ABSTRACTS / RÉSUMÉS DE CONFÉRENCES

JEFFERY-WILLIAMS LECTURE / CONFÉRENCE JEFFERY-WILLIAMS

GEORGE ELLIOTT, Department of Mathematics, University of Toronto, Toronto, Ontario M5S 3G3, Canada (also affiliated with the Fields Institute and the University of Copenhagen)
C^*-algebras—the first fifty years

It is now seventy years since the publication of von Neumann's bicommutant theorem, which might be said to be the beginning of operator algebra theory. During this time, not only have von Neumann algebras—the bicommutants, or double centralizers, of self-adjoint sets of bounded operators in Hilbert space—been studied—in some settings exhaustively—but also, especially in the last fifty years, general norm-closed self-adjoint subalgebras of such operators have been considered. In both categories, the so-called amenable objects are of special interest. Work of Connes and others has resulted in a surprisingly complete theory of amenable von Neumann algebras, including, in particular, a complete classification, in terms of simple invariants. (The conjugacy theory of subalgebras of such algebras, due to Jones and others, should also of course be mentioned.) The theory of amenable C^*-algebras has developed more or less at the same time and in the same way. Far from being complete, however, it is perhaps now entering its most exciting phase of development.

KRIEGER-NELSON LECTURE / CONFÉRENCE KRIEGER-NELSON

CATHERINE SULEM, Department of Mathematics, University of Toronto, Toronto, Ontario M5S 3G3, Canada
Nonlinear Schrödinger equation and wave collapse

Wave propagation describes phenomena in many physical systems : for example water waves, laser beams, plasmas. Wave collapse or blow-up means that some physical quantities change by several orders of magnitude over relatively short times. The most basic mathematical model of wave dynamics is the Nonlinear Schrödinger Equation. The formation of singularities in a solution reflects blow-up or collapse.

Blowing-up of solutions is important because the character of the singularity strongly affects the physics, even when the blow-up is eventually arrested by effects such as dissipation or coupling. I will describe a variety of approaches to the understanding of these phenomena, ranging from mathematical analysis to formal asymptotic expansions and numerical simulations.

PUBLIC LECTURE / CONFÉRENCE PUBLIQUE

F. WILLIAM LAWVERE, Department of Mathematics, SUNY at Buffalo, Buffalo, New York 14214, USA
Everyday physics of extended bodies or why functionals need analyzing

PLENARY SPEAKERS / CONFÉRENCIERS PRINCIPAUX

KENNETH R. DAVIDSON, Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
Polynomially bounded operators

An old problem in operator theory which dates back to the late 1940's asks for a simple criterion to determine if an operator acting on a Hilbert space is similar to a contraction (an operator with norm at most one). In the usual fashion of mathematics, Sz. Nagy proposed a simple criterion as a conjecture. This first attempt was proven wrong, to be replaced by another more sophisticated one popularized by Halmos. This problem was the seed for many deep and important developments in operator theory involving the notion of complete boundedness, which was introduced by Arveson in the late 1960's. This led to the first reasonable condition equivalent to similarity to a contraction by Paulsen. However only very recently has the Halmos conjecture been put to rest by a remarkable counterexample due to Pisier. The purpose of this talk is to survey the history of this problem.

DETLEF GROMOLL, SUNY Stony Brook, Stony Brook, New York 11794-3651, USA
Metric foliations and nonnegative curvature

Metric foliations of a riemannian space have leaves any two of which are locally everywhere equidistant, such as level sets of distance functions or orbits under isometric group actions. Aside from the intrinsic appeal of understanding such configurations both from a global and local point of view, they are playing an increasingly important role in other areas of geometry. They arise prominently in connection with rigidity aspects in the structure theory of nonnegatively curved manifolds, as well as in the construction of various types of examples by warping methods. We will discuss key ideas and developments in this direction, including recent progress in and the current state of classifying metric foliations in round spheres and euclidean spaces.

ERWIN LUTWAK, Department of Applied Mathematics and Physics, Polytechnic University, Brooklyn, New York 11201, USA
The Minkowski problem after 100 years—lots of new questions

The celebrated Minkowski problem (now one hundred years old) has had a significant impact on Twentieth Century mathematics, from discrete and convex geometry to partial differential equations.

The original formulation of the Minkowski problem asks for necessary and sufficient conditions on a given set of vectors in order that there exist a polytope each of whose faces has one of the given vectors as an outer normal and such that the area of each face of the polytope is equal to the length of its corresponding normal vector. In his review of Pogorelov's book on the Minkowski problem, Calabi stated "The importance of the Minkowski problem and its solution is to be felt both in differential geometry and elliptic partial differential equations, on either count going far beyond the impact that the literal statement superficially may have. From the geometric view point it is the Rosetta Stone, from which several related problems can be solved."

It has recently come to be recognized that the Minkowski problem is part of a family of related problems. These problems appear naturally in the study of abrasion of metals, in affine differential geometry, as well as in geometric convexity. Special cases of the one-dimensional versions of these problems can be reformulated as a family of questions regarding polygons in the Euclidean plane. Some of these questions can be explained to, appreciated by, and probably even answered by talented high school students. The higher-dimensional versions of these problems lead to deep questions about a fascinating class of elliptic partial differential equations.

STEPHEN SCHANUEL, Department of Mathmatics, SUNY at Buffalo, Buffalo, New York 14214, USA

Objective number theory

Classical number theory may be thought of as the arithmetic of addition, multiplication, and exponentiation of isomorphism classes of finite sets, *i.e.* natural numbers. Joint work with F. W. Lawvere, generalizing this to the corresponding operations on objects in more general categories, includes analogs of classical algebraic and transcendental number theory, including some results whose analogs in the classical case remain only conjectures.

Category Theory / Théorie des catégories
(Richard Wood, Organizer)

MICHAEL BARR, Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada
$*$-autonomous categories

MARTA BUNGE, Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada
Covering toposes with singularities

The notion in the title refers to complete spreads in Topos Theory, a generalization due to M. Bunge and J. Funk (1996) of the corresponding topological notion introduced by R. H. Fox (*Covering spaces with singularities.* In: (eds., R. H. Fox et al), Algebraic Geometry and Topology: a Symposium in Honor of S. Lefschetz, Princeton Univ. Press, 1957, 243–257).

The purpose of this talk is to first review the various equivalent ways to think of complete spreads that are now available, and then to discuss some of the implications of such identifications. For an $\mathcal{S}$-bounded topos $\mathcal{E}$, the following categories are equivalent to the category of $\mathcal{S}$-valued *distributions* on $\mathcal{E}$ (in the sense of F. W. Lawvere, *Measures in Toposes.* Lectures at the Aarhus Workshop in Categorical Methods in Geometry, 1983): (1) the category of $\mathcal{S}$-points of the symmetric topos $M\mathcal{E}$ (M. Bunge, *Cosheaves and Distributions on Toposes.* Algebra Universalis **34**(1995), 469–484); (2) the category of *$\mathcal{S}$-complete spreads* over $\mathcal{E}$ with locally connected domains (M. Bunge and J. Funk, *Spreads and the Symmetric Topos.* J. Pure. Appl. Algebra **113**(1996), 1–38); (3) the category of *M-discrete fibrations* over $\mathcal{E}$ in Top$/\mathcal{S}$ (M. Bunge and J. Funk, *On a Bicomma Object condition for KZ-doctrines.* J Pure. Appl. Algebra, to appear); and (4) the dual of the category of *distribution algebras* in $\mathcal{E}$ over $\mathcal{S}$ (M. Bunge, J. Funk and Jibladze, *Distribution algebras.* in preparation).

Of particular interest in this program is the interplay that takes place between Functional Analysis (Theory of Distributions), Model Theory (Classifying Toposes), Algebraic Topology (Covering Spaces), Category Theory (Fibered Categories) and Lattice Theory (Heyting Algebras).

PETER FREYD, 2020 1/2 Addison Street, Philadelphia, Pennsylvania 19146, USA
Title to be announced

ANDRÉ JOYAL, Département de mathématiques, Université du Québec à Montréal, Montréal, Québec H3C 3P8, Canada
Title to be announced

F. WILLIAM LAWVERE, Department of Mathmatics, SUNY at Buffalo, Buffalo, New York 14214, USA
Are homotopy types the same as infinitesimal skeleta?

Among the functors $\mathcal{S} \to \mathcal{X}$ between cartesian-closed categories which have both left and right adjoints, there are those special ones in which those two adjoints are isomorphic, *i.e.* in which so to speak every component of an object X contains a unique point of X. For example, $\mathcal{S}$ could be the classifying topos for algebraic field extensions of a given field while $\mathcal{X}$ is the classifying topos for strongly local algebras over the same base; or $\mathcal{X}$ could be the category of presheaves for a category in $\mathcal{S}$ which has a terminal object which is also initial. Such could obviously arise by taking a suitable part $\mathcal{X} = \mathrm{Infl}(\mathcal{Z}) \to \mathcal{Z}$ of a large $\mathcal{Z}$ on which the two adjoints do not necessarily agree. But an opposite way to get from $\mathcal{Z}$ to such a special $\mathcal{X}$ arises by the

Hurewicz construction for the case where the left adjoint from $\mathcal{Z}$ to $\mathcal{S}$ preserves finite products: the resulting re-enrichment $\mathcal{Z} \to \mathcal{H}_o(\mathcal{Z}) = \mathcal{X}$ will satisfy our special equation if the left adjoint actually preserves infinite ($\mathcal{S}$-indexed) products, which is to be expected if components can be detected using continuous intervals, but not if only combinatorial intervals are available in $\mathcal{Z}$. Thus, although considerable fine-tuning of the setting (over fixed $\mathcal{S}$) is still needed, it appears that the answer to the question in the title is: No, they are identical opposites.

