal fluid whose vorticity and velocity are aligned. In this talk I will show that, on the round 3-sphere and the flat 3-torus, there are Beltrami fields having a finite set of periodic orbits and invariant tori of any given knot and link type, provided the eigenvalue is large enough. This is joint work with Alberto Enciso and Daniel Peralta-Salas.

**ZHANG JUN**, University of Montreal
[Friday December 4 / vendredi 4 décembre, 13:00]
*Quantitative Lagrangian embeddings*

Symplectic embedding between domains is a central problem in symplectic geometry. In this talk, we will discuss a different type of embedding - Lagrangian embedding, as well as its resulting obstructions to symplectic embeddings of basic domains (for instance, symplectic embeddings from 4-dimensional polydiscs to ellipsoids). The key tool is the shape invariant, a collection of quantitative data (called area classes) of Lagrangian embeddings. The main theorem in this talk is a computational result of the shape invariant of a large family of 4-dimensional ellipsoids. The computation is based on the symplectic field theory (SFT) and embedded contact homology (ECH) theory. This talk is based on joint work with Richard Hind.

**ILIA KIRILLOV**, University of Toronto
[Saturday December 5 / samedi 5 décembre, 14:00]
*Classification of coadjoint orbits for symplectomorphism groups of surfaces with boundary*

Hydrodynamical Euler's equation describes the motion of an ideal incompressible fluid on a Riemannian manifold. In this talk, I will start by explaining how the kinematics of Euler's equation is related to the coadjoint orbits of the group of volume-preserving diffeomorphisms. In dimension two the volume-preserving diffeomorphisms coincide with the symplectomorphisms. The classification of generic coadjoint orbits for symplectomorphism groups of closed surfaces was obtained by Izosimov, Khesin, and Mousavi in 2016. I will explain how to generalize this result to the case of symplectic surfaces with boundary.

**JEREMY LANE**, McMaster University
[Saturday December 5 / samedi 5 décembre, 15:00]
*Canonical bases, toric degenerations, and collective integrable systems*

There are three important settings for studying actions of reductive Lie groups: modules, algebraic group actions, and Hamiltonian group actions. In the study of modules one encounters various constructions of nice bases which are in some sense canonical (e.g. Gelfand-Zeitlin, Lusztig). In the study of algebraic group actions canonical bases give rise to toric degenerations; deformations of the G-variety to a toric variety (cf. Caldero, Alexeev-Brion). The symplectic analogue of these constructions is collective integrable systems. We show how canonical bases and toric degenerations give rise to collective integrable systems on arbitrary symplectic manifolds equipped with Hamiltonian group actions. This generalizes a family of well-known examples of collective integrable systems called Gelfand-Zeitlin systems. As a by-product, we generalize some results of Harada and Kaveh.

This talk is based on joint work with Benjamin Hoffman. arXiv:2008.13656

**LARA SUAREZ LOPEZ**, Ruhr Universitaet Bochum
[Tuesday December 8 / mardi 8 décembre, 11:50]
*On the rigidity of Legendrian cobordisms*

It is a natural question in differential topology whether an isotopy invariant of a manifold is also a cobordism invariant. In symplectic and contact topology there are different notions of cobordisms. One of them due to Arnold concerns Lagrangian and Legendrian cobordisms between Lagrangian/Legendrian submanifolds. For Lagrangian cobordisms, Biran-Cornea showed that monotone ones preserve Floer homology. In the first part of this talk I will show a similar statement for Legendrian cobordisms that are hypertight. Then I will talk about positive Legendrian cobordism. This last part is based on a joint project with Maÿlis Limouzineau.

**JORDAN PAYETTE**, Université de Montréal and CIRGET
[Saturday December 5 / samedi 5 décembre, 16:00]
*Mean value inequalities for the Poisson bracket invariant*

In this talk, motivated by a conjecture of Polterovich from 2012, I shall discuss the existence of the following mean value phenomenon in symplectic topology: "The more localized the supports of the functions forming a partition of unity on a symplectic manifold are, the more Poisson-noncommutative the functions are."

