Symposium on the Geometry and Topology of Manifolds

Speaker Abstracts

Plenary Speakers

1. Martin Bridson: (Oxford University)
   Title and Abstract (TBA)

2. Ruth Charney: (Brandeis University)
   Week 2
   Morse Boundaries
   Boundaries play an important role in the study of hyperbolic spaces and hyperbolic groups. Analogous boundaries exist for CAT(0) spaces but they are not quasi-isometry invariant and hence do not give a well-defined boundary for a CAT(0) group. In joint work with H. Sultan, we define a “contracting boundary” for CAT(0) spaces by restricting to rays with hyperbolic-like behavior and we prove that the contracting boundary is a quasi-isometry invariant. More recently, M. Cordes has shown that these ideas can be generalized to any proper geodesic metric space by restricting to Morse geodesics.

3. Octav Cornea: (Université de Montréal)
   Week 1 & 2
   Lagrangian cobordism and Fukaya categories (Week 1)
   This talk is based on joint work with Paul Biran (ETH). The derived Fukaya category has emerged out of work of Gromov, Floer, Donaldson, Kontsevich, Fukaya, Seidel and many others starting in the 1980’s. It is a triangulated category associated to a symplectic manifold that, in favourable cases, allows one to use iterated exact triangles to recover properties of a given Lagrangian submanifold from knowledge of a class of simpler objects. Constructions of exact triangles associated to specific geometric settings are essential from this perspective. The first important such construction is due to Seidel (2003) and is associated to a Dehn twist. Another class of examples has emerged more recently in work of Biran and myself (2013) and is a reflection of the relation given by Lagrangian cobordism, a natural notion introduced by Arnold at the end of the 1970’s. After giving the relevant background, the purpose of this talk is to explain the relation between cobordism and the derived Fukaya category and show how Seidel’s exact triangle fits into the picture.
4. **Mike Davis: (Ohio State University)**
   Week 2
   **The action dimension of RAAGs**
   The "action dimension" of a discrete group $G$ is the smallest dimension of a contractible manifold which admits a proper action of $G$. Associated to any flag complex $L$ there is a right-angled Artin group, $A_L$. We compute the action dimension of $A_L$ for many $L$. Our calculations come close to confirming the conjecture that if the $L^2$-Betti number of $A_L$ in degree $l$ is nonzero, then the action dimension of $A_L$ is greater than or equal to $2l$. This is a report on joint work with Grigori Avramidi, Boris Okun and Kevin Schreve.

5. **Tom Farrell: (Tsinghua University)**
   Week 2
   **General Lecture: Bundles with extra geometric structure.**
   The structure of smooth fiber bundles whose concrete fibers are each equipped with a Riemannian metric whose sectional curvatures are constrained to lie in a fixed interval $S$ of real numbers (called $S$-bundles) will be explored in this talk. Some interesting cases being $S = (-\infty,0), (-\infty,0], (-4,-1), [0,\infty), (0,\infty)$ and $(1,4)$. In examining negatively curved bundles -- i.e. the case where $S = (-\infty,0)$ -- important use of Anosov flow bundles is made -- i.e. bundles whose concrete fibers are each equipped with an Anosov flow. This leads to an interesting partial result on the conjecture that negatively curved bundles with compact fibers and simply connected base space must be topologically trivial.

   **Specialized Lecture: Space of constrained Riemannian metrics and their associated Teichmüller spaces.**
   This talk will focus on trying to make transparent some of the key ideas underlying the results mentioned in my first talk. For example how it is seen that the Teichmüller space of negatively curved metrics on many high dimensional closed smooth manifolds is not contractible. Also recent results about quarter pinched positively curved bundles and the space of non-negatively curved Riemannian metrics on certain open manifolds will be discussed.

   These lectures represent work of many people including Pedro Ontaneda, Andrey Gogolev, Igor Belegradek, Vitali Kapovitch, Dan Knopf and Zhou Gang.

