Banff International Research Station
for Mathematical Innovation and Discovery

Interactions of geometry and topology in low dimensions
March 26th to March 30th 2007

MEETING ROOMS

All lectures will be held in Max Bell 159 (Max Bell Building accessible by bridge on 2nd floor of Corbett Hall). Hours: 6 am–12 midnight. LCD projector, overhead projectors and blackboards are available for presentations.

MEALS

*Breakfast (Buffet): 7:00–9:00 am, Donald Cameron Hall, Monday–Friday
*Lunch (Buffet): 11:30 am–1:30 pm, Donald Cameron Hall, Monday–Friday
*Dinner (Buffet): 5:30–7:30 pm, Donald Cameron Hall, Sunday–Thursday
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

SCHEDULE

Sunday

16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours) Lecture rooms available after 16:00 (for keen participants)
17:30–19:30	Buffet Dinner, Donald Cameron Hall
20:00	Informal gathering in 2nd floor lounge, Corbett Hall Beverages and small assortment of snacks available on a cash honour-system.

Monday

7:00–8:45	Breakfast
8:45–9:00	Introduction and Welcome to BIRS by BIRS Station Manager, Max Bell 159
9:00	Michael Hutchings (University of California Berkeley) *Embedded contact homology.*
10:00	Olga Plamenevskaya (SUNY Stony Brook) *A combinatorial description of the Heegaard Floer contact invariant.* Coffee Break, 2nd floor lounge, Corbett Hall
11.15	Matthew Hedden (MIT) *Lens space surgeries, contact structures, the braid group, and algebraic curves.*
12:15–13:00	Lunch
13:00–14:00	Guided Tour of The Banff Centre (optional); meet in the 2nd floor lounge, Corbett Hall
14:00	Group Photo; meet on the front steps of Corbett Hall
14.15	Ron Stern (University of California Irvine) *Reverse engineering and smooth structures on simply-connected smooth manifolds.* Coffee Break, 2nd floor lounge, Corbett Hall
15:30	Baptiste Chantraine (UQAM) *Cobordisms of Legendrian knots.*
16:30	Brendan Owens (Lousiana State University) *Slicing numbers of knots.*
17:30–19:30	Dinner

Tuesday

7:00–9:00	Breakfast
9:00	Stanislav Jabuka (University of Nevada at Reno) *Knot concordance and Heegaard Floer homology.*
10:00	Steven Boyer (UQAM) *On families of virtually fibred Montesinos link exteriors.*
	Coffee Break, 2nd floor lounge, Corbett Hall
11:15	Nikolai Saveliev (University of Miami) *Dirac operators on manifolds with periodic ends*
12:15–14:45	Lunch and free discussion
14:45–15:00	Coffee Break
15:00	Lenhard Ng (Duke University) *Transverse knots and Heegaard Floer homology.*
16:00	Inanc Baykur (Michigan State University) *Folded-Kaehler structures on 4-manifolds*
17:00	Scott Baldridge (Louisiana State University) *Small symplectic building blocks and the geography problem.*
17:30–19:30	Dinner

Wednesday

7:00–8:30	Breakfast
8:30	Tim Perutz (Cambridge University) *A symplectic Gysin sequence and the Floer homology of connected sums.*
9:30	Benjamin Himpel (University of Bonn) *A splitting formula for spectral flow and the SU(3) Casson invariant for spliced sums.*
	Coffee Break, 2nd floor lounge, Corbett Hall
10:45	Stefan Friedl (UQAM) *Symplectic 4-manifolds with a free circle action.*
11:45	Ko Honda (University of Southern California) *Invariants of exact Lagrangian cobordisms.*
12:45–13:30	Lunch
	Free discussion in the afternoon
17:30–19:30	Dinner