I shall first present an elementary approach to prove "mean value inequalities" for closed symplectic surfaces. For surfaces of genus at least one, this implies Polterovich's conjecture – which has been recently established for all closed surfaces by Buhovsky–Logunov–Tanny by other means. I shall then describe a work in progress with L. Buhovsky and S. Tanny aiming to use pseudoholomorphic curves to deduce "mean value inequalities" for higher-dimensional symplectic manifolds from the known two-dimensional results.

**DOMINIQUE RATHEL-FOURNIER**, Université de Montréal
[Sunday December 6 / dimanche 6 décembre, 15:00]
*Unobstructed Lagrangian cobordism groups of surfaces*

The Lagrangian cobordism groups of a symplectic manifold encode the relations between Lagrangian submanifolds given by suitable classes of Lagrangian cobordisms. Biran and Cornea showed that, in certain circumstances, there is a natural morphism from the Lagrangian cobordism group to the Grothendieck group of the derived Fukaya category of the manifold.

In this talk, we consider the case of a surface of genus $g \geq 2$. In the first part, we show how to extend the result of Biran and Cornea to a class of immersed cobordisms satisfying a non-obstruction assumption.

In the second part, we show that in this case the morphism from the cobordism group to $K_0(\mathrm{DFuk})$ is an isomorphism. The proof builds upon previous work of Perrier, and also relies on Abouzaid's computation of $K_0(\mathrm{DFuk})$ for higher genus surfaces. Our main contribution is the proof that a large class of surgery cobordisms are topologically unobstructed, in the sense that they do not bound non-trivial disks or teardrops.

**XIUDI TANG**, University of Toronto
[Tuesday December 8 / mardi 8 décembre, 11:00]
*Symplectic ray removal*

We remove a properly embedded ray from a noncompact symplectic manifold without changing the symplectic structure.

Reference: https://arxiv.org/abs/1812.00444.

**SHIRA TANNY**, Tel Aviv University
[Tuesday December 8 / mardi 8 décembre, 14:10]
*The Poisson bracket invariant: elementary and hard approaches.*

In 2006 Entov and Polterovich proved that functions forming a partition of unity with displaceable supports cannot commute with respect to the Poisson bracket. In 2012 Polterovich conjectured a quantitative version of this theorem. I will discuss three interconnected topics: a solution of this conjecture in dimension two (with Lev Buhovsky and Alexander Logunov), a link between this problem and Grothendieck's theorem from functional analysis (with Efim Gluskin), and new results related to the Floer-theoretical approach to this conjecture (with Yaniv Ganor).

**QUN WANG**, Toronto
[Tuesday December 8 / mardi 8 décembre, 13:10]
*Choreographies in the N-Vortex Problem*

Initially emerged from the study of the N-body problem in celestial mechanics, the choreographies are periodic orbits in which all the bodies are equally spread out along a single trajectory. In this talk, we study the existence of the choreographies in the N-vortex problem arising from the Euler equation. The identical vorticity permits us to construct the symmetric holomorphic spheres. Using this tool we prove that there exist infinitely many non-trivial choreographies for the identical n-vortex problem.

**CHENG YANG**, University of Toronto
[Tuesday December 8 / mardi 8 décembre, 16:20]
*Symplectic reduction and perturbation theory*

In this talk, we show that the averaged equation for a one-frequency fast-oscillating Hamiltonian system is the result of symplectic reduction of a certain natural system on the corresponding $S^1$-bundle with respect to the circle action. Furthermore,

if the reduced configuration space happens to be a group, then under natural assumptions the averaged system turns out to be the Euler equation on a central extension of that group. This gives a new explanation of the drift, common in averaged system, as a similar shift is typically present in symplectic reductions and central extensions. This is a joint work with Boris Khesin.

