Mathematics Seminar
of the
University of Luxembourg
in cooperation with the
Luxembourg Mathematical Society

January 2007

30 January 2007 at 5 pm **Room 3.04 bs**

Vladimir Roubtsov
University of Angers

Sklyanin elliptic algebras and associated integrable systems

Abstract

We construct new integrable systems, both classical and quantum, associated with Sklyanin elliptic algebras. Our constructions are based both on a construction of commuting families in skew fields and on properties of the elliptic algebras and their representations. We give some examples showing how these integrable systems are related to previously studied systems.

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March 2007

6 March 2007 at 5 pm **Room 3.04 bs**

Hidenori Fujiwara
Kinki University

Intertwining operators for irreducible monomial representations of exponential groups

Abstract

In many aspects of representation theory, it turns out useful to get an explicit form of intertwining operators. In the framework of the orbit method for exponential solvable Lie groups, we are interested to construct explicitly an intertwining operator between two irreducible monomial representations constructed at the same linear form on the Lie algebra, starting from two polarizations satisfying the Pukanszky condition.

13 March 2007 at 6 pm **Room 0.03 bs**

Anton Thalmaier
University of Luxembourg
Public opening lecture

Brownian motion: from pollen grains in water to global geometry

Abstract

In 1828 Robert Brown, a famous nineteenth century botanist, published his microscopical investigations that dust grains suspended in water perform a rapid and highly irregular motion. With the most careful scrutiny, he ruled out that these erratic movements were signatures of life.

In 1905 Albert Einstein, unaware of the work of Brown, predicted the phenomenon on theoretical grounds, caused through a bombardment by the molecules of the liquid, and formulated a correct quantitative theory of it.

It is remarkable that already 5 years before Einstein, in 1900 Louis Bachelier defended at the Sorbonne his thesis "Thorie de la Speculation" in which the mathematical theory of Brownian motion is initiated and used for the modeling of price movements and evaluation of contingent claims in financial markets.

During the last 100 years Brownian motion became not only the keystone of a fully probabilistic formulation of statistical mechanics, as well as for financial engineering on the stock markets, in mathematics it grew to an universal object that lies at the interface of Analysis, Geometry and Probability. Brownian motion feels curved spaces and helps to connect local and global geometry. In our talk we give a small panorama of some examples.

13 March 2007 at 6:45 pm **Room 0.03 bs**

Martin Olbrich
University of Luxembourg
Public opening lecture

Fourier series and their generalisations: a glimpse of harmonic analysis

Abstract

About 200 years ago investigations of vibrating strings led to the discovery that quite arbitrary periodic functions on the real axis should be representable as infinite sums of elementary oscillations, i.e., of sine and cosine functions. Nowadays, these infinite sums are called Fourier series, after Joseph Fourier (1768-1830). The theory of Fourier series, which has found numerous applications in technics and physics is the prototype of (commutative) harmonic analysis. The word commutative refers to the commutativity of addition of real numbers.

We will explain the basic ideas of this theory and present some surprising mathematical applications of it. Then we will leave the commutative world and explain by analogy questions of recent mathematical research that can be attacked by techniques of noncommutative harmonic analysis.

20 March 2007 at 5 pm **Room 3.04 bs**

Heinz Koenig
University of Saarbrücken

Stochastic processes under new concepts in measure theory

Abstract

The traditional concept of a stochastic process has - in case of an uncountable time domain - the problem that the domain of its canonical measure in the path space is much too small, so that one needs extensions (or versions) of an a priori unknown multitude. In the present talk, the author uses his recent work in measure and integration to produce a modified concept of a stochastic process. It replaces the canonical measure with a unique

new measure in the path space, which has a large domain and appears to have adequate properties. The two kinds of processes are in one-to-one correspondence when the state space is a Polish topological space. The new measure is then an extension of the previous canonical one.

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April 2007

17 April 2007 at 5 pm **Room 3.04 bs**

Friedrich Wagemann
University of Nantes

Gerbes and crossed modules of Lie groupoids

Abstract

In categories $\mathcal{C}$ like the category of groups or (Lie-)algebras, *crossed modules* are known to be linked to abelian 3-cohomology. A crossed module is, roughly speaking, a morphism $\mu : X \to Y$ between objects X, Y of the category $\mathcal{C}$, together with a compatible action of Y on X. To such a crossed module, one associates a 4-term exact sequence obtained by passing to kernel and cokernel of μ.

On the other hand, integral singular 3-cohomology of a manifold M can be described in terms of *gerbes with band* S^1. This comes from the interpretation of this kind of gerbes as $PU(\mathcal{H})$-principal bundles P on M, where $\mathcal{H}$ is an infinite dimensional, separable Hilbert space. More precisely, lifting the structure group of P to $U(\mathcal{H})$ defines locally (on M) the category of principal $U(\mathcal{H})$-bundles $\hat{P}$ whose quotient by the center is P. This sheaf of categories is a gerbe with band S^1.

The purpose of my talk is to show in general that the lifting of the structure group K of a K-principal bundle P on M to a central extension $\hat{K}$ of K by an abelian group Z gives rise to a gerbe with trivial band Z on M. The key point for this is to interprete the data in terms of a crossed module of Lie groupoids, based on the *Atiyah groupoid* associated to P. Crossed module of Lie groupoids whose kernel is a trivial bundle $Z \times M$ with abelian Z and whose cokernel is the pair groupoid $M \times M$ are shown to be in one-to-one correspondence to gerbes with abelian trivial band. The corresponding 3-cohomology obstruction class of the crossed module gives the Dixmier-Douady class of the gerbe.

