ABSTRACTS

Geometry, Analysis and Quantum Field Theory

26/09/2011–01/10/2011

September 8, 2011

- **Clara Aldana** (Einstein Institut Potsdam)

  Determinants of Laplacians on surfaces

  Determinants of pseudo differential operators have been widely studied, in analysis, geometry and physics. I will talk about zeta determinants of Laplacians on non-compact surfaces that are asymptotically hyperbolic. I will explain how such a determinant is defined, describe its extremal properties and comment on some applications.

- **Christian Becker** (Univ. Potsdam)

  Cheeger-Chern-Simons theory and geometric String structures

  For a compact Lie group G with Lie algebra $\mathfrak{g}$ and an invariant map $\lambda : \mathfrak{g}^k \to \mathbb{R}$, the Chern-Weil construction associates to any G-principal bundle $P \to X$ with connection a closed $2k$-form $CW(\lambda) \in \Omega^{2k}(X)$. This construction has two well-known refinements: the Chern-Simons form $CS(\lambda) \in \Omega^{2k-1}(P)$ and the Cheeger-Simons differential character with curvature $CW(\lambda)$. We show that these fit together nicely to a relative differential character with curvature $CW(\lambda)$ and covariant derivative $CS(\lambda)$. This is what we call Cheeger-Chern-Simons theory. Geometric String structures have been introduced in the context of bundle gerbes by Waldorf as a trivialization of Chern-Simons theory for $G = Spin(n)$ and $\lambda = \frac{p_1}{2}$. We show how Cheeger-Chern-Simons theory gives rise to an analogous construction for any compact Lie group G and any universal characteristic class in $H^*(BG, \mathbb{Z})$.

- **Maxim Braverman** (North Eastern Univ., Boston)

  Background cohomology of non-compact Kaehler manifolds

  Dolbeault cohomology of holomorphic vector bundles over compact Kahler manifolds have many nice properties (such as Kodaira vanishing theorem, holomorphic Morse inequalities, Guillemin-Sternberg "quantization commutes with reduction" property) which in general don't hold for non-compact manifolds. In the talk I will present a new normalization construction of cohomology of equivariant vector bundles over a non-compact Kahler manifold endowed with an action of a compact Lie group G. The new cohomology, which is called the "background cohomology", has many properties of Dolbeault cohomology of a compact manifold. It is also related to the index theory for non-compact G-manifolds, which was developed several years ago by P.-E. Paradan and myself.

- **Ulrich Bunke**

  Transfer in differential algebraic K-theory (joint work with D. Gepner)

  I will explain a spectrum version of differential cohomology which allows to define a differential Becker-Gottlieb transfer. As an application I discuss differential algebraic K-theory and a cycle map for local systems of projective modules over a number ring. I will show how the interplay between homotopy theory and analysis and geometry gives interesting arithmetic statements (conjectures and partial results) about higher torsion invariants.

- **David Elworthy** (Univ. of Warwick)

  L^2 cohomology and harmonic one-forms on path spaces of Riemannian manifolds

  Following Len Gross's work on infinite dimensional potential theory in the late 1960's the natural calculus for analysis on path spaces with diffusion measures has been based on differentiation in the directions of so-called "Bismut tangent spaces" . In this talk I will describe the basic calculus and some recent results on vanishing of L^2 one-forms. In particular:

  - In general the "Bismut tangent bundle" is not integrable leading to difficulties in setting up an exterior calculus for L^2 forms. An approach to this was suggested by the author and Xue-Mei Li, with a detailed treatment for one-forms in 2008. Recently, work by the author with his student Yuxin Yang has provided a proof of vanishing of first L^2 cohomology groups for based path spaces in this context, with corresponding vanishing of L^2 harmonic one-forms. The proof demonstrates a pleasing interplay between the differential geometry of the Bismut tangent spaces and the temporal structure of the underlying path space.
  - For based loops on compact Lie groups the Bismut tangent bundle can be chosen to be integrable so the above problems do not arise. In a remarkable paper Aida has recently shown that for this situation the first L^2 cohomology group vanishes if the compact group is simply connected. That proof uses techniques of rough path theory, and no details will be given.