# The legacy of Mindstorms / L'héritage de Mindstorms

Org: **Andrijana Burazin** (Toronto) and/et **Peter Taylor** (Queen's University)

## Schedule/Horaire

| Tuesday December 8 | mardi 8 décembre |
|---|---|
| 13:00 - 13:20 | Peter Taylor (peter.taylor@queensu.ca), *Let's invite Seymour into our calculus classroom.* (p. 201) |
| 13:20 - 13:40 | Alfonso Gracia-Saz (alfonso@math.toronto.edu), *Playing with Desmos in the classroom* (p. 200) |
| 13:40 - 14:00 | Andrew McEachern (andrewm6@yorku.ca), *Tournaments in a Proofs Class* (p. 200) |
| 14:00 - 14:20 | Bernardo Galvao-Sousa (beni@math.toronto.edu), *Open ended modelling problems* (p. 200) |
| 14:20 - 14:40 | Sarah Mayes-Tang (smt@math.toronto.edu), *Using Stories to Learn Math in A First-Year Seminar* (p. 200) |
| 14:40 - 15:00 | General Discussion (p. 200) |

## Abstracts/Résumés

**GENERAL DISCUSSION**,
[Tuesday December 8 / mardi 8 décembre, 14:40]

**BERNARDO GALVAO-SOUSA**, University of Toronto
[Tuesday December 8 / mardi 8 décembre, 14:00]
*Open ended modelling problems*

In a second year Modelling with Differential and Difference Equations, I introduced open ended modelling problems. Taking advantage of the online setting where students have access to computer algebra systems, students are allowed to make use of them to approximate and study differential and difference equations to analyze them. In my talk, I'll show some of the results.

**ALFONSO GRACIA-SAZ**, University of Toronto
[Tuesday December 8 / mardi 8 décembre, 13:20]
*Playing with Desmos in the classroom*

How do we help students play, explore, investigate, make conjectures, and discover math ? I will share the tale of one successful classroom activity that students embraced, rather than rolled their eyes at.

**SARAH MAYES-TANG**, University of Toronto
[Tuesday December 8 / mardi 8 décembre, 14:20]
*Using Stories to Learn Math in A First-Year Seminar*

We often teach math to young children through picture books: it is taken for granted that using stories to teach math can build children's enjoyment and curiosity about math while also introducing new concepts, promoting mathematical thinking, and inviting them into a mathematical world. In this talk I will discuss how I designed a seminar for first-year students that uses the same principles, with literature in place of picture books. I will introduce the texts, activities, and assessments that I hope will make this vision come to life in the first offering of this seminar in the Spring of 2021, and how I am adapting it to now be offered fully online.

**ANDREW MCEACHERN**, amceachern6@gmail.com
[Tuesday December 8 / mardi 8 décembre, 13:40]
*Tournaments in a Proofs Class*

What possible place does a tournament have in the middle of an introductory proofs class? I've known many instructors, including myself, who have included the odd riddle or math problem that is seemingly unrelated to the material currently being studied. Working on the same kinds of problems leads to a certain kind of fatigue with which we are all familiar, and I believe the injection of a different kind of problem into the standard curriculum gives the brains of our students a chance to shift gears. A game can be thought of as specific kind of riddle, and putting a prize at the end engages even the students who are not normally competitive. It sparks their logic, creativity, and clear strategic thinking, which are essential ingredients in the construction of proofs. In this talk, I'll describe my version of the Colonel Blotto Tournament, how my class responded, and then we'll play a round of the tournament together.

**PETER TAYLOR**, Queen's
[Tuesday December 8 / mardi 8 décembre, 13:00]
*Let's invite Seymour into our calculus classroom.*

I will discuss the reasons that most calculus instructors would find him to be an awkward guest, but I will then propose a few activities that Seymour would quite enjoy.

# Variational Analysis: Theory and Applications / Analyse Variationnelle : Théorie et Applications

Org: **Heinz Bauschke** (UBC), **Walaa Moursi** (Waterloo), **Shawn Wang** (UBC) and/et **Henry Wolkowicz** (Waterloo)

## Schedule/Horaire

### Friday December 4 — vendredi 4 décembre

| | |
|---|---|
| 15:30 - 16:00 | Boris Mordukhovich (Wayne State), *A Generalized Newton Method for Subgradient Systems* (p. 204) |
| 16:00 - 16:30 | Walaa Moursi (Waterloo) (p. 204) |