MICHAEL MAKKAI, Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada
Weak higher dimensional categories: a progress report

SUSAN NIEFIELD, Union College, Schenectady, New York 12308, USA
Monoidal (bi)categories, bimodules, and adjunctions

In this joint work with Richard Wood, we consider variations of the following earlier result of the speaker. If $\mathcal{V}$ is a monoidal category with coequalizers preserved by $\otimes$, then there is an adjoint pair

$$\mathrm{Mod}(\mathcal{V})^{\mathrm{op}} \underset{\mathrm{Ev}}{\overset{\mathrm{Mod}}{\rightleftarrows}} \mathrm{Moncat}\,/\mathcal{V}$$

where Mod takes a $\mathcal{V}$-monoid M to the category of M-M-bimodules and Ev takes a monoidal functor $p\colon \mathcal{W} \to \mathcal{V}$ to the $\mathcal{V}$-monoid pI.

In each case, we consider a "module" functor which takes values in a category of monoidal categories with a suitable choice of morphisms. First, we replace $\mathrm{Mon}(\mathcal{V})$ by $\mathcal{V}$-cat and $\mathrm{Moncat}\,/\mathcal{V}$ by monoidal categories over certain categories of matrices in $\mathcal{V}$. Next, we assume $\mathcal{V}$ is symmetric and obtain an adjunction between commutative $\mathcal{V}$-monoids and monoidal $\mathcal{V}$-categories. Finally, we generalize this to an adjunction between braided monoidal $\mathcal{V}$-categories and monoidal $\mathcal{V}$-bicategories.

ROBERT PARÉ, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3J 3J5, Canada
Functorial finite differences

JOAN WICK PELLETIER, Department of Mathematics and Statistics, York University, Toronto, Ontario M4J 1P3, Canada
Points and simplicity in quantales

The formulation of the notion of point of a quantale has been at the heart of several papers by the author and others. One method of approaching the question in the context of involutive Gelfand quantales is to extrapolate from the situation of the spectrum $\mathrm{Max}\,A$ of a C^*-algebra A. Here the intuitive feeling that points should be irreducible representations leads to the definition of point as an irreducible representation $Q \to \mathcal{Q}(S)$, where $\mathcal{Q}(S)$ is the Hilbert quantale on the complete atomic orthomodular lattice S. This definition is validated by the fact that $\mathcal{Q}(S)$ admits no points in this sense save the identity. Alternatively, the notion of point of a quantale can derive from that of a simple quantale, that is, a quantale having only trivial quotients. Recent characterizations of simple quantales show that the class of simple involutive quantales properly contains the above quantales $\mathcal{Q}(S)$. The different notions of points are investigated and compared.

WALTER P. THOLEN, Department of Mathematics and Statistics, York University, Toronto, Ontario M3J 1P3, Canada
Topology based on maps

Compared with the large variety of notions on spaces, maps seem to play a minor role in General Topology. We wish to show that it is beneficial to think of fundamental object notions as being induced by particular classes of morphisms. Hence, with any class $\mathcal{F}$ of morphisms in a category satisfying some weak but essential properties we associate two new classes of morphisms, $\mathcal{F}^*$ and $\mathcal{F}'$, and two classes of objects, $C\mathcal{F}$ and $D\mathcal{F}$, such that, under suitable restriction, both C and D belong to known and fundamental Galois correspondences. For example, for $\mathcal{F}$ the class of closed continuous maps in the category of topological spaces, $\mathcal{F}^*$ and $\mathcal{F}'$ are the classes of proper and of separated maps, respectively, and $C\mathcal{F}$ and $D\mathcal{F}$ are the categories of compact spaces and of Hausdorff spaces, respectively. Other interesting choices for $\mathcal{F}$ would include the classes of open maps and of dense maps. Among other things we wish to

- explore the interaction of the classes $C\mathcal{F}$ and $D\mathcal{F}$ and derive their standard properties which, in the paradigmatic example, gives a surprisingly complete theory of compactness/Hausdorff separation/perfectness
- discuss with the same general methods connectedness/total disconnectness, both at the object and map levels
- show that the required axioms are satisfied for the three basic choices for $\mathcal{F}$ (as mentioned above for spaces) and are actually available in any category which comes equipped with a (reasonably good) closure operator
- demonstrate that the morphism-object interaction is advantageously reversed by slicing the categories in question, giving us also a safe guideline for the "right" fibrewise notions
- apply the theory in particular to Diers' Zariski closure for algebraic sets (with respect to any monad over sets).

MYLES TIERNEY, Department of Mathematics, Rutgers University, New Brunswick, New Jersey 08903, USA
Some remarks on torsors

In this talk, which is joint work with André Joyal, we examine various notions of torsors as representors of sheaf cohomology. Specifically, we compare our $K(\pi, n-1)$ torsors with the $K(\pi, n)$ torsors of Duskin.

ROBERT F. C. WALTERS, Sydney
Bicategories of processes

Convex Geometry / Géométrie convexe
(A. C. Thompson, Organizer)

LYNN BATTEN, Department of Mathematics, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada
Linear binary codes of minimum distance

A linear binary $[n, k, d]$-code C is a k-dimensional subspace of $V(n, 2)$. Here, d refers to the *minimum distance* of the code, which is the minimum of all Hamming distances between two distinct vectors (Hamming distance being defined as the number of positions in which two vectors differ).

A good $[n, k, d]$-code has small n (for fast transmission of messages), large k (to enable transmission of many messages) and large d (to correct many errors). These aims conflict, and produce the *main coding theory problem* which is to optimize one of the three parameters for fixed values of the other two. It turns out that maximizing n and maximizing k are equivalent problems.

If C has minimum distance d the *packing radius* is $t = (d-1)/2$. Thus, each codeword is located at the *centre* of a sphere of radius t in which it is the only codeword. The best error correction is therefore achieved for largest possible t, and hence largest possible d. Thus the *packing problem* of covering $V(n, 2)$ with large spheres, is equivalent to maximizing d in C.

Much is known about the maximum $n(k)$ possible when $k(n)$ and d are fixed and d is ≤ 4. However, for $d = 5$ there are still many questions which need answers.

In this talk we review what is known for $d = 4$, and consider what needs to be done for $d = 5$.

ANDRÁS BEZDEK, The Mathematical Institute of the Hungarian Academy of Science, Budapest, Auburn University, Auburn, Alabama 36849-5310, USA
On fat polygons and polyhedra

(Joint work with Ferenc Fodor)

We investigate the problem of finding the polygons (polyhedra resp.) with n vertices and of diameter 1 which have the largest possible width $w(n)$ (W(n) resp). We prove that $w(3) = w(4) = \frac{\sqrt{3}}{2}$ and $W(4) = W(5) = \frac{1}{\sqrt{2}}$ and in general $w(n) \leq \cos\frac{\pi}{2n}$. In the later upper bound equality holds if n has an odd divisor greater than 1 and in this case a polygon $\mathcal{P}$ is extremal if and only if it has equal sides and it is inscribed in a Reuleaux polygon of constant width 1, so that the vertices of the Reuleaux polygon are also vertices of $\mathcal{P}$.

TIBOR BISZTRICZKY, Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T2N 1N4, Canada
A construction for periodically-cyclic $(2m)$*-polytopes*

For each v, k and m such that $v \geq k \geq 2m+2 \geq 8$, we construct a periodically-cyclic Gale $2m$-polytope with v vertices and the period k. For such a polytope,there is a complete description of its facets based upon a labelling(total ordering) of the vertices such that every subset of k successive vertices generates a cyclic $2m$-polytope.

J. BRACHO, Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, Circuito Exterior, Ciudad Universitaria, Mexico
A three-dimensional Hadwiger-type theorem for transversals

BEIFANG CHEN, Department of Mathematics, Hong Kong University of Science and Technology, Kowloon, Hong Kong
Minkowski algebra of convex sets

The Minkowski algebra of convex sets is the vector space generated by characteristic functions of closed convex sets and relatively open convex sets, where the multiplication is induced by the Minkowski sum of convex bodies. The homomorphisms, sub-algebras, units, and embedding of this algebra will be studied. The Euler-Radon transform with respect to the Euler measure is considered, and have shown it is injective. This injectivity solves a syzygy problem on affine Grassmannians. The purpose to study Minkowski algebra is to set up a general framework so that mixed volume theory and integral geometry can be developed algebraically.

ROBERT DAWSON, Department of Mathematics and Computer Science, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
A generalized face number for regular hyperbolic honeycombs

If, seeing an icosahedron for the first time, one wanted to find out how many faces it icosahedron had, one might might use Euler's formula in combination with the vertex figure. One might look at the curvature accounted for by each face of a spherical icosahedron. Or one might simply count the faces in a systematic manner. One would, of course, expect the same answer in every case.