Thursday

7:00–9:00	Breakfast
9:00	Julia Grigsby (Columbia University) *Knot concordance and Heegaard Floer homology invariants in branched covers*
10:00	Hao Wu (University of Massachusetts) *The Khovanov-Rozansky cohomology and Bennequin inequalities*
	Coffee Break, 2nd floor lounge, Corbett Hall
11:15	Thomas Mark (University of Virginia) *On perturbed Heegaard Floer invariants*
12:15–14:45	Lunch and free discussion
14:45–15:00	Coffee Break
15:00	Chris Wendl (MIT) *Intersection theory and compactness for holomorphic curves in low dimensions*
16:00	Hee Jung Kim (McMaster University) *Topological triviality of smoothly knotted surfaces in 4-manifolds*
17:00	Gordana Matić (University of Georgia) *Open books and contact class in Heegaard Floer Homology*
17:30–19:30	Dinner

Friday

7:00–9:00	Breakfast
	Free discussion in the morning
11:30–13:30	Lunch

Checkout by 12 noon.

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ABSTRACTS

Speaker: **Scott Baldridge** (Louisiana State University)
Title: *Small symplectic building blocks and the geography problem*
Abstract: I'll show how to construct many simply connected and non- simply connected symplectic and smooth manifolds, including a minimal symplectic manifold homeomorphic to $\mathbb{C}P^2 \sharp\, 3(-CP^2)$ containing a symplectic genus 2 surface with simply connected complement. This is joint work with Paul Kirk.

Speaker: **Inanc Baykur** (Michigan State University)
Title: *Folded-Kaehler structures on 4-manifolds*
Abstract: In this talk, we will show the existence of a generalization of symplectic structures on arbitrary closed smooth oriented 4-manifolds, called "folded-Kaehler structures". This result comes along with a decomposition theorem, which states that every closed smooth oriented 4-manifold can be decomposed into two compact Stein manifolds (one with reversed orientation), such that the induced contact structures agree on a separating convex hypersurface. We will prove that there is a natural topological counterpart for these structures: "folded Lefschetz fibrations". A brief discussion on the correspondence between achiral Lefschetz fibrations and the folded-symplectic structures will also be included in the talk.

Speaker: **Steven Boyer** (UQAM)
Title: *On families of virtually fibred Montesinos link exteriors*
Abstract: William Thurston conjectured over twenty years ago that every compact hyperbolic 3-manifold whose boundary is a possibly empty union of tori is *virtually fibred*, that is, has a finite cover which fibres over the circle. If true, it provides a significant amount of global information about the topology of such manifolds. To date, there has been remarkably little evidence to support the conjecture. For instance, there is only one published non-trivial example of a closed virtually fibred hyperbolic rational homology 3-sphere. (*Non-trivial* in this context means that the manifold neither fibres nor semi-fibres.)

In this talk I will report on joint work with Xingru Zhang which shows that the conjecture holds for the exteriors of many Montesinos links. As a consequence, we construct an infinite family of closed virtually fibred hyperbolic rational homology 3-spheres. Another byproduct of the construction is that we are able to verify that the fundamental groups of the exteriors of many Montesinos links have a finite index bi-orderable subgroup.

Speaker: **Baptiste Chantraine** (UQAM)
Title: *Cobordisms of Legendrian knots*
Abstract: One generalization of cobordism theory of knots in the Legendrian category is asking that such cobordisms are realised by Lagrangian surfaces in the symplectization. From a study of relative Gromov-Lee theorems and the behaviour of the classical invariants, we immediatly see that this relation is rigid (unlike in the topological case where only the Thom-Pontryagin construction is needed). The first step in studying this relation (and the relation of Lagrangian concordance) is to show that Legendrian-isotopic knots are Lagrangian concordant. In this talk I'll provide the basic definitions and theorems which are the

starting point of the theory. I'll also provide some non-trivial examples of Lagrangian cobordisms implying that this relation is non-symmetric. I will conclude with some expected applications of the theory together with some remarks about the difference between the algebraic and geometric aspects.

Speaker: **Stefan Friedl** (UQAM)
Title: *Symplectic 4-manifolds with a free circle action*
Abstract: Let W be a symplecitc 4-manifold with free circle action. We will show that if the fundamental group of the orbit space satisfied certain separability properties, then the orbit space fibers over S^1. We will also use the Lubotzky alternative to show that the conclusion holds if the canonical is trivial. This is joint work with Stefano Vidussi.