### Saturday December 5 — samedi 5 décembre

| | |
|---|---|
| 14:00 - 14:30 | Patrick Combettes (NCSU), *Proximal Analysis of Deep Neural Networks* (p. 203) |
| 14:30 - 15:00 | Minh Bui (NCSU), *Multivariate Monotone Inclusions in Saddle Form* (p. 203) |
| 15:00 - 15:30 | Hao Hu (Waterloo), *Computing the Nearest Doubly Stochastic Matrix by a Newton-type Method* (p. 203) |
| 15:30 - 16:00 | Kimon Fountoulakis (Waterloo) (p. 203) |
| 16:00 - 16:30 | Mohamed Tawhid (TRU), *Improved Salp Swarm Optimization Algorithm for Data Clustering* (p. 204) |
| 16:30 - 17:00 | Salihah Alwadani (UBCO), *Resolvents and Yosida approximations of displacement mappings of isometries* (p. 202) |

### Sunday December 6 — dimanche 6 décembre

| | |
|---|---|
| 14:00 - 14:30 | Levent Tuncel (Waterloo), *A journey from the theory of self-concordant functions and variable metrics to applications in convex optimization* (p. 204) |
| 14:30 - 15:00 | Steve Vavasis (Waterloo) (p. 205) |
| 15:00 - 15:30 | Hristo Sendov (Western), *A unified approach to operator monotone functions* (p. 204) |
| 15:30 - 16:00 | Sedi Bartz (UM Lowell), *Open questions in multi-marginal monotonicity and convex analysis* (p. 202) |
| 16:00 - 16:30 | Tim Hoheisel (McGill), *From perspective maps to epigraphical projections* (p. 203) |
| 16:30 - 17:00 | Jane Ye (Victoria), *Second-order optimality conditions for non-convex set-constrained optimization problems* (p. 205) |

## Abstracts/Résumés

**SALIHAH ALWADANI**, UBC, Okanagan
[Saturday December 5 / samedi 5 décembre, 16:30]
*Resolvents and Yosida approximations of displacement mappings of isometries*

Maximally monotone operators are fundamental objects in modern optimization. We study in detail a nice class of monotone operators: displacement mappings of isometries of finite order. We derive explicit formulae for resolvents, Yosida approximations, and (set-valued and Moore-Penrose) inverses. We illustrate our results by considering rational rotators and circular shift operators.

**SEDI BARTZ**, University of Massachusetts Lowell
[Sunday December 6 / dimanche 6 décembre, 15:30]
*Open questions in multi-marginal monotonicity and convex analysis*

In the two-marginal case, aspects of monotonicity and convex analysis underline optimal transport theory. Similarly to the two-marginal case, multi-marginal monotonicity and convex analysis underline multi-marginal optimal transport theory yet can

be studied as an independent topic. We discuss basic extensions of the classical theory and point out several open questions regarding the construction of multi-marginal convex antiderivatives, a multi-marginal Minty type characterization of maximal monotonicity and a multi-marginal extension of the maximal monotonicity of the convex subdifferential. We illustrate our discussion by several examples.

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**MINH BUI**, North Carolina State University
[Saturday December 5 / samedi 5 décembre, 14:30]
*Multivariate Monotone Inclusions in Saddle Form*

We propose a novel approach to monotone operator splitting based on the notion of a saddle operator. Under investigation is a highly structured multivariate monotone inclusion problem involving a mix of set-valued, cocoercive, and Lipschitzian monotone operators, as well as various monotonicity-preserving operations among them. This model encompasses most formulations found in the literature. The analysis leads to an algorithm of unprecedented flexibility, which achieves full splitting, exploits the specific attributes of each operator, is asynchronous, and requires to activate only blocks of operators at each iteration, as opposed to activating all of them. Several applications are discussed.

Joint work with P. L. Combettes.

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**PATRICK COMBETTES**, North Carolina State University
[Saturday December 5 / samedi 5 décembre, 14:00]
*Proximal Analysis of Deep Neural Networks*

We show that proximal calculus and variational inequalities can be used to model and analyze neural networks and better understand the behavior of deep learning structures.

Joint work with J.-C. Pesquet.