The first two methods generalize fairly easily to a regular hyperbolic honeycomb. The third, also, generalizes, via divergent series. We will first examine the consistency of telescoping as a method of summing the series, and then use that method, too, on honeycombs. It will be seen that while the resulting "face numbers" may not be positive, or even integers, the three methods—based on combinatorics, differential geometry, and divergent series—still agree.

BORIS DEKSTER, Department of Mathematics and Computer Science, Mount Allison University, Sackville, New Brunswick E4L 1E6, Canada
A version of the illumination problem

Let C be a convex n-dimensional body and d be a direction. A point $p \in \partial C$ is said to be *illuminated* by d if the line through p having the direction d contains a point $q \in \operatorname{int} C$ which follows p. The body C is illuminated by a set $D = \{d_1, d_2, \ldots\}$ of directions if each of its boundary points is illuminated by a $d_i \in D$. The illumination problem is to establish the minimum integer I_n such that, given C, one can choose a set of I_n directions illuminating C. This problem is open for $n \geq 3$. According to the Hadwiger conjecture, $I_n \leq \binom{2n}{n} n(\log n + \log\log n + 5)$.

A convex n-dimensional body C is said to be *exposable* to $D = \{d_1, d_2, \ldots\}$ if there is a linear transformation $L\colon E^n \to E^n$ such that $L(C)$ and each body isometric to $L(C)$ is illuminated by D. Denote by E_n the minimum integer such that each C is exposable to a (fixed) set D of cardinality E_n. Obviously, $I_n \leq E_n$ since C is illuminated by $L^{-1}(D)$ when C is exposable to D. (For $n = 2$, $I_n = 4$ and $E_n = 7$). We establish here an upper bound for E_n. (This does not improve however either the Rogers and Zong estimate or the best known upper bound $I_e \leq 20$, due to Lassak.)

We introduce here also an affine invariant s, called *sharpness*, of a convex body. It ranges from 0 (for smooth and some other convex bodies) to $s_n = \cos^{-1}(1/n)$ (for any n-simplex). Then we use it to specify our estimates. For instance, each convex n-body of sharpness $< \sin^{-1}(1/n)$ can be illuminated by $n+1$ directions. This is an extension of a known Hadwiger's result saying that each smooth convex n-body is illuminated by $n+1$ directions.

ROBERT ERDAHL, Department of Mathematics and Statistics, Queen's University, Kingston, Ontario K7L 3N6, Canada
Dicings, Zonotopes, and Voronoi's conjecture on parallelohedra

In 1909 Voronoi conjectured that if some selection of translates of a polytope forms a facet-to-facet tiling of Euclidean space, then the polytope is affinely equivalent to the Voronoi polytope for some lattice. I show that Voronoi's conjecture holds for the special case where the parallelohedron is a zonotope.

RICHARD J. GARDNER, Department of Mathematics, Western Washington University, Bellingham, Washington 98225-9063, USA
Discrete tomography—a brief survey of recent results

New techniques in high resolution transmission electron microscopy can be used to register the number of atoms in a crystalline structure lying on each line parallel to certain special directions. For each such direction, the corresponding image is called a *discrete X-ray*. The main goal of discrete tomography is to reconstruct the structure from discrete X-rays taken in several directions.

This very young subject (really only about five years old) has already yielded substantial results. The talk will survey some of these, focussing on joint work of the speaker with Peter Gritzmann and Dieter Prangenberg.

PAUL GOODEY, Department of Mathematics, University of Oklahoma, Norman, Oklahoma 73019, USA
Inequalities between projection functions of convex bodies

(Joint work with Gaoyong Zhang)

A convex body in n-dimensional Euclidean space $\mathbb{E}^n$ is a compact convex subset with non-empty interior. It is said to be *centrally symmetric* if it is a translate of its reflection in the origin. The starting point of our investigations can be found in the work of Shephard [1964] who asked the following question:

If K and L are centrally symmetric convex bodies in $\mathbb{E}^n$, is there the implication

$$\mathrm{vol}_{n-1}(K|u^\perp) \geq \mathrm{vol}_{n-1}(L|u^\perp), \quad \forall u \in S^{n-1} \Rightarrow \mathrm{vol}_n(K) \geq \mathrm{vol}_n(L)?$$

Here, $K|u^\perp$ is the orthogonal projection of K onto the subspace of $\mathbb{E}^n$ orthogonal to the unit vector $u \in S^{n-1}$. The question was answered independently by Petty [1967] and Schneider [1967]. They both showed that the answer is affirmative if it is further assumed that K is a zonoid. Both authors also showed that this further assumption cannot be suppressed.

The generalization of the Shephard problem for lower dimensional projections of convex bodies has been open since Petty and Schneider's work, see question 4.2.1 of Gardner [1995]. It states:

If K and L are centrally symmetric convex bodies in $\mathbb{E}^n$, and $i \in \{1, \ldots, n-1\}$, is there the implication

$$\mathrm{vol}_i(K|E) \geq \mathrm{vol}_i(L|E) \quad \forall E \in \mathcal{L}_i^n \Rightarrow \mathrm{vol}_n(K) \geq \mathrm{vol}_n(L)?$$

Here $\mathcal{L}_i^n$ denotes the Grassmann manifold of all i-dimensional subspaces of $\mathbb{E}^n$. The counterpart of this problem for cross sections of convex bodies is considered by Bourgain and Zhang [1996], and by Zhang [1996].

We will obtain an answer to this generalization of Shephard's problem which is analogous to the results of Petty and Schneider. This will be achieved by establishing injectivity results for various integral transforms on Grassmann manifolds. These transforms arise very naturally in the geometry of convex bodies and their injectivity properties have special implications for bodies of revolution.

ERIC L. GRINBERG, Department of Mathematics, Temple University, Philadelphia, Pennsylvania 19122, USA
Operational properties of the cosine transform

The brightness function on the space of convex bodies can be extended to give an integral transform on function spaces that imbed convex bodies. The mapping properties of this transform can, in turn, be interpreted to give information about the original bodies. We will describe such operational properties and discuss possible applications.

PETER M. GRUBER, Vienna Technical University, A-1040 Vienna, Austria
Optimal arrangements of points on Riemannian 2-manifolds and applications

First a stability version of a theorem of L. Fejes Tóth on sums of moments is given: a large finite point set in a 2-dimensional Riemannian manifold, for which a certain sum of moments is minimal, must be approximately a regular hexagonal pattern. This result is then applied to show the following: (i) The nodes of optimal numerical integration formulae for Hoelder continuous functions on such manifolds form approximately regular hexagonal patterns if the number of nodes is large. (ii) Given a smooth convex body in $\mathbb{E}^3$, most facets of the circumscribed convex polytopes of minimum volume in essence are affine regular hexagons if the number of facets is large. A similar result holds with volume replaced by mean width. (iii) A convex polytope in $\mathbb{E}^3$ of minimal surface area, amongst those of given volume and given number of facets, has the property that most of its facets are almost regular hexagons assuming the number of facets is large.

DANIEL KLAIN, School of Mathematics, Georgia Institute of Technology, Atlanta, Georgia 30332-0160, USA
An Euler relation for valuations on polytopes

A general Euler-type relation is derived for valuations on polytopes, leading in turn to formulas for valuations on a polytope P in terms of the enumeration of polytopes contained in P that are free with respect to a given locally finite set of points in Euclidean space. Special cases include Euler relations for volume, surface area, the Euler characteristic, and integer lattice point enumeration, as well as the Dehn-Sommerville equations and Macdonald's relation for compact simplicial manifolds.

ALEXANDER KOLDOBSKY, University of Texas at San Antonio, San Antonio, Texas 78249, USA
A functional analytic approach to the Busemann-Petty problem on sections of convex bodies

The 1956 Busemann-Petty problem asks whether symmetric convex bodies in $\mathbb{R}^n$ with larger central hyperplane sections must also have greater volume. The solution to the problem has recently been completed, and the answer is negative if $n \geq 5$ and affirmative when $n \leq 4$. We show a more general result, where the inequalities for the volume of central sections are replaced by similar inequalities for the derivatives of the parallel section functions. For example, if n is an even integer, K and L are origin-symmetric convex bodies in $\mathbb{R}^n$ with $C^{(n-4)}$-boundaries and the $(n-4)$-th derivatives of the parallel section functions of K at zero (in every direction) are smaller than the corresponding derivatives for L, then $\mathrm{vol}_n(K) \leq \mathrm{vol}_n(L)$. However, if n is odd, similar inequalities for the $(n-5)$-th derivatives do not necessarily imply that the volume of K is smaller.

WLODZIMIERZ KUPERBERG, Department of Mathematics, Auburn University, Auburn, Alabama 36849-5310, USA
Packing space with congruent convex cones

(Joint work with A. Bezdek)

We consider packing arrangements of congruent cones with a convex base and finite height in 3-dimensional Euclidean space and we estimate the maximum density attained by such packings. Various admissibility restrictions on the arrangements produce various maximum densities, such as the lattice packing density, the translational packing density, and the packing density under arbitrary rigid motions. We provide some upper and lower bounds for the translational and lattice packing densities, common for all convex cones with centro-symmetric bases, and we discuss the problem of determining the packing densities of some specific cones, such as the circular cone and the square pyramid. We find of particular interest the problem of pinpointing the two "extreme" cones, one on each end of the spectrum, with respect to their translational or lattice packing densities.