6. **Benson Farb: (University of Chicago)**
   Week 1
   **Title and Abstract (TBA)**

7. **Soren Galatius: (Stanford University)**
   Week 2
   **Title and Abstract (TBA)**

8. **Marco Gualtieri: (University of Toronto)**
   **Title and Abstract (TBA)**
9. **Wolfgang Lueck: (Universität Bonn)**

   **Week 1 & 2**

   **Research talk: Universal torsion, \(L^2\)-invariants, polytopes and the Thurston norm.**

   We introduce universal torsion which is defined for \(L^2\)-acyclic manifolds with torsionfree fundamental group and takes values in certain \(K_1\)-groups of a skew field associated to the integral group ring. It encompasses well-known invariants such as the Alexander polynomial and \(L^2\)-torsion. We discuss also twisted \(L^2\)-torsion and higher order Alexander polynomials which can also be derived from the universal invariant and assign certain polytopes to the universal torsion. This gives especially in dimension 3 interesting invariants which recover for instance the Thurston norm.

   **Expository talk: Introduction to the Farrell-Jones Conjecture.**

   The Farrell-Jones Conjecture identifies the algebraic \(K\)- and \(L\)-groups for group rings with certain equivariant homology groups. We will give some details of its formulation, its status and indicate some ideas of proofs for certain classes of groups. We will try to convince the audience about its significance by considering special cases and presenting the surprising large range of its applications to prominent problems in topology, geometry, and group theory.

10. **Ib Henning Madsen: (Copenhagen University)**

   **Week 1**

   **Automorphisms of manifolds and graph homology**

   The lecture will describe the rational cohomology of the classifying space of the groups of homotopy automorphisms and block automorphisms of 2d-dimensional "generalized surfaces". The results will be given in terms of Lie algebra cohomology, and graph homology.

   The lecture represents joint work with Alexander Berglund.

11. **Ciprian Manolescu: (University of California, LA)**

   **Week 2**

   **Involutive Heegaard Floer homology**

   Using the conjugation symmetry on Heegaard Floer complexes, we define a three-manifold invariant called involutive Heegaard Floer homology, which is meant to correspond to \(Z_4\)-equivariant Seiberg-Witten Floer homology. Further, we obtain two new invariants of homology cobordism, explicitly computable for surgeries on \(L\)-space knots and thin knots. As applications, we give new bounds on the slice genus of alternating knots. This is joint work with Kristen Hendricks.

   **Expository lecture: The triangulation conjecture**

   The triangulation conjecture stated that any \(n\)-dimensional topological manifold is homeomorphic to a simplicial complex. It is true in dimensions at most 3, but false in dimension 4 by the work of Casson and Freedman. In this talk I will explain the proof that the conjecture is also false in higher dimensions. This result is based on previous work of Galewski-Stern and Matumoto, who reduced the problem to a question in low dimensions (the existence of elements of order 2 and Rokhlin invariant one in the 3-dimensional homology cobordism group). The low-dimensional question can be answered in the negative using a variant of Floer homology, \(\text{Pin}(2)\)-equivariant Seiberg-Witten Floer homology.
12. **John Pardon: (Stanford University)**
   Week 2
   **Existence of Lefschetz fibrations on Stein/Weinstein domains**
   I will describe joint work with E. Giroux in which we show that every Weinstein domain admits a Lefschetz fibration over the disk (that is, a singular fibration with Weinstein fibers and Morse singularities). We also prove an analogous result for Stein domains in the complex analytic setting. The main tool used to prove these results is Donaldson’s quantitative transversality.

13. **Oscar Randal-Williams: (Cambridge University)**
   Week 1
   **Title and Abstract (TBA)**

14. **Daniel Ruberman: (Brandeis University)**
   Week 1
   **End-periodic index theory**
   We extend the Atiyah, Patodi, and Singer index theorem from the context of manifolds with cylindrical ends to manifolds with periodic ends. This theorem provides a natural complement to Taubes’ Fredholm theory for general end-periodic operators. Our index theorem is expressed in terms of a new periodic eta-invariant that equals the Atiyah-Patodi-Singer eta-invariant in the cylindrical setting. We apply this periodic eta-invariant to the study of moduli spaces of Riemannian metrics of positive scalar curvature. (Joint work with Tom Mrowka and Nikolai Saveliev)

15. **Gang Tian: (Princeton University)**
   Week 1
   **Title and Abstract (TBA)**
Invited Participants

1. **R. Inanc Baykur: (University of Massachusetts)**
   
   Week 1 & 2
   
   **Multisections of Lefschetz fibrations and topology of symplectic 4-manifolds**
   
   We initiate an extensive study of positive factorizations in framed mapping class groups, which allows us to effectively build symplectic 4-manifolds with essential information on various surfaces in them. In this talk, we will demonstrate how these techniques can be used to reformulate and address several interesting problems related to the topology of symplectic 4-manifolds and Lefschetz pencils. Different parts of this work is joint with K. Hayano and N. Monden.