- **Pedram Hekmati** (Australian Nat. Univ.)

  Caloron Correspondence for Gauge Group Bundles

  In its simplest form, the Caloron correspondence is an equivalence of categories between loop group bundles over a manifold M and G-bundles over $M \times S^1$. The correspondence works also at the level of connections by introducing Higgs fields, and provides a mean for defining characteristic classes for LG- bundles. In this talk, I will describe how to extend these results to gauge group bundles. This is joint work with M. Murray and R. Vozzo.

- **Man Ho** (Boston Univ.)

  Differential K-theory and the differential index theorem

  The Atiyah-Singer family index theorem can be stated as the equality of analytic and topological index maps in K-theory. In recent years, extensions of K-theory, called differential or smooth K-theory, have been developed, with motivation from mathematical physics. There are several models of differential K-theory, due to Bunke-Schick, Freed-Lott, Hopkins-Singer and Simon-Sullivan. The family index theorem has been generalized to differential K-theory by Bunke-Schick and Freed-Lott.

  In this talk, we define Bunke-Schick, Simons-Sullivan and Freed-Lott differential K-theory, and construct an explicit isomorphism between the latter two. Finally, we state the differential index theorem in Freed-Lott theory and discuss the problem in defining the analytic index in Simons-Sullivan theory.

- **Bruno Iochum** (University of Provence, Marseille)

  Spectral action beyond its asymptotics expansion

  After few basics on spectral action, the case of a non-compact commutative spectral triple will be computed covariantly in a gauge perturbation up to order 2 in full generality. As a consequence, the Yang-Mills spectral action is not super-renormalizable.

- **Paul Kirk** (Bloomington, US)

  Coisotropic Luttinger surgery and Symplectic 6-manifolds with $c_1 = 0$.

  We introduce a surgery operation on symplectic manifolds generalizing Luttinger surgery on Lagrangian tori in 4-manifolds and use it to produce infinitely many distinct non-Kahler symplectic 6 manifolds with $c_1 = 0$ not of the form $M \times F$ for F a surface.

- **Dirk Kreimer** (Humboldt Univ., Berlin)

  On QFT

  We review the understanding of renormalizable QFT from the viewpoint of Hopf algebras and parametric representations. We discuss in particular broken scale invariance in field theory, and its connection to the coradical filtration of the Hopf algebra of Feynman graphs.

- **Andres Larrain** (Boston Univ.)

  K-Theories for Classes of Infinite Rank Bundles

  Several authors have recently constructed characteristic classes for classes of infinite rank vector bundles including the tangent bundle to the space of maps between manifolds and bundles with invertible pseudodifferential operators as structure group.In this talk, a construction of the corresponding K-theories for these types of bundles is presented. We develop the formalism of these theories and use their Chern character to detect a large class of nontrivial elements.

- **Matthias Lesch** (University of Bonn)

  Semiclassical heat expansions, multiparameter resolvent expansions and regularized determinants

  In this survey type talk I will first recall the parameter dependent pseudodifferential calculus which is a fundamental tool in microlocal analysis. I will then discuss a new multiparameter resolvent expansion which follows easily from the parameter dependent calculus. As a first application a short proof of the semiclassical heat expansion for arbitrary elliptic differential operators will be given.

  Finally I will report on an ongoing joint project with Boris Vertman. First we prove a Fubini type Theorem for regularized integrals. As a new feature a correction term shows up when exchanging the order of integration. Combining this result with (an extension of) the above mentioned multiparameter expansion and the Euler McLaurin formula we are able to give formulas for the zeta–regularized determinants of Schrödinger operators on surfaces of revolution. So far, such formulas have been around only in the 1D case.

- **Xue Mei Li** (Univ. of Warwick)

  Random perturbation of SDE's on the orthonormal frame bundle

  Consider a stochastic differentiation equation (SDE) on the orthonormal frame bundle of a Riemannian manifold with random perturbation. This will be studied together with the corresponding linearised SDEs using linear connections associated with the SDE. We are specially interested in conservation laws, effective diffusions, and applications to analysis on path spaces.

