Program of the Arbeitstagung 2017 on "Physical Mathematics" in honor of Yuri Manin

Mon, 19 Jun 2017

08:30 - 09:30	*Registration*
09:30 - 10:30	MPIM Lecture Hall Dan Freed *Some applications of topology to physics I*
10:30 - 11:00	*Coffee break*
11:00 - 12:00	MPIM Lecture Hall Boris Tsygan (Northwestern) *Microlocal category of a symplectic manifold*
12:00 - 14:00	*Lunch break*
14:00 - 15:00	MPIM Lecture Hall Yuri I. Manin (MPIM Bonn) *Derived deformations and quantum cohomology*
15:00 - 16:00	MPIM Lecture Hall Vadim Schechtman (U. Paul Sabatier, Toulouse) *Fourier-Sato transform and Lusztig symmetries*
16:00 - 16:30	*Tea*
16:30 - 17:30	MPIM Lecture Hall Matilde Marcolli (California Institute of Technology) *Non-Archimedean Holography*

Tue, 20 Jun 2017

09:30 - 10:30	MPIM Lecture Hall Dan Freed *Some applications of topology to physics II*
10:30 - 11:00	*Coffee break*
11:00 - 12:00	MPIM Lecture Hall Thomas Willwacher (ETH Zürich) *Real models for the framed little n-disks operad*
12:00 - 15:00	*Lunch break*
15:00 - 16:00	MPIM Lecture Hall Vera Serganova (U. California, Berkeley) *Universal tensor categories via representation theory of supergroups*
16:00 - 16:30	*Tea*
16:30 - 17:30	MPIM Lecture Hall Nigel Hitchin (U. Oxford) *Higgs bundles and mirror symmetry*
19:00 - 22:00	University Club Bonn *Conference dinner*

Wed, 21 Jun 2017

09:30 - 10:30	MPIM Lecture Hall Dan Freed *Some applications of topology to physics III*
10:30 - 11:00	*Coffee break*
11:00 - 12:00	MPIM Lecture Hall Jacob Lurie (Harvard) *Brauer Groups in Algebraic Topology I*
12:00 - 13:00	MPIM Lecture Hall Alexander Goncharov (Yale U.) *Quantum Hodge Field Theory*
13:00 - 22:00	*Free afternoon*

Thu, 22 Jun 2017

09:30 - 10:30	MPIM Lecture Hall Jacob Lurie (Harvard) *Brauer Groups in Algebraic Topology II*
10:30 - 11:00	*Coffee break*
11:00 - 12:00	MPIM Lecture Hall Bertrand Toen (U. Toulouse) *Non-commutative geometry, trace formula and Bloch's conductor formula*
12:00 - 15:00	*Lunch break*
15:00 - 16:00	MPIM Lecture Hall Bhargav Bhatt (U. Michigan) *Integral p-adic Hodge theory and THH*
16:00 - 16:30	*Tea*
16:30 - 17:30	MPIM Lecture Hall Gonçalo Tabuada (MIT) *Grothendieck's standard conjectures via noncommutative algebraic geometry*

Fri, 23 Jun 2017

09:30 - 10:30	MPIM Lecture Hall Jacob Lurie (Harvard) *Brauer Groups in Algebraic Topology III*
10:30 - 11:00	*Coffee break*
11:00 - 12:00	MPIM Lecture Hall Ivan Cherednik (UNC Chapel Hill, RIMS) *Plane Curve Singularities via DAHA*
12:00 - 14:00	*Lunch break*
14:00 - 15:00	MPIM Lecture Hall Vladimir Drinfeld (U. Chicago) *On the pro-semisimple completion of the fundamental group of a smooth variety over a finite field*
15:00 - 15:30	*Tea*
15:30 - 16:30	MPIM Lecture Hall Maxim Kontsevich (IHES) *From classical to quantum, and back*

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Titles and abstracts of talks

DAN FREED

Some applications of topology to physics I

An axiom system for special quantum field theories was introduced over 25 years ago by Segal and Atiyah. It has been much elaborated and developed, particularly in the topological case. In these three lectures I will discuss aspects of this mathematical theory and applications to problems in physics.