TED LEWIS, Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada
An Apollonius theorem for convex sets

(Joint work with Balder Von Hohenbalken)

The classical Apollonius Problem in the plane of finding a circle tangent to three given circles can be extended to convex bodies in $\mathbf{R}^d$. The extensions and limitations thereof are discussed.

BARRY MONSON, Department of Mathematics and Statistics, University of New Brunswick-Fredericton, Fredericton, New Brunswick E3B 5A3, Canada
Realizations of regular toroidal maps

A *regular abstract polytope* $\mathcal{P}$ is a poset having the essential structural features of the face lattice of a regular convex polytope, including transitivity of $\mathrm{Aut}(\mathcal{P})$ on flags. Other examples include the regular tessellations, star polyhedra and maps on compact surfaces. (Actually, $\mathcal{P}$ need not be a lattice or have a particularly nice geometric realization.)

Indeed, McMullen (1989) has developed the basic theory of *realizations* for $\mathcal{P}$, basically by using geometric methods to describe the real representations for $\mathrm{Aut}(\mathcal{P})$.

Asia Ivić Weiss and I have recently examined the case that $\mathcal{P}$ is the toroidal map $\{4,4\}_{(b,0)}$. In a pretty and unexpected way, the data for the realizations (and group representations) are encoded in a simple picture of the map.

KONSTANTIN RYBNIKOV, Department of Mathematics and Statistics, Queen's University, Kingston, Ontario K7L 3N6, Canada, and Fields Institute, Toronto, Ontario M5T 3J1, Canada
Oriented matroids from liftings and stresses

An oriented matroid is a combinatorial abstraction which naturally appears in the study of combinatorial and algebraic properties of hyperplane arrangements, convex polytopes, polyhedral scenes, directed graphs, Delaunay decompositions, lattice points, zonotopes, and other objects of discrete geometry.

A realization of vertices of an abstract incidence structure (V, F, I) in R^d gives rise to an oriented matroid of liftings. A polyhedral complex in R^d gives rise to oriented matroids of k-stresses, $k = 2, \ldots, d$. For example, a 2-stress is simply a Maxwell stress on the framework formed by the 1-skeleton of the complex. Matroids from polyhedral scenes and stresses were studied by Crapo, Edmonds, Lovasz, White, Whiteley et al. When (V, F, I) is the incidence structure of a homology manifold $\mathcal{M}^d$ realized in R^d, there is a natural relationship between dependent sets of the matroid of liftings and dependent sets of the matroid of d-stresses. We prove that the oriented matroid of liftings is isomorphic to the oriented matroid of d-stresses when $H_1(\mathcal{M}^d, Z_2) = 0$, and investigate some properties of this matroid.

ROLF SCHNEIDER, Albert-Ludwigs-Universität, Math. Institut, Eckerstr. 1, D-79104 Freiburg, Germany
Convex bodies in singular relative positions

A common boundary point x of the convex bodies K, K' in Euclidean n-space is *exceptional* if the linear hulls of the normal cones of K and K' at x have a non-zero intersection. A common support hyperplane H of K and K' is *exceptional* if the affine hulls of the support sets $H \cap K$ and $H \cap K'$ have a nonempty intersection or contain parallel lines.

Theorem 1. *The set of all rigid motions g for which K and gK' have some exceptional common boundary point is of Haar measure zero.*

Theorem 2. *The set of all rigid motions g for which K and gK' have some exceptional common support hyperplane is of Haar measure zero.*

These results continue a line of research on the boundary structure of convex bodies that started with a question of Victor Klee. The proof applies the 'cap covering method' due to Ewald, Larman and Rogers. Both theorems were conjectured by Stefan Glasauer; they are needed in integral-geometric investigations on generalized curvature measures of convex bodies.

RICK VITALE, University of Connecticut, Storrs, Connecticut 06269, USA
Intrinsic volumes and Gaussian random processes

We describe the extension of intrinsic volumes to a sub-class of compact, convex subsets of Hilbert space. This is effected by the use of Gaussian measure and, in fact, provides a link with several questions of interest in probability theory.

ELIZABETH WERNER, Department of Mathematics, Case Western Reserve University, Cleveland, Ohio 44106-4901, USA
Santalo regions and polytopes

(Joint work with M. Meyer)

Santalo-regions for general convex bodies were introduced in an earlier paper by the authors and their connection with the affine surface area was established. In this paper we study how the Santalo-regions behave for polytopes.

GAOYONG ZHANG, Department of Mathematics, Polytechnic University, Brooklyn, New York 11201, USA
The p-Minkowski problem of polytopes

The p-surface area measure of a convex body is defined as the product of the usual surface area measure and the $(1-p)$-th power of the support function of the convex body. The p-Minkowski problem states: Given a non-negative measure on the unit sphere, what are the necessary and sufficient conditions so that the given measure is the p-surface area measure of a convex body? We give a solution to the problem for polytopes.

Operator Theory / Théorie des opérateurs
(Heydar Radjavi, Organizer)

HARI BERCOVICI, Mathematics Department, Indiana University, Bloomington, Indiana 47405, USA
Norm ideal perturbations of commuting self-adjoint operators

Given an n-tuple $T = (T_1, T_2, \ldots, T_n)$ of commuting self-adjoint operators, and an ideal J of compact operators, one is interested in the existence of an n-tuple $K \in J^n$ such that $T + K$ is diagonal in some orthonormal basis. When such an n-tuple K does not exist then we say that J is an obstruction ideal (for the diagonalization of T). We will discuss some cases when Lorentz ideals are obstruction ideals. We will also consider the perturbation problems which arise when T is replaced by an infinite family. Some of Voiculescu's characterizations of obstruction ideals (involving, *e.g.*, quasicentral approximate units) can be extended to cover such families.

MAN-DUEN CHOI, Department of Mathematics, University of Toronto, Toronto, Ontario M5S 3G3, USA
Can an acute-angled cone be embedded in a right-angled cone?

The title question is non-trivial even in the low dimensional cases. Here comes the notion of sums of squares linking different branches of mathematics. In particular, we see into the structure of different sorts of positive operators.

KENNETH R. DAVIDSON, Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
Nevanlinna-Pick interpolation for non-commutative analytic Toeplitz algebras

The non-commutative analytic Toeplitz algebra is the WOT-closed algebra generated by the left regular representation of the free semigroup on n generators. We obtain a distance formula to an arbitrary WOT-closed right ideal and thereby show that the quotient is completely isometrically isomorphic to the compression of the algebra to the orthogonal complement of the range of the ideal. This is used to obtain Nevanlinna-Pick type interpolation theorems.

ALLAN DONSIG, Department of Mathematics and Statistics, University of Nebraska-Lincoln, Lincoln, Nebraska 68505-0323, USA
Algebraic isomorphisms of limit algebras

(Joint work with T. D. Hudson and E. G. Katsoulis)

A limit algebra is a closed union of a nested sequence of subalgebras of matrix algebras. The subalgebras are required to contain the diagonal matrices and the inclusion maps from one subalgebra to the next are required to extend to the generated C^*-algebra, so that the limit algebra is a subalgebra of an inductive limit of direct sums of matrix algebras, *i.e.*, an AF C^*-algebra. Finally, the inclusions are required to respect the normalizers of the diagonal matricies, that is, to send matrix units to sums of matrix units. Examples of such algebras include limits of upper-triangular $2^n \times 2^n$ matrices, T_{2^n}, with embeddings such as $\sigma_n : T_{2^n} \to T_{2^{n+1}}$ given by $\sigma_n(A) = A \oplus A$ and $\rho_n : T_{2^n} \to T_{2^{n+1}}$ given by $\rho_n\big((a_{ij})\big) = (a_{ij} I_2)$.

We establish automatic continuity for algebraic isomorphisms of limit algebras. It follows that, for inductive limits of finite-dimensional nest algebras, the C*-envelope is an invariant for algebraic isomorphisms. Also, for strongly maximal TAF algebras generated by their order preserving normalizers, algebraic isomorphism is shown to be equivalent to isometric isomorphism.

ROMAN DRNOVSEK, Faculty of Mathematics and Physics, University of Ljubljana, 1000 Ljubljana, Slovenia

On reducibility of semigroups of compact quasinilpotent operators

Using the famous Lomonosov-Hilden technique we proved the following invariant subspace theorem. Let $\mathcal{S}$ be a multiplicative semigroup of compact operators on a Banach space X of dimension greater than 1 such that $\hat{r}(S_1, \ldots, S_n) = 0$ for every finite subset $\{S_1, \ldots, S_n\}$ of $\mathcal{S}$, where $\hat{r}$ denotes the Rota-Strang spectral radius. Then $\mathcal{S}$ is reducible, *i.e.*, there exists a closed subspace of X, other than $\{0\}$ and X, which is invariant under every member of $\mathcal{S}$.

This result implies that the following assertions are equivalent:

(A) For each infinite-dimensional complex Hilbert space $\mathcal{H}$, every semigroup of compact quasinilpotent operators on $\mathcal{H}$ is reducible.

(B) For every complex Hilbert space $\mathcal{H}$, for every semigroup of compact quasinilpotent operators on $\mathcal{H}$, and for every finite subset $\{S_1, \ldots, S_n\}$ of $\mathcal{S}$ it holds that $\hat{r}(S_1, \ldots, S_n) = 0$.