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**KIMON FOUNTOULAKIS**, Waterloo
[Saturday December 5 / samedi 5 décembre, 15:30]

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**TIM HOHEISEL**, McGill University
[Sunday December 6 / dimanche 6 décembre, 16:00]
*From perspective maps to epigraphical projections*

The projection onto the epigraph or a level set of a closed, proper, convex function can be done by finding a root of a scalar function that involves the proximal operator as a function of the proximal parameter. To study the variational-analytic properties of this function, we consider general optimization problems that are (partial) infimal projections of the function in question and the perspective map of a kernel. When the latter is the Euclidean norm squared, we recover the proximal map as the solution map, and extract properties such as local Lipschitz continuity, directional differentiability, and semismoothness under suitable assumptions. Based on this, we establish an SC1 optimization framework for computing epigraphical and level set projections, which is competitive with methods tailored specifically to certain instances such as the projection onto the l1-unit ball.

This is joint work with Michael P. Friedlander (UBC) and Ariel Goodwin (McGill).

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**HAO HU**, University of Waterloo
[Saturday December 5 / samedi 5 décembre, 15:00]
*Computing the Nearest Doubly Stochastic Matrix by a Newton-type Method*

In this talk, we present a Newton-type method for finding the nearest doubly stochastic matrix in the Frobenius norm to a given matrix. The optimality condition of this problem can be stated as a system of strongly semismooth functions. We study

a Newton-type method to solve this system, and thus finding the nearest doubly stochastic matrix. We provide a sufficient condition for the quadratic convergence of the semismooth Newton method. We also propose a modified Newton method for the general case. This is a joint work with Haesol Im, Xinxin Li and Henry Wolkowicz.

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**BORIS MORDUKHOVICH**, Wayne State University
[Friday December 4 / vendredi 4 décembre, 15:30]
*A Generalized Newton Method for Subgradient Systems*

This talk presents a new Newton-type algorithm to solve subdifferential inclusions defined by subgradients of extended-real-valued prox-regular functions. The proposed algorithm is formulated in terms of the second-order subdifferential of such functions that enjoys extensive calculus rules and can be efficiently computed for broad classes of extended-real-valued functions. Based on this and on metric regularity and subregularity properties of subgradient mappings, we establish verifiable conditions ensuring well-posedness of the proposed algorithm and its local superlinear convergence. The obtained results are also new for the class of equations defined by continuously differentiable functions with Lipschitzian derivatives , which is the underlying case of our consideration. The developed algorithm for prox-regular functions is formulated in terms of proximal mappings related to and reduces to Moreau envelopes. Besides numerous illustrative examples and comparison with known algorithms, we present applications of the proposed algorithm to the practically important class of Lasso problems arising in statistics and machine learning. Based on joint work with P.D. Khanh (University of Chile) and V. T. Phat (Wayne State University)

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**WALAA MOURSI**, Waterloo
[Friday December 4 / vendredi 4 décembre, 16:00]

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**HRISTO SENDOV**, The University of Western Ontario
[Sunday December 6 / dimanche 6 décembre, 15:00]
*A unified approach to operator monotone functions*

The notion of operator monotonicity dates back to a work by Löwner in 1934. A map $F : S^n \to S^m$ is called $operator\ monotone$, if $A \succeq B$ implies $F(A) \succeq F(B)$. (Here, $S^n$ is the space of symmetric matrices with the semidefinite partial order $\succeq$.) Often, the function $F$ is defined in terms of an underlying simpler function $f$. Of main interest is to find the properties of $f$ that characterize operator monotonicity of $F$. In that case, it is said that $f$ is also operator monotone. Classical examples are the Löwner operators and the spectral (scalar-valued isotropic) functions. Operator monotonicity for these two classes of functions is characterized in seemingly very different ways.

This talk extends the notion of operator monotonicity to symmetric functions $f$ on $k$ arguments. The latter is used to define $(generated)\ k\text{-}isotropic\ maps\ F : S^n \to S^{\binom{n}{k}}$ for any $n \geq k$. Necessary and sufficient conditions are given for $f$ to generate an operator monotone $k$-isotropic map $F$. When $k = 1$, the $k$-isotropic map becomes a Löwner operator and when $k = n$ it becomes a spectral function. This allows us to reconcile and explain the differences between the conditions for monotonicity for the Löwner operators and the spectral functions.