Speaker: **David Gay** (University of Cape Town)
Title: *Symplectic rational blow-down along Seifert fibered 3-manifolds*
Abstract: Stipsicz, Szabo and Wahl give us a large class of plumbing trees such that a configuration of spheres in a 4-manifold intersect according to one of these trees can be "rationally blown down". We extend techniques of Symington, and use some recent results on classification of tight contact structures on Seifert fibered 3-manifolds, to show that a large class of these rational blow-downs can be carried out symplectically. This is joint work with Andras Stipsicz.

Speaker: **Julia Grigsby** (Columbia University)
Title: *Knot concordance and Heegaard Floer homology invariants in branched covers*
Abstract: Let $K \subset S^3 = \partial B^4$ be a classical knot. The *smooth concordance order* of K is defined as the smallest $n \in \mathbb{Z}_+$ for which the connected sum of n copies of K bounds a smoothly-embedded disk in B^4. I will describe two new invariants which yield an obstruction to a knot having finite smooth concordance order. These invariants are defined by examining analogues of "classical" Heegaard Floer homology invariants in the double-branched cover of K. Using a simple combinatorial description of these invariants in the case where K is a two-bridge knot, we are able to conclude that all two-bridge knots of 12 or fewer crossings for which the concordance order was previously unknown have infinite concordance order. This is joint work with Daniel Ruberman and Sašo Strle.

Speaker: **Matthew Hedden** (MIT)
Title: *Lens space surgeries, contact structures, the braid group, and algebraic curves*
Abstract: I'll show that if Dehn surgery on a knot, K, yields a lens space then K arises as the transverse intersection of an algebraic curve in $\mathbb{C}^2$ with the three-sphere. Furthermore, the genus of the piece of the curve inside the four-ball is equal to the Seifert genus of K. Knots arising in this way are more general than the well-understood links of singularities, as their singular sets may be more complicated. The result follows from a theorem stating that an invariant defined using Ozsvath-Szabo theory detects when fibered knots arise from algebraic curves with a genus constraint as above. This theorem, in turn, follows from connections between Ozsvath-Szabo theory and Giroux's work on three-dimensional contact geometry, and work of Rudolph relating the knot theory of algebraic curves to the braid group. I will discuss this theorem and say how the result on knots admitting lens space surgeries follows readily from it and theorems of Ozsvath and Szabo, and Ni, respectively.

Speaker: **Benjamin Himpel** (University of Bonn)
Title: *A splitting formula for spectral flow and the SU(3) Casson invariant for spliced sums*
Abstract: The $SU(3)$ Casson Invariant does not behave well under spliced sums of homology 3-spheres. However, for splicings of complements of torus knots, Hans Boden and Chris Herald conjectured a formula relating the $SU(3)$ Casson invariant to the $SU(2)$ Casson invariant of the knot complements. The main tool for this is a splitting formula for the $su(N)$ spectral flow of the twisted odd signature for 3-manifolds cut along a torus coupled to a path of $SU(N)$ connections. This is a project with Hans Boden.

Speaker: **Ko Honda** (University of Southern California)
Title: *Invariants of exact Lagrangian cobordisms*
Abstract: We give constructions of exact Lagrangian cobordisms between two Legendrian knots in the symplectization of the standard contact $\mathbb{R}^3$, and discuss invariants arising from Legendrian contact homology and Khovanov homology. This joint work with Tobias Ekholm and Tamas Kalman.

Speaker: **Michael Hutchings** (University of California Berkeley)
Title: *Embedded contact homology*
Abstract: Embedded contact homology (ECH) is a kind of Floer theory defined for a contact 3-manifold Y, whose differential counts certain embedded pseudoholomorphic curves in the symplectization $\mathbb{R} \times Y$. ECH is conjecturally isomorphic to versions of the Seiberg-Witten and Ozsvath-Szabo Floer homologies. We review the definition of this theory and discuss some of the associated open problems and conjectures.