The question whether the assertion (A) is true was considered by Nordgren, Radjavi and Rosenthal (and independently by Shul'man) in 1984, and it seems to be still open.

DOUGLAS FARENICK, Department of Mathematics and Statistics, University of Regina, Regina, Saskatchewan S4S 0A2, Canada

Extremal matrix states on operator systems

A classical result of Kadison concerning the extension, via the Hahn-Banach theorem, of extremal states on unital selfadjoint linear manifolds (*i.e.* operator systems) in C^*-algebras is generalised to the setting of noncommutatve convexity, where one has matrix states (*i.e.* unital completely positive linear maps) and matrix convexity. I will explain here that if φ is a matrix extreme point of the matrix state space of an operator system R in a unital C^*-algebra A, then φ has a completely positive extension to a matrix extreme point Φ of the matrix state space of A. This result then leads to a characterisation of extremal matrix states as pure completely positive maps, which is relevant to the recent work of Webster and Winkler on a Krein-Milman theorem in operator convexity.

DON HADWIN, Mathematics Department, University of New Hampshire, Durham, New Hampshire 03824, USA

Finitely strongly reductive operators

Abstract: A Hilbert space operator is finitely strongly reductive (fsr) if every sequence of approximately invariant finite-dimensional subspaces is approximately reducing. Not every normal operator is fsr (*e.g.*, the approximate point spectrum must have empty interior), not every fsr operator is normal (*e.g.*, isometries are fsr). We obtain some results (*e.g.*, every essentially normal quasitriangular fsr operator is normal), and pose some interesting open problems.

MICHAEL P. LAMOUREUX, Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T2N 1N4, Canada

Title to be announced

LEO LIVSHITS, Colby College, Waterville, Maine 04901, USA

Locally linearly dependent spaces of matrices

(Joint work with D. Hadwin and B. Mathes)

A subspace Ψ of $M_{m\times n}(\mathbf{C})$ is said to be *locally linearly dependent* ("LLD") if $\{T(x) \mid T \in \Psi\}$ is linearly dependent for every $x \in \mathbf{F}^n$. Locally linearly independent (*i.e.* not dependent) spaces are exactly those possessing a separating vector. If such a space is proper and does not have a one-dimensional LLD extention, then it is reflexive. (Converse is false.)

We will present several results about LLD spaces. For example: no LLD subspace of $M_n(\mathbf{C})$, $n \geq 3$ can contain both an invertible and a cyclic operator.

V. LOMONOSOV, Department of Mathematics, Kent State University, Kent, Ohio 44242, USA
Density theorems in Banach algebras

It is possible to describe the Stone-Weierstrass Theorem and Burnside's Type Theorems on Operator Algebras from one point of view using some kind of approximation technique in the space of weakly continuous vector functions.

GORDON MACDONALD, Department of Mathematics and Computer Science, University of Prince Edward Island, Charlottetown, Prince Edward Island C1A 4P3, Canada
Principal-ideal bands

A band is a semigroup of idempotents. A canonical form will be presented for principal-ideal bands of linear transformations acting on a finite-dimensional vector space over a general field. This canonical form will be brought to bear on the question of whether idempotents of all possible ranks are present in maximal principal-ideal bands.

(Joint work with P. Fillmore, M. Radjabalipour and H. Radjavi.)

LAURENT W. MARCOUX, University of Alberta, Edmonton, Alberta T6G 2G1, Canada
Unitarily-invariant linear spaces in C^*-algebras

In this talk we will present some characterisations and containment results for linear subspaces of unital C^*-algebras that are invariant under conjugation by sets of unitary elements of the algebra. As an example, the linear span of the projections in a simple, unital C^*-algebra having non-scalar projections is shown to contain all additive commutators of the algebra and, in certain cases (for example—UHF C^*-algebras), to be equal to the algebra. This is joint work with Gerard Murphy of University College Cork.

MATJAZ OMLADIC, Department of Mathematics, University of Ljubljana, Jadranska 19, 1000 Ljubljana, Slovenia
Irreducible semigroups with multiplicative spectral radius

Irreducible multiplicative semigroups of complex matrices with some additional properties are studied. Each of the properties: submultiplicativity of the spectral radius, its multiplicativity, or its constancy, as well as a certain property called the "Rota condition" implies that every member of such a semigroup is, except for a scalar coefficient, similar to the direct sum of an isometry and a nilpotent operator.

MIHAR PUTINAR AND HAROLD S. SHAPIRO, Royal Institute of Technology, S-10044 Stockholm, Sweden and Mathematics Department, University of California at Santa Barbara, Santa Barbara, California 93106, USA,
The Friedrichs operator of a planar domain

K. Friedrichs has interpreted some basic problems in plane elasticity theory into spectral problems of an antilinear operator (now called the Friedrichs operator), acting on the Bergman space of a bounded planar domain. We will discuss how the spectrum of the Friedrichs operator reflects the geometry of the domain; the corresponding inverse spectral problem will be shown to have incomplete data. Some related aspects of function theory and operator theory in the Bergman space of a planar domain will be also presented.

PETER ROSENTHAL, Department of Mathematics, University of Toronto, Toronto, Ontario M5S 3G3, Canada
Orbit-reflexivity versus orbit-transitivity

The concept of orbit reflexivity was introduced some years ago by Hadwin, Nordgren, Radjavi and the speaker (J. London Math. Soc. (2)**34**(1986), 111–119). A little more generally, a collection of bounded linear operators is said to be orbit-reflexive if it contains every operator which leaves invariant all the closed sets invariant under the collection. This is a perturbation of the standard definition of reflexivity, in which "set" is replaced by "subspace". Every reflexive collection is a strongly closed algebra; every orbit-reflexive collection is a strongly closed semigroup.

A transitive collection of operators is a collection having only trivial invariant subspaces; an orbit-transitive collection is defined to be one that has only trivial invariant closed sets.

In this talk, a general study of orbit-reflexivity and orbit-transitivity will be proposed. A few preliminary results will be presented, including a sufficient condition (obtained in joint work with Radjavi) that a semigroup have a non-trivial invariant closed set. A number of related open problems will be discussed.

PETER SEMRL, University of Maribor, 2000 Maribor, Slovenia
Elementary operators

This is a report on my joint work with Matej Brešar. We introduce the concept of an elementary operator between two algebras, and thereby extend the study of operators of the form $x \mapsto \sum_{i=1}^{n} a_i x b_i$ where a_i, b_i are fixed elements in an algebra. Elementary operators on some classes of algebras are considered and their general form is described in some special cases.

AHMED RAMZI SOUROUR, Department of Mathematics and Statistics, University of Victoria, Victoria, British Columbia V8W 3P4, Canada
Lie isomorphisms between nest algebras

A Lie isomorphism between two algebras is a bijective linear map ϕ satisfying the condition $\phi(ab - ba) = \phi(a)\phi(b) - \phi(b)\phi(a)$. We give a complete description of the Lie isomorphisms between two nest algebras. (Joint work with Laurent Marcoux).

Relativity and Geometry / Relativité et géométrie
(Jacques Hurtubise and Niky Kamran, Organizers)

ROGER BIELAWSKI, Max Planck Institute, Bonn, Germany
T^n-invariant hyperkähler $4n$-manifolds

We prove that a connected simply connected complete hyperkähler $4n$-manifold of finite topological type equipped with an effective tri-Hamiltonian action of T^n is isometric to a hyperkähler quotient of a flat $\mathbb{H}^{d+m}$ by $T^{d-n} \times \mathbb{R}^m$. As a consequence, such manifolds are classified, up to canonical deformations by arrangements of codimension 3 affine subspaces in $\mathbb{R}^{3n}$.

We show a similar result for two other classes of Einstein manifolds: compact 3-Sasakian and compact quaternion-Kähler with positive scalar curvature. In the latter case, we are able to conclude that such a $4n$-manifold admitting a group of isometries of rank $n+1$ is either $\mathbb{H}P^n$ or $\mathrm{Gr}_2(\mathbb{C}^{n+2})$.

CHARLES P. BOYER, Department of Mathematics, University of New Mexico, Albuquerque, New Mexico 87131 USA
Contact geometry and Einstein manifolds

We discuss a procedure of symmetry reduction for certain contact manifolds in the Riemannian setting. This leads to new examples of compact simply connected Einstein manifolds of positive scalar curvature. As a special case we obtain 7-dimensional compact Einstein manifolds with arbitrary second Betti number.

A. COLEY, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3J 3J5, Canada
Title to be announced

ANDREW DANCER, Department of Mathematics and Statistics, McMaster University, Hamilton, Ontario L8S 4K1, Canada
Einstein metrics of cohomogeneity one

We study Riemannian manifolds admitting an isometric group action with principal orbits of codimension one. We focus particularly on quaternionic Kähler and 3-Sasakian manifolds.

PAUL EHRLICH, University of Florida, Gainesville, Florida 32611-8105, USA
Bochner's technique for compact Lorentzian manifolds (after A. Romero and M. Sanchez)

Recent work of Professors Alfonso Romero and Miguel Sanchez of the University of Granada, Spain, on applying the Bochner technique to rigid and Killing vector fields on compact Lorentzian manifolds will be discussed.