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**MOHAMED TAWHID**, Thompson Rivers University
[Saturday December 5 / samedi 5 décembre, 16:00]
*Improved Salp Swarm Optimization Algorithm for Data Clustering*

In this works, an improved Salp Swarm Optimization algorithm is proposed for data clustering. Our proposed algorithm utilizes the crossover operator to obtain an improvised version of the existing Salp Swarm Optimization algorithm. The performance of our suggested algorithm is tested by comparing the proposed algorithms with standard Salp Swarm Optimization algorithm and other existing algorithms in the literature. The performance of our algorithm outperforms the performance of other algorithms for the data clustering problem in terms of computational time and accuracy.

**LEVENT TUNCEL**, University of Waterloo
[Sunday December 6 / dimanche 6 décembre, 14:00]
*A journey from the theory of self-concordant functions and variable metrics to applications in convex optimization*

Abstract: Self-concordant functions (variation of the Hessian is bounded by a suitable function of the Hessian) and variable metric methods are central to many of the successful approaches for solving convex optimization problems. We will report on some of the recent progress on solving convex optimization problems by algorithms designed via self-concordant functions and variable metric methods. We will treat convex optimization problems that can be formulated by using, in some combination, second-order cones, cones of symmetric positive semidefinite matrices, power functions and $p$-norms, entropy function, relative vector entropy, quantum entropy, hyperbolic multivariate polynomial inequalities, nuclear norm and many others. Among important features of our approach are that our algorithms deliver dual certificates and that our algorithms are easily extensible to cover new classes of convex sets.

This talk is based on joint work with Mehdi Karimi.

**STEVE VAVASIS**, Waterloo
[Sunday December 6 / dimanche 6 décembre, 14:30]

**JANE YE**, University of Victoria
[Sunday December 6 / dimanche 6 décembre, 16:30]
*Second-order optimality conditions for non-convex set-constrained optimization problems*

In this paper we study second-order optimality conditions for non-convex set-constrained optimization problems. For a convex set-constrained optimization problem, it is well-known that second-order optimality conditions involve the support function of the second-order tangent set. In this paper we propose two approaches for establishing second-order optimality conditions for the non-convex case. In the first approach we extend the concept of the support function so that it is applicable to general non-convex set-constrained problems, whereas in the second approach we introduce the notion of the directional regular tangent cone and apply classical results of convex duality theory. Besides the second-order optimality conditions, the novelty of our approach lies in the systematic introduction and use, respectively, of directional versions of well-known concepts from variational analysis.

## Abstracts/Résumés

**JOSE ALVILEZ**, University of Waterloo

**ALI ASADI-VASFI**, University of Tehran

*The radius of comparison of the crossed product by a tracially strictly approximately inner action*

Let $G$ be a finite group, let $A$ be an infinite-dimensional stably finite simple unital C*-algebra, and let $\alpha\colon G \to \mathrm{Aut}(A)$ be a tracially strictly approximately inner action of $G$ on $A$. Then the radius of comparison satisfies $\mathrm{rc}(A) \leq \mathrm{rc}\left(A \rtimes_\alpha G\right)$ and if $A \rtimes_\alpha G$ is simple, then $\mathrm{rc}(A) \leq \mathrm{rc}\left(A \rtimes_\alpha G\right) \leq \mathrm{rc}(A^\alpha)$.

Also, for every finite group $G$ and for every $\eta \in \left(0, \frac{1}{\mathrm{card}(G)}\right)$, we construct a simple separable unital AH algebra $A$ with stable rank one and a strictly approximately inner action $\alpha\colon G \to \mathrm{Aut}(A)$ such that:

(1) $\alpha$ is pointwise outer and doesn't have the weak tracial Rokhlin property.

(2) $\mathrm{rc}(A) = \mathrm{rc}\left(A \rtimes_\alpha G\right) = \eta$.