BORIS TSYGAN

Microlocal category of a symplectic manifold

Given a symplectic manifold M, one can consider its deformation quantization, i.e. an associative multiplication law on functions on M that depends on a formal parameter h. When M is the cotangent bundle of a manifold X, one essentially recovers the algebra of differential operators on X, or rather of h-differential operators $P(x, hd/dx)$. Modules over differential operators are well known to have interesting applications to PDE and other topics, so it is natural to hope that modules over deformation quantization would be interesting as well.However, what one really encounters in PDE and quantum mechanics is some sort of modules where two formal parameters are involved: h and $\exp(1/h)$. What we present in the talk is a construction of modules over a bigger algebra that contains not only expressions $P(q, p, h)$ as in deformation quantization but also $\exp(f(q, p)/h)$. Here q and p are local Darboux coordinates on M.Note that from a module over differential operators on X one can pass to a sheaf on X (the module is a generalized bundle with a flat connection, and the sheaf is its De Rham complex). Since our construction (for a cotangent bundle) is the enlarged algebra of differential operators, one can ask whether its sheaf-theoretic counterpart exists. This is indeed the case. This sheaf-theoretical counterpart is given by Tamarkin's category of sheaves on $X \times \mathbb{R}$ (t on $\mathbb{R}$ roughly corresponds to $\exp(t/h)$). This construction was recently generalized by Tamarkin to a general symplectic manifold.The above constructions are conjecturally connected by some version of a Riemann-Hilbert correspondence (as D-modules and sheaves are). They have some of the features possessed by the Fukaya category of a symplectic manifold. We do not know of any functor going in either direction. The talk will give a broad overview of the topic, not assuming any prior knowledge and using the example of the plane for much of the construction.

YURI I. MANIN

Derived deformations and quantum cohomology

The simplest example of the interpretation of quantum cohomology as a deformation phenomenon is served by the comparison of (genus zero) quantum cohomology ring of P^n with miniversal unfolding space of the singularity A_n. I will be discussing the vast generalization of the deformation formalism and speculating about its possible applications to quantum cohomology theory.

VADIM SCHECHTMAN

Fourier-Sato transform and Lusztig symmetries

In this talk I will explain how to compute, in terms of linear algebra data, the Fourier-Sato transform of perverse sheaves over a complex affine space, smooth along a hyperplane arrangement. As an example a geometric interpretation, and a generalization, of Lusztig's braid group action on representations of quantum groups will be given. A joint work with M. Finkelberg and M. Kapranov

MATILDE MARCOLLI

Non-Archimedean Holography

We propose a discretization of the AdS/CFT correspondence with bulk space the p-adic Bruhat-Tits trees. In addition to a consistent description of field theory on the boundary and gravity on the bulk, this approach allows for a natural interpretation of the more recent viewpoint on holography, where bulk geometry emerges from quantum entanglement on the boundary, in terms of a construction of holographic classical and quantum codes on the Bruhat-Tits trees.

THOMAS WILLWACHER

Real models for the framed little n-disks operad

The little n-disks operad D_n is a topological operad of rectilinear embeddings of a number of disjoint "little" disks into the unit disk. Its real homotopy type is known: Due to work of Kontsevich it is formal (over $\mathbb{R}$), i.e., there is a zigzag of (homotopy) Hopf cooperads relating the cooperad of differential forms $\Omega(D_n)$ with the cohomology cooperad $H(D_n)$. The framed little n-disks operad fD_n is a generalization of D_n in which one allows the little disks to be rotated. It is known to be formal over $\mathbb{R}$ for $n = 2$ due to work of Giansiracusa-Salvatore and Severa. We describe the real homotopy type of fD_n for higher n. Concretely, we show that $\Omega(fD_n)$ is quasi-isomorphic to $H(fD_n)$ (only) for n even, and quasi-isomorphic to an explicitly described combinatorial Hopf cooperad for n odd. In particular $fD_n(n >= 2)$ is formal over $\mathbb{R}$ iff n is even.

VERA SERGANOVA

Universal tensor categories via representation theory of supergroups

For each of the four series of classical supergroups $GL(m|n)$, $OSP(m|n)$, $P(n)$ and $Q(n)$ we construct universal symmetric monoidal rigid categories by taking certain inverse limits . In the first two cases these categories are abelian envelopes of the Deligne categories $GL(t)$ and $O(t)$ (when t is an integer) while for P and Q we obtain some new tensor categories. We also show that the categories in question are highest weight (in the sense of Cline, Parshall and Scott) using interaction with representations of the ind (super)groups $GL(\infty)$, $O(\infty)$, $P(\infty)$, and $Q(\infty)$. (Most of the talk is based on joint work with I. Entova-Aizenbud and V. Hinich.)

NIGEL HITCHIN

Higgs bundles and mirror symmetry

The SYZ mirror of the moduli space of Higgs bundles for a group G is interpreted as the moduli space for the Langlands dual group. The talk will discuss some of the outcomes and problems related to this, with particular reference to holomorphic Lagrangian submanifolds. Some instructive examples arise from a recent paper of Gaiotto.

JACOB LURIE

Brauer Groups in Algebraic Topology I

Let k be a field. The collection of (isomorphism classes of) central division algebras over k can be organized into an abelian group $\mathrm{Br}(k)$, called the Brauer group of k. In this series of talks, I'll describe some joint work with Mike Hopkins on a variant of the Brauer group which arises in algebraic topology, controlling the classification of certain cohomology theories known as Morava K-theories.