Speaker: **Stanislav Jabuka** (University of Nevada at Reno)
Title: *Knot concordance and Heegaard Floer homology*
Abstract: The knot concordance group has been introduced by J. Milnor and R. Fox in the mid 1960s and has since been studied by many mathematicians. Despite great efforts to understand this group, very little is known about it and many basic questions (such as the existence of n-torsion for $n > 2$) still have no answer.

After describing some of the open questions, I will talk about new results concerning knot concordance which have been obtained by using Heegaard Floer homology. I will present a an obstruction for a knot to be of order $n > 0$ in the concordance group and examine this obstruction for small crossing knots (as of this writing there are still 8-crossing knots with unknown concordance order). I will also present a Heegaard Floer proof of a theorem first obtained by Fintushel and Stern according to which the only 3-stranded pretzel knot $P(p, q, r)$ (with p, q, r odd) with trivial Alexander polynomial and which is of finite concordance order, is the unknot. I will also discuss a generalization of their result to pretzel knots with nontrivial Alexander polynomial. Most results are from joint work with Swatee Naik.

Speaker: **Hee Jung Kim** (McMaster University)
Title: *Topological triviality of smoothly knotted surfaces in 4-manifolds*
Abstract: Some generalizations and variations of the Fintushel-Stern rim surgery are known to produce smoothly knotted surfaces. We show that if the fundamental groups of their complements are cyclic, then these surfaces are topologically unknotted. Using a twist-spinning construction from high-dimensional knot theory, we construct examples of knotted surfaces whose complements have cyclic fundamental groups.

Speaker: **Thomas Mark** (University of Virginia)
Title: *On perturbed Heegaard Floer invariants*
Abstract: We describe a version of Heegaard Floer homology with coefficients in certain Novikov rings. The construction depends on the choice of a 2- dimensional real cohomology class; when this "perturbation" is nonzero the reducible part of the Floer homology vanishes, in close analogy with Seiberg-Witten theory. We use this construction to describe a version of the Ozsváth-Szabó invariants for closed 4- manifolds with $b^+ > 0$, and to define well-behaved relative invariants for 4-manifolds with boundary. If time permits, we will describe some calculations and applications of these relative invariants.

Speaker: **Gordana Matić** (University of Georgia)
Title: *Open books and contact class in Heegaard Floer Homology*
Abstract: We present an alternate, simple description of the Ozsváth-Szabó contact class in Heegaard Floer homology for the closed manifold, and some consequences of this approach. We then extend this variant of the contact class to define a new contact class for the contact manifold with convex boundary which lives in the Juhász's sutured Floer homology. This is joint work with Ko Honda and Will Kazez.

Speaker: **Lenhard Ng** (Duke University)
Title: *Transverse knots and Heegaard Floer homology*
Abstract: The recently discovered combinatorial form for knot Floer homology has an unexpected application in contact geometry. I will describe how one can use knot Floer homology to produce an effective invariant of transverse knots, and show several new examples of transversely non-simple knot types.

Speaker: **Brendan Owens** (Louisiana State University)
Title: *Slicing numbers of knots*
Abstract: The slicing number $u_s(K)$ of a knot in S^3 is the least number of crossing changes to convert K to a slice knot. This gives an upper bound for the slice genus $g_s(K)$. Livingston defined an invariant $U_s(K)$ which takes into account signs of crossings, with $g_s \leq U_s \leq u_s$. I will show that Heegaard Floer theory and also Donaldson's theorem give information on these numbers, and describe an infinite family of knots K_n with slice genus n and $U_s > n$.

Speaker: **Tim Perutz** (Cambridge University)
Title: *A symplectic Gysin sequence and the Floer homology of connected sums*
Abstract: This work (still in progress) is part of a project to study the structure of symplectic models for gauge-theoretic TQFTs on singularly-fibred 3- and 4-manifolds. I'll explain that the Gysin sequence for the cohomology of a sphere-bundle has a symplectic Floer- theoretic counterpart, which in turn is precisely analogous to a sequence describing Floer homology for connected sums of 3-manifolds.