CONRAD HEWITT, Department of Applied Mathematics, St. Jerome's University, Waterloo, Ontario N2L 3G3, Canada
Three dimensional symmetry groups in cosmology

We consider spacetimes which admit a two-dimensional Abelian group of isometries together with an additional symmetry. These models may be classified according to the action of this Abelian subgroup, and the causal nature of the element of transitivity surface.

There are two cases of particular interest in cosmology. The first case arises when the additional symmetry is also an isometry and the resulting group orbits are spatially homogeneous. The simplest subclass is formed by the orthogonal spatially homogeneous models, in which the cosmological fluid lies orthogonal to the group orbits. In the second case, the additional symmetry is a homothety and the resulting group orbits are timelike. The simplest subclass arises when the cosmological fluid flow is tangential to the group orbits. The Einstein field equations for all of these models may be written as an autonomous system of ordinary differential equations. A qualitative description of their properties can be given using the theory of dynamical systems.

MAREK KOSSOWSKI, Mathematics Department, University of South Carolina, Columbia, South Carolina 29208, USA
Characteristic classes for pseudo Riemannian manifolds with volume-resolvable metric singularities

We consider C^∞ compact orientied m-dimensional manifolds M, $\partial M = \sigma$, with symmetric $(0,2)$-tensors $\langle\,,\,\rangle$ which have maximal rank on an open dense subset, $M - (D^0 \cup D^\infty)$. The tensor $\langle\,,\,\rangle$ will change bilinear type on a hypersurface $D^0 \subset M$, in a smooth transverse manner. The associated dual tensor $^*\langle\,,\,\rangle$ will also change bilinear type on a hypersurface $D^\infty \subset M$, in a smooth, transverse manner. The objective of this paper is to identify classes of $(M, \langle\,,\,\rangle)$ for which the Chern-Weil construction adapts without residue. (We also examine the case of surfaces with "corners" where D^0 and D^∞ intersect transversally and a geometric residue naturally arises.) This is accomplished by way of the cannonical Volume blow up $\rho\colon \mathrm{VB}^\pm \to M - (D^0 \cup D^\infty)$, *i.e.*, the pullback metric $\rho^*\langle\,,\,\rangle$ will be "less singular" than $\langle\,,\,\rangle$. Moreover, the C^∞-manifolds $\mathrm{VB}^\pm$, provide a natural geometric setting for the resulting characteristics classes.

HANS-PETER KÜNZLE, Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta T6G 2G1, Canada
SU(n)-*Einstein-Yang-Mills fields in spherically symmetric and cosmological space-times*

The classification of the possible Yang-Mills connections over space-time that are invariant under space-time symmetry groups is somewhat analogous to the representation theory of these groups and leads to many interesting geometrical and analytical problems. After a quick survey of the possible equations in the static spherically symmetric case and for the locally rotationally symmetric cosmologies some of the simpler resulting systems of ordinary differential equations will be analyzed and (mostly numerically) integrated. These include solutions outside and inside static black holes and, in very similar form, the evolutions of the Bianchi cosmologies with Yang-Mills sources and fourdimensional isometry groups.

ROB MILSON, Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada
Realization of reflection quotients by singular metrics

The Killing-Hopf theorem states that a complete surface of constant curvature is the quotient of a simply connected space form by a group of orientation preserving isometries. I will discuss a generalization of this classical theorem that deals with quotients by reflection groups. The geometric setting for this generalization is furnished by a certain class of singular metric tensors such that the fixed points of the generating reflections correspond to the locus of the metric's singularity.

MAUNG MIN-OO, Department of Mathematics and Statistics, McMaster University, Hamilton, Ontario L8S 4K1, USA
Mass, scalar curvature and K-area

This talk will give a short selected survey of some old and new results about scalar curvature rigidity of Riemannian manifolds. Many of the ideas have their origins in Witten's spinorial proof of the positive mass conjecture and in the classical work by Gromov and Lawson on obstruction to positive scalar curvature metrics. Some of the newer results are concerned with good estimates of an invariant called the K-area, which was introduced by Gromov in 1994. We will give "sharp" inequalities for the K-area of Hermitian symmetric spaces in terms of the scalar curvature.

JOHN WAINWRIGHT, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
Title to be announced

MCKENZIE Y. WANG, Department of Mathematics and Statistics, McMaster University, Hamilton, Ontario L8S 4K1, Canada
The cohomogeneity one Einstein equations

In Riemannian geometry, an Einstein metric is a positive definite metric whose Ricci tensor is proportional to the metric. A compact Lie group of isometries of some metric is said to act with cohomogeneity one if the generic orbits of the action are hypersurfaces. In this talk we will discuss some properties of the Einstein equation for metrics of cohomogeneity one as well as some examples.

GILBERT WEINSTEIN, University of Alabama at Birmingham
Title to be announced

Low Dimensional Topology / Topologie en basses dimensions

(Jack Gegenberg, Organizer)

STEVEN BRAHAM, Simon Fraser University

Title to be announced

JOHN M. BRYDEN, University of Calgary, Calgary, Alberta T2N 1N4, Canada

3-manifold invariants associated to topological quantum field theories

Let M be a closed orientable 3-manifold obtained from surgery on a framed link. Given a primitive nth (resp. $2n$-th) root of unity, q, for an odd (resp. even) positive integer n, there are a series of invariants, $Z_n(M,q)$, defined by Murakami, Ohtsuki and Okada which are invariant up to homotopy type. The definition of these invariants is in terms of Gauss sums. In fact these invariants have now been generalized by Deloup to give a new abelian quantum invariant which can be expressed as a product of Gauss sums. These invariants can be determined from the linking matrix and the cohomolgy algebra of the manifold. When M is a Seifert manifold joint work with C. Hayat-Legrand, H. Zieschang and P. Zvengrowski can be used to complete the computation of these invariants in a simple way. This framework can also be used to calculate the Dijkgraaf-Witten invariants for a class of topological quantum field theories, as long as M is a Seifert manifold.

Although there has been some progress made in understanding the combinatorial nature of these and other quantum invariants, their geometric nature and their relationship to the fundamental group and to cohomology is not understood. An initial attempt to understand these invariants in the context of algebraic topology is to interpret the surgery in the cohomology algebras of Seifert manifolds.

STEVE CARLIP, Department of Physics, University of California at Davis, Davis, California 95616, USA

Einstein manifolds, spacetime foam, and the cosmological constant

In Wheeler's "spacetime foam" model, the quantum mechanical state of the universe is a superposition of many different spacetime topologies. In a saddle point approximation for the partition function, each Einstein manifold M contributes a term of the form $\exp\{k\,\mathrm{Vol}(M)/\Lambda\}$, where Λ is the cosmological constant and $\mathrm{Vol}(M)$ is the volume of M with scalar curvature normalized to ± 12. For $\Lambda < 0$, one therefore naively expects the sum over topologies to be dominated by a few manifolds with small volumes. Contrary to this expectation, I show that the number of hyperbolic manifolds grows so fast with volume that the sum over topologies is dominated by arbitrarily large manifolds with arbitrarily complicated topologies. This phenomenon indicates an instability in the sum over topologies that may be relevant to the "cosmological constant problem," the observation that the vacuum energy density of the universe is at least 120 orders of magnitude smaller than one would expect from quantum fluctuations at the Planck scale. Processes that would normally increase $|\Lambda|$ may instead merely drive the production of more and more complicated spacetime foam.

LISA JEFFREY, Department of Mathematics and Statistics, McGill University, Montreal, Quebec H3A 2K6, Canada

Holomorphic bundles and the Verlinde formula

The moduli space $M(n,d)$ of semistable holomorphic bundles of (coprime) rank n and degree d over a closed Riemann surface of genus g is a smooth Kahler manifold. We show how to use the Riemann-Roch formula and formulas for the intersection numbers in the cohomology of $M(n,d)$ (proved in joint work with F. Kirwan) to establish the Verlinde formula, which is a formula for the dimension of the space of holomorphic sections of a line bundle over $M(n,d)$. We also show how to extend our proof to prove a more general version of the Verlinde formula which gives the dimension of the space of holomorphic sections of line bundles over more general moduli spaces related to $M(n,d)$.

NABIL SAYARI, Département de Mathématiques, Université de Québec à Montréal, Montréal, Québec H2X 3Y7, Canada
The reducibilty of surgered 3-manifolds and great Scharlemann cycles

We are interested in the following question: can a reducible manifold $K(r)$ be obtained by a Dehn surgery on a nontrivial knot K? It is conjectured that only pq-Dehn surgery on nontrivial (p,q)-cable knots gives a reducible manifold. In the talk we consider this question using the techniques that Gordon and Luecke developped for the knot complement problem. The idea is to analyse the intersection of two planar surfaces P and Q properly embedded in the exterior of the knot K. This gives two planar graphs G_P and G_Q. When $K(r)$ is reducible, G_Q must contain a Scharlemann cycle. It follows that $K(r)$ contains a lens space as a connected summand. We use a slight generalisation of this construction: we study the intersection of a system of punctured spheres $P_1,\dots,P_{m-1}$ with a level surface, Q, where the completed spheres, $\hat{P}_1,\dots,\hat{P}_{m-1}$, give a decomposition of $K(r)$ into m prime factors. We find that the graph G_Q contains at least $m-1$ different Scharlemann cycles.

