# Circle valued Morse theory and Alexander invariants
# November 16 - 19, 2011

Room 002
Graduate School of Mathematical Sciences
The University of Tokyo
3-8-1 Komaba, Meguro-ku, Tokyo 153-8914, Japan

Talk Schedule

| Time | 16 November WED | 17 November THU |
|---|---|---|
| 9:30–10:30 | Pajitnov | Lekili |
| 11:00–12:00 | Laudenbach | Suzuki |
| 14:00–15:00 | Lekili | Tange |
| 15:30–16:30 | Ishikawa | Yamaguchi |
| 16:45–17:45 | Morifuji | Kitayama |

| Time | 18 November FRI | 19 November SAT |
|---|---|---|
| 9:30–10:30 | Laudenbach | Pajitnov |
| 11:00–12:00 | Lekili | Kitano |
| 14:00–15:00 | Kalman | — |
| 15:30–16:30 | Sakasai | — |
| 16:45–17:45 | Bao | — |

Banquet : November 17, 19:00 –

## Talk Title

### 16 November WEDNESDAY

09:30-10:30 **Andrei Pajitnov** (Université de Nantes)
Circle-valued Morse theory for 3-manifolds

11:00-12:00 **Francois Laudenbach** (Université de Nantes)
Morse complexes for manifolds with non-empty bondary and $A_\infty$ - structures. Applications to links in $S^3$.

14:00-15:00 **Yanki Lekili** (University of Cambridge)
Heegaard Floer homology of broken fibrations

15:30-16:30 **Masaharu Ishikawa** (Tohoku University)
Tangle sums and factorization of A-polynomials

16:45-17:45 **Takayuki Morifuji** (Tokyo University of A & T)
Representation spaces of torus knots and twisted Alexander polynomials

### 17 November THURSDAY

09:30-10:30 **Yanki Lekili** (University of Cambridge)
Heegaard Floer homology of broken fibrations

11:00-12:00 **Masaaki Suzuki** (Akita University)
Epimorphisms between knot groups and the images of meridians

14:00-15:00 **Motoo Tange** (RIMS, Kyoto University)
Lens space surgery and Alexander polynomial

15:30-16:30 **Yoshikazu Yamaguchi** (Tokyo Institute of Technology)
On the twisted Alexander polynomial for hyperbolic fibered links via twisted monodromy

16:45-17:45 **Takahiro Kitayama** (RIMS, Kyoto University)
Non-commutative Reidemeister torsion, higher-order Alexander polynomials and circle valued Morse theory

19:00 – **Banquet**

## 18 November FRIDAY

09:30-10:30 **Francois Laudenbach** (Université de Nantes)

Morse complexes for manifolds with non-empty bondary and $A_\infty$ - structures. Applications to links in $S^3$.

11:00-12:00 **Yanki Lekili** (University of Cambridge)

Heegaard Floer homology of broken fibrations

14:00-15:00 **Tamas Kalman** (Tokyo Institute of Technology)

A new type of combinatorics in knot theory

15:30-16:30 **Takuya Sakasai** (Tokyo Institute of Technology)

The Magnus representation and homology cobordism groups of homology cylinders

16:45-17:45 **Yuanyuan Bao** (Tokyo Institute of Technology)

Polynomial splittings of Ozsváth and Szabó's correction term

## 19 November SATURDAY

09:30-10:30 **Andrei Pajitnov** (Université de Nantes)

Circle-valued Morse theory for 3-manifolds

11:00-12:00 **Teruaki Kitano** (Soka University)

On the Alexander polynomial of a knot as an obstruction for linear representations of a knot group

## Abstract

- Yuanyuan Bao (Tokyo Institute of Technology)
  Polynomial splittings of Ozsváth and Szabó's correction term
  Abstract: For any rational homology 3-sphere and one of its spin$^c$-structures, Ozsváth and Szabó defined an invariant, called correction term. Given a knot in the 3-sphere, the correction terms associated with the prime-power-fold branched covers are smooth concordance invariants. These invariants bear some structural resemblances to Casson-Gordon invariants. Segoo Kim found a polynomial splitting property for Casson-Gordon invariants. In this talk, we show a similar result for Ozsváth and Szabó's correction terms. We give some applications of the result.