Speaker: **Olga Plamenevskaya** (SUNY Stony Brook)
Title: *A combinatorial description of the Heegaard Floer contact invariant*
Abstract: In recent months it was shown, by Manolescu–Ozsvath–Sarkar and others, that certain Heegaard Floer homologies admit a purely combinatorial description. In particular, Sarkar and Wang developed an algorithm to modify a given Heegaard diagram for a 3-manifold so that the holomorphic disks can be combinatorially understood. Using the geometric description of the contact invariant due to Honda–Kazez-Matic, we apply a version of this algorithm in the context of open books to show that the Heegaard Floer contact invariant is combinatorial.

Speaker: **Nikolai Saveliev** (University of Miami)
Title: *Dirac operators on manifolds with periodic ends*
Abstract: This research is a part of the ongoing project with Daniel Ruberman concerning relationships between classical invariants of low-dimensional topology and certain invariants arising in 4-dimensional gauge theory.

We study Dirac operators on non-compact spin manifolds with periodic ends of dimension at least four. We provide a necessary and sufficient condition for such an operator to be Fredholm for a generic end-periodic metric. We further use these end-periodic Dirac operators to prove that an invariant introduced by Cappell and Shaneson in the 1970's provides an obstruction to the existence of metrics of positive scalar curvature on some non-orientable 4-manifolds. As an application, we show that some exotic 4-manifolds do not admit a metric of positive scalar curvature (in some cases, even if their orientation double covers do).

Speaker: **Ron Stern** (University of California Irvine)
Title: *Reverse engineering and smooth structures on simply-connected smooth manifolds*
Abstract: In this talk I will introduce a procedure called 'reverse engineering' which can be used to construct infinite families of smooth 4-manifolds in a given homeomorphism type. This is a very general technique that recovers many of the known techniques for producing smooth structures on a given simply-connected 4-manifold. As one of the applications of this technique, we produce an infinite family of pairwise nondiffeomorphic 4-manifolds homeomorphic to $S^2 \times S^2$.

Reverse engineering is a three step process for constructing infinite families of distinct smooth structures on simply connected 4-manifolds. One starts with a model manifold which has nontrivial Seiberg-Witten

invariant and the same euler number and signature as the simply connected manifold that one is trying to construct, but with $b_1 > 0$. The second step is to find b_1 essential tori that carry generators of H_1 and to surger each of these tori in order to kill H_1 and, in favorable circumstances, to kill π_1. The third step is to compute Seiberg-Witten invariants. After each surgery one needs to be careful to preserve the fact that the Seiberg-Witten invariant is nonzero.

As a one example, the model manifold that we use to construct fake $S^2 \times S^2$'s is the product of two genus 2 surfaces. One can construct exotic structures on many simply-connected smooth manifold starting with an irregular complex surface. Reverse engineering is joint work with Ron Fintushel and the computation of the fundamental group for the fake $S^2 \times S^2$'s and other small 4-manifolds is joint work with Ron Fintushel and Doug Park.

Speaker: **Hao Wu** (University of Massachusetts)
Title: *The Khovanov-Rozansky cohomology and Bennequin inequalities*
Abstract: I'll review Bennequin type inequalities established using various versions of the Khovanov-Rozansky cohomology, then give a new proof of a Bennequin type inequality established by the author, and derive new Bennequin type inequalities for knots using Gornik's version of the Khovanov-Rozansky cohomology, which generalize those established by Shumakovitch, Plamenevskaya and Kawamura using the Rasmussen invariant.

Speaker: **Chris Wendl** (MIT)
Title: *Intersection theory and compactness for holomorphic curves in low dimensions*
Abstract: I will explain a recent result strengthening the standard compactness theorem for a geometrically natural class of embedded holomorphic curves in contact 3-manifolds: it turns out the intersection theory of punctured holomorphic curves can be used to rule out multiple covers in the limit, so that transversality is never a problem. This has applications to the theory of finite energy foliations (generalizations of planar open book decompositions), and also suggests an approach for defining distinctly "low dimensional" versions of Contact Homology and SFT. I will then describe some related results in symplectic 4-manifolds and nontrivial symplectic cobordisms. These are part of a larger program to justify the statement that "nice holomorphic curves degenerate nicely".