DENIS SJERVE, Mathematics Department, University of British Columbia, Vancouver, British Columbia V6T 1Z2, Canada
Genus 0 actions on Riemann surfaces and spherical space forms

In this lecture we address the problem of which finite groups G admit effective analytic actions on some connected compact Riemann surface S so that all quotient surfaces S/H have genus 0, where H is any non-trivial subgroup of G. We relate this problem to the spherical space form problem through the associated action of G on the vector space V of holomorphic differentials on S.

PETER ZVENGROWSKI, Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T2N 1N4, Canada
Diagonal formulae in group cohomology

For any group G, its cohomology $H^*(G)$ can be defined to be the cohomology of the Eilenberg-MacLane space $K(G,1)$. From this definition, or otherwise, one sees that the cohomology $H^*(G;R)$ with coefficients in a ring R forms a graded algebra under the cup product operation. One method to find these cup products is to start with a projective resolution $\mathcal{C}$ of Z over the group ring ZG and then find a diagonal map $\Delta\colon \mathcal{C} \to \mathcal{C} \otimes \mathcal{C}$. We will concern ourselves with the existence of explicit diagonal formulae of this type for certain groups arising as the fundamental group of a 3-manifold, with emphasis on the Seifert manifolds, and also mention some of the applications of the cup products.

Discrete Mathematics / Mathématiques discrètes

(Brian Alspach, Katherine Heinrich and Abraham Punnen, Organizers)

JASON I. BROWN, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3J 3J5, Canada

Roots of chromatic polynomials

Roots of chromatic polynomials have attracted considerable attention from the very beginning, as, of course, one more than the largest integral root is the chromatic number. We will survey here some recent results on both the nature and location of the roots, including some bounds derived from both complex analysis and commutative algebra.

RAMASWAMY CHANDRASEKARAN, The University of Texas at Dallas, Richardson, Texas 75083-0688, USA

Nonnegative integer solutions to linear systems

We consider the problem of finding nonnegative integer solutions to linear equations. This is the central problem in integer programming. In general this problem is NP-hard. However, under certain conditions on the constraint matrix the problem is solvable in polynomial time and it is these cases that we consider. This work is a continuation of some previous work for TDI systems.

KAREN L. COLLINS, Wesleyan University, Middletown, Connecticut 06459, USA

Symmetry breaking in graphs

A labeling of the vertices of a graph G is said to be *r-distinguishing*, provided no non-trivial automorphism of the graph preserves all of the vertex labels. We define the distinguishing number of G, $D(G)$, to be the minimum r such that G has an r-distinguishing labeling. For example, $D(C_n) = 3$ for $n = 3, 4, 5$, but $D(C_n) = 2$ if $n \geq 6$. For any group J, we define $D(J) = \{D(G) \mid \mathrm{Aut}(G) \text{ is isomorphic to } J\}$. Let H_n be the dihedral group with $2n$ elements. Then $D(H_n) = \{2\}$ unless $n = 3, 4, 5, 6, 10$, in which case, $D(H_n) = \{2, 3\}$. This talk will be a survey of distinguishing results for groups and graphs, with special attention to symmetric groups.

SHANNON FITZPATRICK, University of New Brunswick, St. John, New Brunswick E2L 4L5, Canada

The isometric path number of a graph

An isometric path is merely any shortest path between two vertices. Inspired by the game of 'Cops and Robber' and a result by Aigner & Fromme, the problem is to determine the minimum number of isometric paths required to cover the vertices of a graph. This number has been found exactly for trees and grid graphs. In this talk, I will present these results as well as give a lower bound on this number in terms of the diameter of the graph and its subgraphs.

GREGORY GUTIN, Department of Mathematics and Statistics, Brunel, The University of West London, Uxbridge UB8 3PH, UK

Polynomially searchable sets of tours for the travelling salesman problem: theoretical and experimental results

For an NP-hard combinatorial optimization problem P, a set S of solutions is called *polynomially searchable* (PS) if the best solution in S can be found in polynomial time (in size of P). We describe some PS sets of tours for the asymmetric TSP that can be used in construction and local search type algorithms. We present theoretical and computational results on these PS sets.

BERT HARTNELL, Department of Mathematics and Computing Science, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
The Watchman's walk problem

Consider the problem of a security firm that is asked to provide protection for a business by monitoring on a regular basis each node of a network. Each point of interest must either be visited or seen from a neighbouring point by a watchman but this need not be on a continuous basis. However, there can be no more than a specified period of time between such monitoring. The security company is to provide the minimum number of watchmen, and to specify the rounds they would have to take, to satisfy this condition. It is not surprising that the general problem does not admit an easy solution, but by imposing suitable restrictions some observations can be made.

PENNY HAXELL, Department of Combinatorics and Optimization, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada
Packing and covering triangles in dense graphs

For a graph G, let $\nu(G)$ denote the maximum size of a set of pairwise edge-disjoint triangles in G, and $\tau(G)$ denote the minimum size of a set of edges C of G such that every triangle of G contains an edge from C. A conjecture of Tuza states that $\tau(G) \leq 2\nu(G)$ for every graph G. Some results on this conjecture will be presented, in particular that it is approximately true for dense graphs.

SANTOSH KABADI, Faculty of Administration, University of New Brunswick, Fredericton, New Brunswick E3B 5A3, Canada
Delta-matroid theory

A delta matroid is a proper generalization of a matroid, which properly generalizes important properties of matroids such as (i) the greedy algorithm, (ii) the submodularity of the rank function, (iii) the independence axiom. In this talk we shall (i) survey existing results on delta matroids, (ii) use the results on delta matroids to produce alternate, simple proofs of some existing results in matroid theory, and (iii) present some new results.

RICHARD NOWAKOWSKI, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3J 3J5, Canada
Multiplicative measures on graphs

Graph products have been used to find the *'essential'* value of a graph parameter (such as independence number or chromatic number) of a graph G by 'multiplying' G by itself n times and examining the growth of the parameter on G^n. For example, the **Shannon capacity** of a graph G is defined by

$$\Theta(G) = \lim_{k\to\infty} \beta(\otimes_{i=1}^{k} G)^{1/k}$$

where $\otimes$ is the strong product of graphs and $\beta(H)$ denotes the independence number of graph H. Another such concept, introduced by Hilton, Rado & Scott, is the *ultimate chromatic number* of a graph G; that is

$$\chi_u(G) = \lim_{k\to\infty} \left(\chi(\bullet_{i=1}^{k} G)\right)^{1/k}$$

here $\bullet$ denotes the lexicographic product and $\chi(H)$ the chromatic number of H.

SUZANNE SEAGER, Department of Mathematics, Mount Saint Vincent University, Halifax, Nova Scotia B3M 1M6, Canada
Variants of competition graphs

The food web of an ecosystem is the directed graph in which the arcs indicate which species prey on which other species. The competition graph of a food web is obtained by putting an edge between two species if and only if they have a common prey. Competition graphs arose in biology, but many graph theorists have worked on the problems such as characterizing which graphs can theoretically occur as competition graphs. Others have introduced variants involving common predators as well as common prey. We will look at these variants, and some of the characterization results that can be obtained for them.

KAREN SEYFFARTH, Department of Mathematics and Statistics, University of Calgary, Calgary, Alberta T2N 1N4, Canada
Small cycle double covers of line graphs

A *cycle double cover* of a graph, G, is a collection of cycles, $\mathcal{C}$ such that every edge of G lies in precisely two cycles of $\mathcal{C}$. If G is simple and has at most n vertices, then a cycle double cover of G may require as many as $n-1$ cycles, and we say that $\mathcal{C}$ is a *small cycle double cover* (SCDC) of G if $\mathcal{C}$ contains at most $n-1$ cycles. The *Small Cycle Double Cover Conjecture*, due to J. A. Bondy, states that every simple bridgeless graph has an SCDC, and is a strengthening of the well-known *Cycle Double Cover Conjecture*. I will describe some recent work with G. MacGillivray on proving the SCDC Conjecture for certain line graphs, in particular, line graphs of complete graphs, complete bipartite graphs, and planar graphs. The techniques used in these proofs can also be used to verify the SCDC Conjecture for some other types of line graphs.

NABIL SHALABY, Department of Mathematics and Statistics, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7, Canada
Skolem sequences: survey and new results

A Skolem sequence of order n is a sequence $S = (s_1, s_2, \ldots, s_{2n})$ of $2n$ integers satisfying the conditions:

1. for every $k \in \{1, 2, \ldots, n\}$, there exist exactly two elements $s_i, s_j \in S$ such that $s_i = s_j = k$.
2. if $s_i = s_j$ with $i < j$, then $j - i = k$.

It is well known that Skolem sequences link several combinatorial objects *e.g.* Steiner triple systems, Room squares and graph factorizations. We survey several known results and introduce some new applications of Skolem sequences to combinatorial designs and graph factorizations.

Education / Éducation
Mathematicians Teaching Statistics
Des mathématiciens qui enseignent la statistique
(Barry Monson and Maureen Tingley, Organizers)

ROBERT DAWSON, Department of Mathematics and Computer Science, Saint Mary's University, Halifax, Nova Scotia B3H 3C3, Canada
How I learned to teach statistics

David Moore wrote, a decade ago, that "mathematicians should not teach statistics"; and it would be fair to say that many mathematicians would reply "And we don't want to!". However, some mathematicians, (including myself,) find themselves thrust by circumstances beyond their control in front of a statistics class. In this talk, aimed both at the morbidly curious and at those who might find themselves in the same situation, I want to talk about what it's like, and about how to not just survive but actually enjoy it.