2. **Alexander Berglund: (Stockholm University)**
   
   Title and Abstract: TBA

3. **Steven Boyer: (Université du Québec à Montréal)**
   
   Week 1 & 2
   
   **Foliations, left-orders, and L-spaces (Week 1)**
   
   Much work has been devoted in recent years to examining relationships between the existence of a co-oriented taut foliation on a closed, connected, prime 3-manifold W, the left-orderability of the fundamental group of W, and the property that W not be a Heegaard-Floer L-space. Classic work shows that each of these conditions holds when W has a positive first Betti number and it has been conjectured that they coincide when the first Betti number of W is zero. In this talk I will discuss the known connections between these conditions and survey the current status of the conjectures.

4. **Ryan Budney: (University of Victoria)**
   
   Week 1
   
   **Triangulations of 4-manifolds**
   
   I will outline some developments in the study of PL-triangulations of 4-manifolds, a developing census, algorithmic challenges and some simple attacks on long-standing open problems.

5. **Gil Cavalcanti: (Universiteit Utrecht)**
   
   Week 1 & 2
   
   **Stable generalized complex structures**
   
   Stable generalized complex structures are a special class of generalized complex manifolds which are not too far from being symplectic. We show that the stable condition can be rephrased by saying that the structure is equivalent to a symplectic structure on a Lie algebroid. This equivalence allows us to show that deformations of these structures are unobstructed and we obtain a local normal form for the set of points where the structure fails to be symplectic. Some topological restrictions to the existence of such structures follow from the normal form.
6. **Weimin Chen: (University of Massachusetts Amherst)**

   **Week 1**

   **Toward an equivariant version of Gromov-Taubes invariant**

   Gromov-Taubes invariant of a symplectic four-manifold is defined by counting EMBEDDED pseudo-holomorphic curves (maybe disconnected) whose homology class is Poincare dual to a given cohomology class. The seminar work of Taubes asserts that the Gromov-Taubes invariant equals the gauge-theoretic Seiberg-Witten invariant of the underlying smooth four-manifold. Taubes’ work has profoundly influenced the research in four-manifold topology (and beyond). Some of the most important consequences include a symplectic characterization and classification of rational and ruled surfaces (following the pioneering works of Gromov and McDuff), the equivalence of symplectic minimality and smooth minimality, and a new, differential and symplectic topology interpretation of the Kodaira dimension of complex surfaces. More recently, Taubes’ work has been extended to the level of Floer homology, which, in particular, resulted in a resolution of the Weinstein conjecture in dimension three and an isomorphism between the various Floer homologies of three-manifolds.

   It is a natural problem to extend Taubes’ work to certain singular spaces. Two important cases which may yield interesting geometric or topological applications are normal projective surfaces and symplectic finite group actions (in which case the corresponding singular space is the quotient space of the group action). In this talk, we will discuss the problem of constructing an equivariant version of Gromov-Taubes invariant -- what can be done and what are the obstacles, as well as some of the geometric and topological applications obtained so far.

7. **Xiuxiong Chen: (Stony Brook University)**

   Title and Abstract: TBA

8. **Ralph Cohen: (Stanford University)**

   Title and Abstract: TBA

9. **Diarmuid Crowley: (University of Aberdeen)**

   **Week 1 & 2**

   **Exotic G_2-manifolds**

   I present shall present examples of smooth 2-connected 7-manifolds M_0 and M_1 which admit G_2 holonomy metrics and which are homeomorphic but not diffeomorphic. These are the first examples of exotic manifolds with special holonomy. The key invariant is an extension of the classical Eells-Kuiper invariant for spin 7-manifolds. The extended Eells-Kuiper invariant also appears in complete classifications for 2-connected 7-manifolds and 2-connected 7-manifolds with G_2 structure. This work is joint with Johannes Nordström.
10. Andrew Dancer: (University of Oxford)
Week 1 & 2

Hyperkahler implosion and Nahm’s equations
We describe implosion constructions in symplectic and hyperkahler geometry. We show how the latter case may be approached via Nahm moduli spaces, and also describe quasi-Hamiltonian analogues of implosion.

