Differential Geometry and Mathematical Physics
Géométrie différentielle et physique mathématique
(Org: **Eric Bahuaud** (Seattle University) and/et **Frédéric Rochon** (UQÀM))

ARAM ALYOUSEF, University of Alberta
Yamabe Flow on Asymptotically Hyperbolic Manifolds

We study the Yamabe flow on conformally compact asymptotically hyperbolic manifolds, establishing short-time existence and uniqueness, and investigating the preservation of the asymptotically hyperbolic structure, including the polyhomogeneous regularity of the flow at conformal infinity. Under suitable assumptions on the conformal class, we establish long-time existence and convergence to a metric of constant negative scalar curvature. Our approach combines geometric maximum principles with parabolic analysis in weighted Hölder spaces. This is joint work with Eric Bahuaud and Eric Woolgar.

ABDOU OUSSAMA BENABIDA, UBC
Conical asymptotics for conformally balanced and HYM metrics

Motivated by the Chern-Strominger system and conifold transitions, we will discuss a conical asymptotics theorem for conformally balanced metrics near the vertex of a regular Calabi-Yau cone of complex dimension three. Under scale-invariant regularity bounds, and decay of $\partial\bar{\partial}\omega$, we obtain a unique asymptotic Calabi-Yau cone metric with a positive rate of convergence. For non-flat cones, we also establish compatible asymptotics for Hermitian-Yang-Mills metrics on the holomorphic tangent bundle.

MAURICIO BUSTAMANTE, Universidad Católica de Chile
Non-nullbordant aspherical manifolds

A manifold is called aspherical if its universal cover is contractible. Examples of aspherical manifolds are tori, hyperbolic manifolds and nonpositively curved manifolds. Hence the homotopy type of aspherical manifolds is encoded in their fundamental groups. It is therefore interesting to investigate the extent to which other topological properties of these manifolds are constrained by the fundamental group. In that regard, it was conjectured that closed aspherical manifolds whose fundamental group has nontrivial center were boundaries. In my talk I will show how using *hyperbolization* – a process to turn a triangulated manifold into an aspherical manifold– one can disprove this conjecture.

FACUNDO CAMANO, University of Waterloo
Monopolization of Tesserons

Monopolization is a conjecture by Sergey Cherkis that all tesserons (hyperkahler gravitational instantons) may be realized as monopole moduli spaces. In the first half of the talk, we will motivate the conjecture and cover some of the mentioned monopole moduli spaces and the Gromov-Hausdorff relations between them. In the second half of the talk, I will present recent work investigating a particular Gromov-Hausdorff limit of moduli spaces of singular monopoles on R3.

EMILY CLIFF, Université de Sherbrooke
Classification of smooth principal 2-group bundles

A smooth 2-group $\mathcal{G}$ is a categorical analogue of a Lie group: it is a smooth stack with a multiplication morphism, associative up to 2-isomorphism. I will explain several approaches to the classification of principal $\mathcal{G}$-bundles over a smooth manifold or stack, paralleling the classifications of ordinary principal bundles via local/cocycle data or maps into the classifying stack. I will outline the anticipated application of this framework to Chern–Simons theory. This is joint work in progress with Dan Berwick-Evans and Laura Murray, building on previous work with Berwick-Evans, Murray, Apurva Nakade, and Emma Phillips on the classification of principal bundles for finite 2-groups and applications to Dijkgraaf–Witten theory.

BENJAMIN FRIEDMAN, Université du Québec à Montréal
Special Lagrangian submanifolds in non-Kähler Calabi-Yau manifolds

Given a (possibly non-Kähler) Calabi–Yau threefold (X, Ω), we introduce the notion of a (perturbed) special Lagrangian (SL) submanifold of (X, ω, Ω), where ω is a Hermitian metric on X. The equations defining this class of submanifolds reduce to the usual SL equations when ω is a Kähler metric. Using the Sard-Smale technique, we prove the existence of a comeagre set of Hermitian metrics ω on X such that the moduli space of perturbed SL submanifolds in (X, ω, Ω) consists of isolated points. We also explore some of the known results about deformations of SL submanifolds in a non-Kähler setting.

CHRISTINE GUENTHER, Pacific University
Linear and Nonlinear Stability of the Bach flow

The Bach flow is a geometric curvature flow that is associated to the Bach tensor, and decreases the Weyl energy functional in dimension 4. We introduce the flow and discuss its linear and nonlinear stability at 4-dimensional space forms.

ROBERT HARRIS, UQÀM
Exotic structures on non-simply connected 4-manifolds

To build exotic 4-manifolds (homeomorphic manifolds that are not diffeomorphic) with non-trivial π_1, one typically needs two ingredients: A free, smooth action on a simply connected space and an equivariant operation to modify the smooth structure on the quotient. We discuss what makes certain universal covers candidates better than others, some of the obstructions to finding exotic structures on quotients, and one of the end goals for these constructions (definite exotica). This is based on joint work with P. Naylor and B. D. Park.

HARI KUNDURI, McMaster University
A Comparison Theorem For the Mass of ALE and ALF Toric 4-Manifolds

I will outline the proof of sharp lower bounds for the mass of asymptotically locally Euclidean (ALE) and asymptotically locally flat (ALF) toric 4-manifolds with non-negative scalar curvature. These lower bounds can be written in terms of the mass of 'equilibrium' geometries consisting of gravitational instantons - complete Ricci flat manifolds - with the same weighted orbit space structure as the original manifold and an expression determined by the conical angle defects of totally geodesic 2-spheres within the instanton that serve as generators for its second homology. These results may be viewed in the context of positive mass theorems, providing an explanation of how positivity can fail in the ALE/ALF setting (the work is in collaboration with Aghil Alaee and Marcus Khuri).