DAVID HAMILTON, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3J 3J5, Canada
Title to be announced

MAUREEN TINGLEY, University of New Brunswick-Fredericton, Fredericton, New Brunswick E3B 5A3, Canada
Title to be announced

Contributed Talks on Reform Calculus
Séance ouverte sur le Réforme du calcul différentiel et intégral
(Org: Barry Monson and Maureen Tingley)

FRED CHIPMAN, Department of Mathemaitcs, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada
What place has a laptop in teaching undergraduate mathematics?

RICHARD J. NOWAKOWSKI, Department of Mathematics, Statistics and Computing Science, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada
Reform threads in all the years

MARK TAYLOR, Department of Mathematics, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada
Reform calculus: mathematics answer to the colouring book

Graduate Student Seminar / Séminaire pour étudiants diplômés

(Jennifer Mills, Organizer)

XIAOMIN BAO, Department of Mathematics and Astronomy, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

A note on the blocking sets in $S(3,6,22)$ and $S(4,7,23)$

We use the same notations and terminologies as in [1,2]. In [1] it is implied that there are two different types of blocking sets of size nine in $S(3,6,22)$: N_1 and N_0. In [2] the author claims that up to isomorphism there are exactly three types of blocking sets of size eleven in $S(4,7,23)$: E_0, E, E_1. In this short note we prove that N_1 and N_0 are actually the same type of blocking set in $S(3,6,22)$; while E and E_1 are actually the same type of blocking set in $S(4,7,23)$.

References

1. L. Berardi, *Blocking sets in the large Mathieu designs, I: the case $S(3,6,22)$*. Ann. Discrete Math. **37**(1988), 31–42.

2. , *Blocking sets in the large Mathieu designs, II: the case $S(4,7,23)$*. J. Inform. Optim. Sci. (1988), 263–278.

MICHELLE DAVIDSON, Department of Mathematics and Astronomy, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

Skew k-arc and codes

In the projective geometry $\mathrm{PG}(m,2)$ of dimension m over $\mathrm{GF}(2)$, we define a skew k-arc S to be a set of k points such that there are at most two points of each line in S, and the diagonals of any 4 points in S do not meet. I will discuss the relationship between skew k-arcs and linear binary codes. Special attention is paid to the situation where the code has minimum distance 5.

SHAUN FALLAT, Department of Mathematics, College of William and Mary, Williamsburg, Virginia 23187, USA

Maximum determinant of $(0,1)$-matrices with certain constant row and column sums

The maximum absolute value of the determinant of $n \times n$ nonsingular $(0,1)$-matrices that have constant line sums (*i.e.*, row sums and column sums) k is investigated. For $n \neq 4$, $k = 2$, this maximum determinant is determined. A lower bound for the maximum absolute value of the determinant for $k = 3$ is also given, but in general this bound is not tight. Other determinantal values and bounds for specific n and k are provided. This is joint work with Professor Pauline van den Driessche.

XIUZHAN GUO, Deparment of Mathematics and Statistics, York University, North York, Ontario M3J 1P3, Canada

Remarks on descent theory

(Joint work with Walter Tholen)

A theorem of Joyal and Tierney states that, analogously to the result for commutative rings, a morphism in the opposite of the category of commutative monoids is effective for descent iff it is a pure monomorphism (Mem. Amer. Math. Soc. **309**). Based on these results, in this talk, we shall discuss several new directions for descent theory.

ALI MAHVIDI, University of Toronto, Toronto, Ontario M5S 3G3, Canada

Invariant subspaces of composition operators

We will discuss invariant subspaces of composition operators on the classical Hardy spaces. Several results concerning the structure of invariant subspaces of compact composition operators will be presented. Some consequences of all invariant subspaces of one composition operator being invariant under another will also be considered.

RUBÉN A. MARTÍNEZ-AVENDAÑO, Department of Mathematics, University of Toronto, Toronto, Ontario M5S 3G3, Canada
Some spectral properties of Hankel operators

We define Hankel operators and mention some of their basic properties. We discuss the proof of the following theorem: Given any compact subset of the complex plane containing zero, there exists a Hankel operator having this set as its spectrum. This theorem was first proven by Sergei Treil' a few years ago, but never published. With Treil's collaboration, we have written a detailed proof of the theorem.

PADDY MCCRUDDEN, MPCE Macquarie University, Sydney 2109, New South Wales, Australia
Representations of quantum categories

A quantum monoid in a symmetric monoidal category $\mathcal{V}$, is a monoid in $\mathcal{V}$ with extra structure which ensures that the category of representations is a braided monoidal category with a twist. In the case that $\mathcal{V}$ is the category of vector spaces, a quantum monoid is a quasi-triangular quasi-bialgebra with a twist and a quantum group is a quantum monoid with an antipode.

I will prove a converse to the first sentence: that is, if M is a monoid in $\mathcal{V}$ and the category of representations of M is a braided monoidal object with a twist (in a certain symmetric monoidal bicategory) then M is a quantum monoid. I will also extend this theorem to the several object case; quantum categories.

To prove this I will exhibit a biequivalence of symmetric monoidal bicategories which induces a duality between quantum categories and their categories of representations.

NATHAN NG, Department of Mathematics, University of British Columbia, Vancouver, British Columbia V6T 1Z2, Canada
Zeros of the Riemann zeta function and L functions

The purpose of my talk is to give an exposition of the methods and history of computing the non-trivial zeros of the Riemann zeta function. I will also discuss the significance of being able to compute these zeros. Lastly, I will give examples of number theoretic applications that result from knowing the values of zeros: the first application will involve irregularities of the distribution of primes and the second application will involve the solution to the class number two problem for complex quadratic fields.

MARK WEBER, Macquarie University, Sydney 2109, New South Wales, Australia
Characterising strong monoidal functors

Let M be a monoidal V-category. There is a "nice" characterisation of (lax) monoidal V-functors from M to V, namely as monoids in the functor category $[M, V]$ equipped with the convolution tensor product. However, there are many instances in which one is interested only in the strong monoidal V-functors, but at present there is no "nice" characterisation for these objects. The goal of this talk is to describe some aspects of the structure of the category $\mathrm{StrongMon}[M, V]$ of strong monoidal V-functors from M to V, at least in the case $V = \mathrm{Vect}$, with a view to providing the desired characterisations.

KHALID EL YASSINI, Département de mathématiques et d'informatique, Université de Sherbrooke, Sherbrooke, Québec J1K 2R1, Canada
A two parameter mixed penalty algorithm for linear programming

We describe a primal-dual interior-exterior algorithm for linear programming problem. The algorithm is based on path following idea and uses a two parameter mixed penalty function. Each iteration updates the penalty parameters and finds an approximate solution of Karush-Kuhn-Tucker system of equations which characterizes a solution of the mixed penalty function. The approximate solution obtained gives a dual and a lambda-feasible primal points which converge to dual and primal solutions.

BRUCE CLOAD, Brock University, St. Catharines, Ontario L2S 3A1, Canada
Composition operators and their commutants

The field of Composition Operators on the Hardy Space of the Unit Disc is an attractive blend of Hilbert Space Operator Theory and Single Variable Complex Analysis. In this talk, I will first present a brief survey of this field and then discuss the problem of finding the commutant of a Composition Operator.

DANIEL TURCOTTE, Ryerson Polytechnic University, Toronto, Ontario M5B 2K3, Canada
Propagation of involutive properties of analytic functions with values in complex unital Banach algebras with involutions

Let $f \in \mathrm{H}(\Omega, \mathbf{B})$, where $\mathrm{H}(\Omega, \mathbf{B})$ denotes the set of $\mathbf{B}$-valued analytic functions from an open set Ω of the complex plane and $\mathbf{B}$ is a complex unital Banach algebra with involution. We note that in general the function $s \mapsto f(s)^*$ is *not* analytic. However, we show that the principle of analytic continuation can still be applied in a restricted way to $f(s)^*$ to obtain a new principle of $*$-analytic continuation along regular analytic Jordan arcs.

Theorem. *Let $f \in \mathrm{H}(\Omega, \mathbf{B})$. Let Γ be a regular analytic Jordan arc contained in Ω and (s_n) a converging sequence contained in Γ such that $s_n \neq s_m$ for $n \neq m$. If there exists an analytic $\mathbf{B}$-valued function l from an open neighborhood of Γ such that $f(s_n)^* = l(s_n)$ for every s_n, then $f(s)^* = l(s)$ for every $s \in \Gamma$.*

Corollary. *Let $f \in \mathrm{H}(\Omega, \mathbf{B})$. Let Γ be a regular analytic Jordan arc contained in Ω and (s_n) a converging sequence contained in Γ such that $s_n \neq s_m$ for $n \neq m$. If $f(s_n)$ is unitary (resp. normal, self-adjoint, anti-self-adjoint) for every s_n then $f(s)$ is unitary (resp. normal, self-adjoint, anti-self-adjoint) for every $s \in \Gamma$.*