11. Jim Davis: (Indiana University)
Week 1 & 2

Bordism of $L^2$-acyclic manifolds
A manifold is $L^2$-acyclic if all of its $L^2$-betti numbers vanish. (It is also called anharmonic since there are no nontrivial $L^2$-harmonic forms.) For a manifold with fundamental group $\mathbb{Z}^n$, a manifold is $L^2$-acyclic if, and only if, it is acyclic with $\mathbb{Q}(t_{1,\ldots, t_n})$-local coefficients. We are interested in $\Omega^{(2)}_n(BG)$, oriented bordism of $L^2$-acyclic manifolds with respect to a regular $G$-cover.

**Theorem 1:** There is a long exact sequence

$$\cdots \to \Omega^{(2)}_k(B\mathbb{Z}^n) \to \Omega_k(B\mathbb{Z}^n) \to L_k(\mathbb{Q}(t_{1,\ldots, t_n})) \to \cdots$$

and $L_k(\mathbb{Q}(t_{1,\ldots, t_n}))$ vanishes if $k$ is not divisible by four

This is proven by modifying the surgery program with a few tricks. Interesting connections with Witt groups of Hermitian forms will be discussed, as well as generalizations to virtually abelian groups. This is a joint work with Sylvain Cappell and Shmuel Weinberger.

12. Nathan Dunfield: (University of Illinois)
Week 1 & 2

Random knots: their properties and algorithmic challenges. (Week 1)
I will discuss various models of random knots in the 3-sphere, surveying what is known about them theoretically and what is conjectured about them experimentally. In particular, I will discuss experiments that probe the practical/average case complexity of questions like computing the genus of a knot. I will then fit this into a broader picture of open questions about the computational complexity of various problems in 3-dimensional topology.

13. Fuquan Fang: (Capital Normal University)
Week 1 & 2

Nonnegative curvature and Tits buildings
In this talk I will explain a surprise link between non-negatively curved manifolds with polar actions and Tits buildings. A new geometric characterization of normal homogeneous spaces (of certain types) can be described in terms of polar symmetric, where no transitive action is assumed.
14. **Ailana Fraser: (University of British Columbia)**

   Week 1 & 2

   **Minimal surface in the ball (Week 1)**

   I will discuss questions and results on existence, uniqueness, and compactness of free boundary minimal surfaces in the ball of fixed topological type.

15. **Bernhard Hanke: (University of Augsburg)**

   Week 1 & 2

   **Inessential Brown-Peterson homology and bordism of elementary abelian groups .**

   We revisit the bordism theory of free oriented $G$-manifolds, where $G$ is an elementary abelian $p$-group. Complementing previous approaches we pay special attention to elements coming from proper subgroups of $G$. Our results can be applied to the Gromov-Lawson-Rosenberg conjecture concerning the existence of positive scalar curvature metrics on non-simply connected closed manifolds.

16. **Matthew Hedden: (Michigan State University)**

   Week 2

   **Title and Abstract: TBA**

17. **Lizhen Ji: (University of Michigan)**

   **Title and Abstract: TBA**

18. **Vitali Kapovitch: (University of Toronto)**

   **Title and Abstract: TBA**

19. **Matthias Kreck: (Universität Bonn)**

   Week 1

   **Title and Abstract: TBA**

20. **Ian Leary: (University of Southampton)**

   Week 2

   **Concerning KS Brown's question**

   (Joint with Nansen Petrosyan). Using finite extensions of right-angled Coxeter groups we construct groups $G$ for which the minimal dimension of a classifying space for proper actions is strictly greater than the virtual cohomological dimension. In contrast to previous examples these groups do admit a cocompact model for this classifying space.

21. **Peng Lu: (University of Oregon)**

   Week 1 & 2
I will present a joint work with Pengfei Guan and Yiyan Xu. In the work we prove a splitting theorem for complete gradient Ricci soliton with nonnegative curvature and establish a rigidity theorem for codimension one complete shrinking gradient Ricci soliton in $\mathbb{R}^{n+1}$ with nonnegative Ricci curvature.