KUAN-HUI LEE, McGill University
Pluriclosed 3-folds with vanishing Bismut Ricci form

In this talk, we discuss complex 3-dimensional non-Kähler Bismut Ricci flat pluirclosed Hermitian manifolds (BHE) via their dimensional reduction to a special Kähler geometry in complex dimension 2. The reduced geometry satisfies a 6th order non-linear PDE which has infinite dimensional momentum map interpretation, similar to much-studied Kähler metrics of constant scalar curvature (cscK). We use this to associate to the reduced manifold or orbifold Mabuchi functional, as well as to obtain obstructions for the existence of solutions in terms of the automorphism group. Furthermore, we discuss explicit solutions of the PDE on orthotoric Kähler orbifold surfaces which construct some new BHE examples.

MAXENCE MAYRAND, Université de Sherbrooke
Complex abelian varieties and quantum error correction

I will explain how the theory of complex abelian varieties provides a natural and rigorous framework for one of the leading approaches to quantum error correction, known as GKP codes. This makes the tools of complex geometry directly applicable to a concrete and active area of quantum computing. In particular, we show that GKP codes correspond exactly to polarized complex abelian varieties, and that their main features become familiar geometric objects: code states are theta functions, an important class of logical gates comes from automorphisms, and robustness to noise is governed by systolic invariants. Conversely, natural questions in quantum error correction become problems in complex geometry, such as optimization over moduli spaces of polarized abelian varieties. No prior background on quantum error correction will be assumed. This talk is based on joint work with Baptiste Royer, arXiv:2605.28784.

RUXANDRA MORARU, University of Waterloo
Co-Higgs bundles and holomorphic Poisson structures

Co-Higgs bundles on a complex manifold M are pairs (E, ϕ), where E is a holomorphic vector bundle on M and $\phi \in H^0(M, \mathrm{End(E)} \otimes \mathrm{TM})$ is a Higgs field satisfying the integrability condition $\phi \wedge \phi = 0$. Such objects are equivalent to generalized holomorphic bundles on complex manifolds. Moreover, the Higgs field induces a distinguished class of holomorphic Poisson structures on the projectivization $\mathbb{P}(E)$, yielding numerous examples of compact holomorphic Poisson manifolds. This correspondence was first observed by A. Polishchuk, while moduli spaces of stable rank-2 co-Higgs bundles were constructed by S. Rayan on $\mathbb{P}^1$ and $\mathbb{P}^2$. In this talk, we examine the interplay between the algebraic properties of Higgs fields and the geometry of the associated Poisson manifolds, and we present new examples on curves and surfaces.

TRISTAN OZUCH, MIT
Positive Einstein metrics on infinitely many 4-manifolds

We construct Einstein metrics with positive scalar curvature on two infinite families of 4-manifolds. Via Wick rotation, we obtain static axisymmetric Lorentzian spacetimes with positive cosmological constant and arbitrarily many horizons of equal surface gravity. As the topology increases, the metrics collapse to an explicit 2-disk while bubbling off periodic gravitational instantons with Kasner asymptotics, one of which is new.

CRISTINA STOICA, Wilfrid Laurier University
Deformation of Symmetry and Persistence of Dynamics

We investigate the persistence of local dynamics in Hamiltonian systems under deformation from the Euclidean plane to surfaces of constant curvature. For each fixed sign of curvature, we consider Hamiltonian systems on the sphere or hyperbolic plane, recovering the Euclidean plane as the curvature tends to zero. The deformation of symmetry is described by the Inönü–Wigner contraction of Lie algebras from so(3) or so(2,1) to se(2). Using Riemannian exponential coordinates and a local symplectic slice construction, we establish the persistence of non-degenerate relative equilibria and relative periodic orbits for general cotangent-bundle Hamiltonian systems. We illustrate the results with applications to the Newtonian n-body problem on curved spaces.

ERIC WOOLGAR, University of Alberta
Spacetime conformal boundary causal rigidity

A well-known boundary rigidity problem for Riemannian geometry asks whether a manifold-with-boundary, such that all geodesic chords have the same length, is necessarily a round hemisphere. It is, and therefore any chord leaving a given boundary point passes through that point's antipode. For Lorentzian geometry, we pose the following conformal boundary rigidity problem. If all light rays leaving a point p in the distant past (Penrose's conformal infinity) refocus at the same point q in the distant future, and if the same is true for all such p, is the spacetime conformal to a maximally symmetric spacetime? For example, if the spacetime is also asymptotically anti-de Sitter, is it actually anti-de Sitter (up to conformal transformations that preserve the asymptotics)? I will answer this question, assuming that the spacetime is also stationary, based on joint work with Gabriel

Paternain. Time permitting, I will discuss joint work with Alex Sandhu and Giulio Sanzeni on the positive cosmological constant version of this problem.

XUWEN ZHU, Northeastern University
Degenerations of gravitational instantons

Gravitational instantons are noncompact 4-dimensional Calabi-Yau manifolds, and there have been many recent developments in understanding their analytic and geometric properties. Depending on the end structure at infinity, gravitational instantons are divided into six types, ALE/F/G/G*/H*/H. In this talk I will talk about the connections among some of these types, showing that one type of gravitational instanton can degenerate into another type. In particular, I will talk about the following projects: (1) degenerations of ALG and ALH*, in joint work with Yu-Shen Lin and Sid Soundararajan; (2) degenerations of ALF, partly in joint work with Alia Yusaini. Several types of analysis techniques are used here, and all of these can be seen as a step towards building a global compactification of moduli spaces of all gravitational instantons.