- Masaharu Ishikawa (Tohoku University)
  Tangle sums and factorization of A-polynomials
  Abstract: An A-polynomial is a knot invariant derived from the $SL(2,\mathbb{C})$-representations of the fundamental group of the knot's complement. This polynomial is important since we can obtain a lot of geometric information of the knot including the boundary slopes of incompressible surfaces and cyclic/finite Dehn surgeries. Factorization of A-polynomials via epimorphisms were first mentioned by Silver and Whitten and then studied by Hoste and Shanahan in detail. They proved that if there exists an epimorphism $\pi_1(S^3 \setminus K_1) \to \pi_1(S^3 \setminus K_2)$, preserving peripheral structures, then their A-polynomials have the factorization $A_{K_2}(L,M) \mid (L^d-1)A_{K_1}(L^d,M)$.

  In this talk, we show that there exists infinitely many examples of pairs of knots $K_1$ and $K_2$ that have no epimorphism $\pi_1(S^3 \setminus K_1) \to \pi_1(S^3 \setminus K_2)$ preserving peripheral structures although their A-polynomials have the factorization $A_{K_2}(L,M) \mid A_{K_1}(L,M)$. This is a joint work with T.W.Mattman and K.Shimokawa.

- Tamas Kalman (Tokyo Institute of Technology)
  A new type of combinatorics in knot theory
  Abstract: Given a bipartite graph $G$, I will outline the construction of its root polytope $Q_G$ and that of its two hypertree polytopes which are (essentially) cross-sections of $Q_G$. I will explain how these objects are related to low-dimensional topology on two fronts: A) If the plane bipartite graph $G$ is the Seifert graph of the special alternating link $L_G$, then the Homfly polynomial of $L_G$ contains the common $h$-vector of all triangulations of $Q_G$. This is joint work with Hitoshi Murakami. B) The hypertree polytopes of a plane bipartite graph

are recovered as the Euler characteristic of certain sutured Floer homology groups. This result is joint with András Juhász and Jacob Rasmussen.

- Teruaki Kitano (Soka University)
  On the Alexander polynomial of a knot as an obstruction for linear representations of a knot group
  Abstract: Let $K$ be a knot in $S^3$ and $\mathrm{G}(K)$ its knot group. It is known that the special value of the Alexander polynomial of $K$ at an integer $n$ gives an obstruction for the existence of representations of $\mathrm{G}(K)$ into the symmetric group of some degree. In this talk I review this classical theory first. Secondly we mention the existence of $\mathrm{GL}(2, Z/n)$-representations of $\mathrm{G}(K)$ with the non-trivial Alexander polynomial for infinitely many $n$, as an application.

- Takahiro Kitayama (RIMS, Kyoto University)
  Non-commutative Reidemeister torsion, higher-order Alexander polynomials and circle valued Morse theory
  Abstract: For a circle valued Morse function of a manifold, Reidemeister torsion over a non-commutative formal Laurent polynomial ring equals the product of a certain non-commutative Lefschetz-type zeta function and the algebraic torsion of the Novikov complex over the ring. This gives dynamical and Morse theoretical descriptions of higher-order Alexander polynomials of a 3-manifold.

- Francois Laudenbach (Université de Nantes)
  Morse complexes for manifolds with non-empty bondary and $A_\infty$ - structures. Applications to links in $S^3$.
  Abstract: Given a generic Morse function on a manifold with non-empty boundary, two Morse complexes may be defined. The first one yields the absolute homology and the second one yields the homology relative to the boundary. Both of them are endowed with multiplicative structures, $A_\infty$-structures indeed, similarly to a work by Fukaya&Oh for closed manifolds. When it is applied to the complement in the 3-sphere of a tubular neighborhood of a link, equipped with the standard height function, the Massey product is seen with a Morse point of view.