22. **Jason Lotay: (University College London)**

Week 1 & 2

Hyperkaehler 4-manifolds with boundary (Week 2)

Hyperkaehler geometry, which arises in the study of special holonomy and Ricci-flat metrics, is also important for theoretical physics and moduli space problems in gauge theory. In dimension 4, hyperkaehler geometry takes on a special character, and a natural question arises: given a compact 3-dimensional manifold N which can be a hypersurface in a hyperkaehler 4-manifold, when can it actually be "filled in" to a compact hyperkaehler 4-manifold with N as its boundary? In particular, starting from a compact hyperkaehler 4-manifold with boundary, which deformations of the boundary structure can be extended to a hyperkaehler deformation of the interior? I will discuss recent progress on this problem, which is joint work with Joel Fine and Michael Singer.

23. **Johannes Nordstrom: (University of Bath)**

Week 1 & 2

Disconnecting the G_2 moduli space (Week 2)

Little is currently known about the global properties of the G_2 moduli space of a closed 7-manifold, i.e., the space of Riemannian metrics with holonomy G_2 modulo diffeomorphisms. A holonomy G_2 metric has an associated G_2-structure, and I will define a $\mathbb{Z}/48$ valued homotopy invariant of a G_2-structure in terms of the signature and Euler characteristic of a Spin(7)-coboundary. I will describe examples of manifolds with holonomy G_2 metrics where the invariant is amenable to computation in terms of eta invariants, and which are candidates for having a disconnected moduli space. This is joint work in progress with Diarmuid Crowley and Sebastian Goette.

24. **Jongil Park (Seoul National University, Korea)**

Title and Abstract: TBA

25. **Alexandra Pettet: (University of British Columbia)**

Title and Abstract: TBA

26. **Mihaela Pilca: (University of Regensburg)**

Week 1 & 2

Homogeneous Clifford structures on Riemannian manifolds

Clifford structures on Riemannian manifolds generalize almost Hermitian and almost quaternion-Hermitian structures. These recently introduced structures are in a certain sense dual to spin structures. In this talk I will present some recent results on Clifford structures, in particular on their classification in the homogeneous setting. Namely, we will show that there exists an upper
bound for their rank on compact manifolds of non-vanishing Euler characteristic. Furthermore, we will give the complete description of the limiting cases of highest possible rank, which involves four of the exceptional Lie groups. In the other extreme case of rank 3 Clifford structures, i.e. homogeneous almost quaternion-Hermitian manifolds, we show that the manifold is either a Wolf space, the product of two spheres $S^2$ or the complex quadric $SO(7)/U(3)$. The talk is based on joint work with Andrei Moroianu and Uwe Semmelmann.

27. Piotr Przytycki: (McGill University and Polish Academy of Sciences)
   Week 2
   **Title and Abstract:** TBA

28. Andrew Ranicki: (University of Edinburgh)
   Week 1
   **The quadratic construction in surgery theory**
   This talk will be a report on the current state of a joint project with Michael Crabb on the use of the "geometric Hopf invariant" in $\mathbb{Z}_2$-equivariant homotopy theory to extract $\pi_1$-equivariant chain level quadratic structures from manifolds (or more generally Poincare duality spaces) and maps. The chain level Wall surgery obstruction of a normal map is the prime example of such a structure. All such constructions can be extracted from a natural transformation from the "certain exact sequence" of J.H.C. Whitehead involving the Hurewicz map for a Thom space to its algebraic analogue involving the $\mathbb{Q}$-groups of the speaker and Michael Weiss. On the numerical side, 8 plays a prominent role in the proceedings.