ALEXANDER GONCHAROV

Quantum Hodge Field Theory

We introduce quantum Hodge correlators. They have the following format: Take a family X/B of compact Kahler manifolds. Given an oriented topological surface S with special points on the boundary, we assign to each interval between special points an irreducible local system on X, and to each special point an Ext between the neighboring local systems. A quantum Hodge correlator is assigned to this data and lives on the base B. It is a sum of finite dimensional convergent Feynman type integrals. The simplest Hodge correlators are given by the Rankin-Selberg integrals for L-functions.Quantum Hodge correlators can be perceived as Hodge-theoretic analogs of the invariants of knots and threefolds provided by the perturbative Chern-Simons theory. Here is an example: Hodge theory suggests to view a Riemann surface as a threefold, and its points as knots in the threefold. Then the Green function $G(x, y)$, the basic Hodge correlator, is an analog of the linking number, the simplest Chern- Simons type invariant. What do the quantum Hodge correlators do? Let B be a point; consider trivial local systems.Hodge correlators (S is a disc) describe an action of the Hodge Galois group by A_∞ automorphisms of the cohomology algebra $H(X)$ preserving the Poincaré pairing.Quantum Hodge correlators (S is any surface) describe an action of the Hodge Galois group by quantum A_∞ automorphisms of the algebra $H(X)$ with the Poincaré pairing.

BERTRAND TOEN

Non-commutative geometry, trace formula and Bloch's conductor formula

The Bloch conductor formula expresses the variations of Euler characteristics in a family of proper varieties when the parameter specialises to a singular value. In this talk, I will present a general approach to this conjecture based on ideas coming from non-commutative geometry. I will explain how we can use the stable homotopy theory of schemes in order to obtain a trace formula for non-commutative spaces, and how this trace formula can be applied to the setting of the Bloch's conductor formula.

BHARGAV BHATT

Integral p-adic Hodge theory and THH

Given a smooth proper scheme over the ring of integers of an algebraically closed p-adic field, we recently showed that the mod p Betti numbers of the generic fibre are a lower bound for the de Rham Betti numbers of the special fibre. The main innovation was the construction of an integral p-adic cohomology theory that gets rid of certain factorials occurring as denominators in crystalline cohomology.In my talk, I'll recall this story from the point of view of p-adic Hodge theory, and then explain a different perspective on this integral cohomology theory: it arises as a suitable graded piece of (an enrichment of) the Hochschild homology of the scheme relative to the sphere spectrum. In particular, I shall try to explain why working over the sphere spectrum instead of the integers is responsible for getting rid of the aforementioned denominators. (Everything reported is joint work with Matthew Morrow and Peter Scholze.)

GONÇALO TABUADA

Grothendieck's standard conjectures via noncommutative algebraic geometry

Making use of noncommutative algebraic geometry (an area of mathematics introduced by Manin and his students in the eighties), I will explain how to prove Grothendieck's standard conjectures in some new cases.

IVAN CHEREDNIK

Plane Curve Singularities via DAHA

Double Affine Hecke Algebras provide a universal approach to the action of $PSL(2,\mathbb{Z})$ in algebra, analysis and physics. So it is not too surprising that they appeared useful in low-dimensional geometry. The main applications now are in the theory of refined (with extra parameters) Jones, WRT, HOMFLY-PT polynomials of iterated links, including all algebraic ones. The DAHA-Jones polynomials and DAHA-superpolynomials will be defined.The DAHA-superpolynomials of iterated knots conjecturally coincide with their stable Khovanov-Rozansky polynomials. The latter are involved apart from the Khovanov polynomials. The following conjectural relation is more verifiable. The DAHA-superpolynomials can be interpreted in terms of the compactified Jacobians of the corresponding unibranch plane curve singularities. Accordingly they generalize the p-adic orbital integrals (in type A). This includes a presentation of Puiseux exponents of such singularities as proper sequences of $PSL(2,\mathbb{Z})$-matrices (then DAHA is used). An immediate application of this conjecture is that the orbital integrals are topological invariants of singularities. Interestingly, this construction is parallel to that for the periods of cusp forms, which I hope to discuss a bit if time permits.

VLADIMIR DRINFELD

On the pro-semisimple completion of the fundamental group of a smooth variety over a finite field

Let Π be the fundamental group of a smooth variety over a finite field. Let λ be a non-Archimedean place of the field of algebraic numbers. The philosophy of motives predicts that the λ-adic pro-semisimple completion of Π "does not depend" on λ. I will try to explain the prediction (which includes a kind of "reciprocity law" involving a sum over all ℓ-adic cohomology theories). I will also try to explain what can actually be proved.

MAXIM KONTSEVICH

From classical to quantum, and back

I will talk about relations between Lagrangian submanifolds and holonomic D-modules via wall-crossing and p-curvature.