- Yanki Lekili (University of Cambridge)
  Heegaard Floer homology of broken fibrations
  Abstract: Heegaard Floer homology (HF+) is a powerful 3-manifold invariant defined by Ozsváth and Szabó as a Lagrangian intersection theory. We

will first review the original definition. Then, we will describe a new variant construction which uses an indefinite circle valued Morse function instead of a self-indexing Morse function as an auxilary data. This new variant will be called quilted Floer homology (QFH). QFH is an extension of Perutz's 4-manifold invariants making it a 3+1 theory. Our main result is an isomorphism between QFH and HF+ for extremal spin$^c$ structures with respect to the fibre of the Morse function. As applications, we will describe new computations of Heegaard Floer homology and a characterization of sutured Floer homology.

- Takayuki Morifuji (Tokyo University of A & T)
  Representation spaces of torus knots and twisted Alexander polynomials
  Abstract: Using Johnson's description of the representation space of irreducible $SL(2,C)$-representations of a torus knot, we show that the associated twisted Alexander polynomials are locally constant. We also mention some relationship to work of Hirasawa-Murasugi and Silver-Williams. This is a joint work with Teruaki Kitano.

- Andrei Pajitnov (Université de Nantes)
  Circle-valued Morse theory for 3-manifolds
  Abstract: The classical problem of fibering of a 3-manifold over a circle solved by J. Stallings about 50 years ago has recently obtained another solution, in terms of the Alexander invariants, in the works of S. Friedl and S. Vidussi. The fibering problem can be considered as a particular case of a problem of finding the minimal possible number of critical points of a circle-valued Morse function in a given homotopy class. In this survey talk we discuss the recent developments in this domain.

- Takuya Sakasai (Tokyo Institute of Technology)
  The Magnus representation and homology cobordism groups of homology cylinders
  Abstract: A homology cylinder over a compact manifold is a homology cobordism between two copies of the manifold together with a boundary parametrization. We now consider the homology cobordism group of homology cylinders. For homology cylinders over surfaces, it was shown by Cha, Friedl and Kim that their homology cobordism groups have infinitely generated abelian quotient groups by using Reidemeister torsion invariants. In this talk, we discuss higher-dimensional analogue of their results by using another invariant called the Magnus representation.

- Masaaki Suzuki (Akita University)
  Epimorphisms between knot groups and the images of meridians

Abstract: We determined whether there exists an epimorphism between knot groups which maps a meridian to a meridian in case of the knots with up to 11 crossings. The twisted Alexander polynomial is a key tool to determine the non-existence of an epimorphism. In this talk, we show some examples of epimorphisms which do not map meridians to meridians.

- Motoo Tange (RIMS, Kyoto University)
  Lens space surgery and Alexander polynomial
  Abstract: Alexander polynomial of knots yielding lens spaces has a special form. We will illustrate how to use Alexander polynomial for a classification of lens space surgery over $S^3$.

- Yoshikazu Yamaguchi (Tokyo Institute of Technology)
  On the twisted Alexander polynomial for hyperbolic fibered links via twisted monodromy
  Abstract: When the exterior of a link is a surface bundle over the circle, it is called a fibered link. The Alexander polynomial of a fibered link is expressed by the characteristic polynomial of the induced linear map by the monodromy on the homology group of a fiber surface. This can be extended to the twisted Alexander polynomial for fibered links via the induced linear map on the twisted homology group of a fiber surface. We will discuss the relation between this linear map on the twisted homology of a surface and the character variety of the surface when we consider the twisted Alexander polynomial of a hyperbolic fibered link and the composition of an SL(2,C)-representation of the link group with the adjoint action. This talk is based on a joint work with Jerome Dubois.

Organizing Committee : H. Goda, T. Kohno, A. Pajitnov