29. Holger Reich: (Free University of Berlin)
   Week 2
   **Algebraic K-theory of group algebras and the cyclotomic trace**
   The talk will report on joint work with Wolfgang Lueck (Bonn), John Rognes (Oslo) and Marco Varisco (Albany). The Whitehead group $\text{Wh}(G)$ and its higher analogues defined using algebraic K-theory play an important role in geometric topology. There are vanishing conjectures in the case where $G$ is torsionfree. For groups containing torsion the Farrell-Jones conjectures give a conjectural description in terms of group homology. After an introduction to this circle of ideas, I will report on the following new result, which for example detects a large direct summand inside the rationalized Whitehead group of a group like Thompson’s group $T$:

   The Farrell-Jones assembly map for connective algebraic K-theory is rationally injective, under mild homological finiteness conditions on the group and assuming that a weak version of the Leopoldt-Schneider conjecture holds for cyclotomic fields. This generalizes a result of Boekstedt, Hsiang and Madsen, and leads to a concrete description of a large direct summand of $\text{SK}_n (ZG) \otimes \mathbb{Q}$ in terms of group homology. Since the number theoretic assumption holds in low dimensions, this also computes a large direct summand of $\text{Wh}(G) \otimes \mathbb{Q}$. In many cases the number theoretic assumptions always hold, so we obtain rational injectivity results about assembly maps, in particular for Whitehead groups, under homological finiteness assumptions on the group only. The proof uses the cyclotomic trace to topological cyclic homology, Boekstedt-Hsiang-Madsen’s functor $\mathcal{C}$, and new general injectivity results about the assembly maps for $\text{THH}$ and $\mathcal{C}$. 
30. Nikolai Saveliev: (University of Miami)

Week 1 & 2

On the deleted squares of lens spaces (Week 2)

The configuration space \(F_2 (M)\) of ordered pairs of distinct points in a manifold \(M\), also known as the deleted square of \(M\), is not a homotopy invariant of \(M\): Longoni and Salvatore produced examples of homotopy equivalent lens spaces \(M\) and \(N\) of dimension three for which \(F_2 (M)\) and \(F_2 (N)\) are not homotopy equivalent. We study the natural question whether two arbitrary 3-dimensional lens spaces \(M\) and \(N\) must be homeomorphic in order for \(F_2 (M)\) and \(F_2 (N)\) to be homotopy equivalent. Among our tools are the Cheeger--Simons differential characters of deleted squares and the Massey products of their universal covers. This is a joint work with Kyle Evans-Lee.

31. Thomas Schick: (Georg-August Universität Göttingen)

Week 1

Signature and higher index theory

Higson and Roe have used homological algebra over C*-algebras to map the surgery exact sequence for smooth manifolds to an exact sequence of K-theory groups of C*-algebras (the latter containing as particular case the Baum-Connes assembly map). Jointly with Paolo Piazza, we have developed an appropriate secondary large scale index theory to directly construct all the maps involved in terms of higher index theory of the signature operator. This allows in particular to extend the result to the topological category. We present this result. To obtain numerical results we show how one can systematically map further to cyclic homotopy groups to obtain numerical invariants.

32. Dev Sinha: (University of Oregon)

Week 2

Characteristic classes for covering spaces and surface bundles from a Fox-Neuwirth (Schubert) cell point of view.

Fox-Neuwirth cell structures give a concrete geometric approach to cohomology of configuration spaces, akin to Schubert cell decompositions of Grassmannians. They have also recently been connected to the study of \((\infty, n)\) categories through Joyal’s category $\theta_n$. We review how these cell structures have recently been employed in calculations of the cohomology of symmetric groups. And then we give progress on their application to (stable) characteristic classes of surface bundles, building of course on the recent work of Galatius-Madsen-Tillmann-Weiss.

33. Andras Stipsicz: (Alfréd Rényi Institute of Mathematics)

Title and Abstract: TBA

34. Ozgun Unlu: (Bilkent University)

Week 1 & 2

Free Group Actions on Manifolds (Week 1)

In this talk we will discuss some methods for constructing free group actions on manifolds. Then we will talk about applications of these methods when these manifolds are products of spheres. Lastly using the known group theoretic restrictions on finite groups
that can act freely on these manifolds, we will give the characterization of the finite groups which can act freely on certain manifolds.

35. Nathalie Wahl: (University of Copenhagen)  
   Week 1 & 2  
   Homological stability (Week 2)  
   Abstract: TBA

36. Thomas Walpuski: (Imperial College London)  
   Week 1 & 2  
   G2-instantons over twisted connected sums (Week 2)  
   Abstract: TBA

37. McKenzie Y. Wang: (McMaster University)  
   Week 2  
   Construction of gradient Ricci solitons. Abstract: TBA