- **Yoshiaki Maeda** (Keio Univ., Japan)

  Deformation Quantization and Spectral Analysis

  We discuss on the spectral analysis from deformation quantization point of view. We realize the Weyl algebra via deformation quantization with expressing parameters to study the star-exponential functions. We pick up general properties for the star-exponential functions which may show the discreet phenomena for spectral values.

- **Jouko Mickelsson** (University of Helsinki/ Royal Institute of Technology, Stockholm)

  Characteristic classes of certain infinite-rank vector bundles many cases in computations in index theory the (families) index can be expressed formally as Chern character of an infinite-rank vector bundle. However, the curvature form takes values in an infinite-dimensional Lie algebra consisting of non trace-class operators and therefore the naive Chern character is ill-defined. I will discuss a 'renormalization' of the curvature form based on a method in quantum field theory, previously applied to the computation of hamiltonian anomalies and construction of gauge current algebra in Yang-Mills theory in higher than two space-time dimensions.

- **Gerard Misiolek** (Univ. Notre-Dame, US)

  Geometry of diffeomorphism groups with L^2 and H^1 metrics

  I will discuss properties of the Riemannian exponential map of the right-invariant L^2 metric on the group of volume-preserving diffeomorphisms. Time permitting, I will also describe recent results on the geometry of the right-invariant H^1 metric on the space of densities.

- **Elmar Schrohe** (Univ. Hannover)

  A K-theoretic proof of the families index theorem for Boutet de Monvel's calculus

  We define the analytical and the topological indices for continuous families of operators in the C*-closure of the Boutet de Monvel algebra. Using the equivariant Atiyah-Singer theorem for families, equivariant topological K- theory and operator algebra K-theory arguments, we prove that these two indices coincide.

- **Raymond Vozzo** (Austr. Nat. Univ.)

  T-duality via bundle gerbes

  In physics T-duality is a phenomenon which relates certain types of string theories to one another. From a topological point of view, one can view string theory as a duality between line bundles carrying a degree three cohomology class (the H-flux). In this talk we will use bundle gerbes to give a geometric realisation of the H-flux and explain how to construct the T-dual of a line bundle together with its T-dual bundle gerbe.

- **Kondrad Waldorf** (Univ. Regensburg)

  A loop space formulation of the geometry of abelian gerbes

  I will talk about an equivalence between the category of abelian gerbes over a smooth manifold, and a category of certain bundles over the free loop space of that manifold. More precisely, there is one equivalence in a setting where the bundles and gerbes are equipped with connections, and another in a setting without connections. The equivalence is established by a "regression" functor which is inverses to a transgression functor defined by Brylinski and McLaughlin. As an application, I will describe loop space analogues of spin structures and spin connections.

- **John Wolf** (Berkeley, US)

  Principal Series Representations for some Infinite Dimensional Lie groups

  The representation theory of finite dimensional semisimple Lie groups is based on Harish-Chandra's construction of the discrete series. The simplest series those representations is the principal series, which uses the Cartan highest weight theory instead of the discrete series theory. I'll discuss some ways in which the theory of the principal series extends to classical infinite dimensional simple groups such as the linear groups $SL(\infty), U(n, \infty), Sp(\infty, R)$, etc.

- **Tilmann Wurzbacher** (Univ. Bochum and Metz)

  Geodesics on supermanifolds

  Riemannian geometry of supermanifolds is important for a wide range of problems in theoretical physics and related mathematical fields. In this talk we will discuss the notion of a geodesical curve on a Riemannian supermanifold. In our approach we get a geodesic flow whose integral curves are in bijection with the geodesics. We apply our ensuing exponential map to extend the usual faithful linearization of isometries to supermanifolds.

- **Yuxin Yang** (Univ. of Warwick)

  Generalised Clark-Ocone Formula

  l'll describe a few approaches to give an "arrow of time" to certain infinite dimensional manifolds. Such temporal structures can be used to obtain a generalised Clark-Ocone formula, which shows how certain functions can be expressed as divergences of "time-adapted vector fields". We are also interested in topological obstructions to imposing such a structure on a more general manifold, for example loop spaces, where there exist counterexamples to log-Sobolev inequality and spectral gap inequality, both of which are consequences of the classical Clark-Ocone formula. This is based on work in progress with David Elworthy.