**MARYAM BASIRI**, University of Ottawa

**DAMANVIR SINGH BINNER**, Simon Fraser University

*Proofs of Berkovich and Uncu's Conjectures on Integer Partitions using Frobenius numbers*

We use techniques from elementary number theory (such as Frobenius numbers) to combinatorially prove four recent conjectures of Berkovich and Uncu (Ann. Comb. 23 (2019) 263284) regarding inequalities between the sizes of two closely related sets consisting of integer partitions whose parts lie in the interval s, s+1,..., L+s. Further restrictions are placed on the sets by specifying impermissible parts as well as a minimum part.

**BENOÎT CORSINI**, McGill University

**HERMIE MONTERDE**, University of Manitoba

**AARON SLOBODIN**, The University of Victoria

*2-Limited Broadcast Domination in Grid Graphs*

Suppose there is a transmitter located at each vertex of a graph $G$. A $k$-limited broadcast on $G$ is an assignment of the integers $0, 1, \ldots, k$ to the vertices of $G$. The integer assigned to the vertex $x$ represents the strength of the broadcast from $x$, where strength $0$ means the transmitter at $x$ is not broadcasting. A broadcast of positive strength $s$ from $x$ is heard by all vertices at distance at most $s$ from $x$. A $k$-limited broadcast is called dominating if every vertex assigned $0$ is within distance $d$ of a vertex whose transmitter is broadcasting with strength at least $d$. The $k$-limited broadcast domination number of $G$ is the minimum possible value of the sum of the strengths of the broadcasts in a $k$-limited dominating broadcast of $G$. Observe that the $1$-limited broadcast domination number of $G$ equals the domination number of $G$.

We give tight upper and lower bounds for the $2$-limited broadcast domination of Cartesian products of paths. The upper bounds are established by explicit constructions. The methods to obtain the lower bounds utilize the dual of $2$-limited broadcast domination, $2$-limited multipacking.

**NAZANIN ZAKER AND LAURENCE KETCHEMEN TCHOUAGA**, University of Ottawa

*The effect of movement behavior on population density in fragmented landscapes*

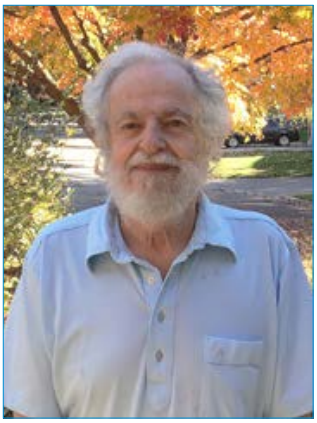
Landscape fragmentation arises from human activities and natural causes, and may create abrupt transitions (interfaces) in landscape quality. How landscape fragmentation affects ecosystems diversity and stability depends, among other things, on how individuals move through the landscape. In this work, we focus on the movement behavior at an interface between habitat patches of different quality. Specifically, we study how this individual-level behavior affects the steady state of a density of a diffusing and logistically growing population in two adjacent patches.

We consider a model for population dynamics in a habitat consisting of two homogeneous one-dimensional patches in a coupled ecological reaction diffusion equation. The movement between patches is incorporated into the interface conditions. We establish the existence, uniqueness, and global asymptotic stability of the steady state. Then we explore how the qualitative properties of the steady state depend on movement behavior.

We apply our analysis to a previous result where it was shown that a randomly diffusing population in a continuously varying habitat can exceed the carrying capacity at steady state. We clarify the role of nonrandom movement in this context. In particular, we determine conditions on movement rates and patch preference, so that the steady-state density exceeds the carrying capacity.

# CMS Fellows 2020 / Fellows de la SMC 2020

**Alejandro Adem**

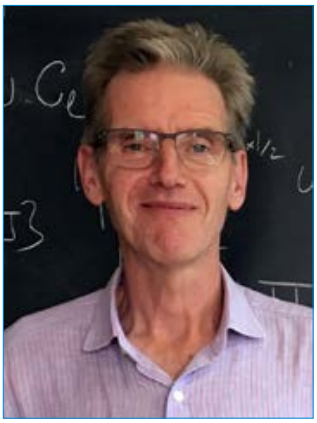


**John Friedlander**

**Robert J. McCann**

**Kai Behrend**

**Kathryn E. Hare**



**James A. Mingo**

**Henri Darmon**

**Claude Levesque**

**Luc Vinet**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