The origin of this joint work Camille Laurent-Gengoux goes back to open questions of Karl-Hermann Neeb who defined obstruction classes in the de Rham 3-cohomology of M using a crossed module of topological Lie algebras associated to P and

$$1 \to Z \to \hat{K} \to K \to 1.$$

The interpretation of the lifting problem in terms of crossed modules of Lie groupoids is due to Kirill Mackenzie and his school.

17 April 2007 at 6:30 pm **Bâtiment de Recherche B, ground floor, common room**

Annual meeting of the Luxembourg Mathematical Society

24 April 2007 at 5 pm **Room 3.04 bs**

Paulo Antunes
École Polytechnique Palaiseau

Big bracket and Lie algebroid structures

Abstract

We will see how structures such as Lie (bi)algebroids and Courant algebroids appear as hamiltonians on a supermanifold with the 'big bracket' as natural Poisson bracket in the cotangent space. We will also show how the 'big bracket' in this supermanifold setting allow us to characterize other algebraic structures.

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May 2007

Monday (!), 7 May 2007, at 5 pm **Room 3.04 bs**

Ines Kath
Johann Wolfgang Goethe-Universität, Frankfurt am Main

Lorentzian extrinsic symmetric spaces

Abstract

A non-degenerate connected submanifold $M \subset \mathbb{R}^{p,q}$ is called extrinsic symmetric if it is invariant under the reflection at each of its affine normal spaces. Extrinsic symmetric spaces in $\mathbb{R}^{p,q}$ are exactly those complete submanifolds whose second fundamental form is parallel. Extrinsic symmetric spaces in the Euclidean space are well understood. A classification of these spaces follows from a nice construction due to Ferus. The pseudo-Riemannian case seems to be more involved. Here we want to discuss some classification results for Lorentzian extrinsic symmetric spaces.

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June 2007

Monday (!), 11 June 2007, at 5 pm **Room 3.04 bs**

Jacques Franchi
University of Strasbourg

Relativistic Diffusion in Gödel's Universe

Abstract

K. Gödel published his exact solution to Einstein's field equations in 1949. On the other hand, a general Lorentz invariant operator, associated to a so-called "relativistic diffusion", and making sense in any Lorentz manifold, was defined recently by Y. Le Jan and myself. I shall expound a study of the relativistic diffusion in the framework of Gödel's universe, which contains matter and is non-causal.

12 June 2007, at 5 pm **Room 3.04 bs**

Benjamin Enriquez
University of Strasbourg

Universal elliptic KZB connections

Abstract

We define a universal version of the Knizhnik-Zamolodchikov-Bernard (KZB) connection in genus 1. This is a flat connection over a principal bundle on the moduli space of elliptic

curves with marked points. It restricts to a flat connection on configuration spaces of points on elliptic curves, which can be used for proving the formality of the pure braid groups on genus 1 surfaces. We study the monodromy of this connection and show that it gives rise to a relation between the KZ associator and a generating series for iterated integrals of Eisenstein forms. We show that the universal KZB connection realizes as the usual KZB connection for simple Lie algebras.

19 June 2007, at 5 pm **Room 3.04 bs**

Marie-Pierre Pausch
University of Luxembourg

Facilities of the University's Library

Abstract

This presentation gives an overview about the facilities of the University's Library, in particular about the network catalogue www.bibnet.lu and about the electronic documentary portal www.portal.bnu.lu

The objective is to give advice in order to improve searches and to give explanations about the content, the structure and technical aspects of these tools, as the metasearch of the portal.

Wednesday (!), 20 June 2007, at 5 pm **Room 3.04 bs**

Elton P. Hsu
Northwestern University

Cameron-Martin-Girsanov Theorem in Stochastic Analysis

Abstract

The Cameron-Martin-Girsanov-Maruyama theorem is the cornerstone of stochastic analysis and plays a crucial role in infinite dimensional analysis and financial mathematics. In this talk we will first briefly review the history of the theorem. We will then discuss the theorem in its most classical form. At the end we will present some latest developments, especially its generalization to noncompact Riemannian manifolds.

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September 2007

25 September 2007, at 5 pm **Room 3.04 bs**

Ulrich Bunke
University of Regensburg

Smooth K-theory and applications

Abstract

I plan to give an introduction to smooth cohomology theories with an emphasis on a model of smooth K-theory. As an application I will show that invariants of secondary index theory can naturally be understood in this framework.

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October 2007

2 October 2007, at 5 pm **Room 3.04 bs**

Pierre Bieliavsky
Catholic University of Louvain

Deformation quantization for actions of non-abelian Lie groups and hyperbolic geometry

Abstract

We define a universal deformation formula (UDF) for the actions of the affine group on Frechet algebras. More precisely, starting with any associative Frechet algebra which the affine group acts on in a strongly continuous and isometrical manner, the UDF produces a family of topological associative algebra structures on the space of smooth vectors of the action deforming the initial product. The deformation field obtained is based over an infinite dimensional parameter space naturally associated with the space of pseudo-differential operators on the real line. We will also present some geometrical aspects of the UDF and in particular its relation with hyperbolic geometry.

9 October 2007, at 5 pm **Room 3.04 bs**

Pierre Mathonet
University of Liège

A review of equivariant and invariant quantizations

Abstract

In the framework of geometric quantization, one can think of a quantization procedure as a linear bijection from the space of classical observables (also called symbols) to a space of differential operators acting on wave functions.

It is known that there is no natural quantization procedure. In other words, the spaces of symbols and of differential operators are not isomorphic as representations of $Diff(M)$.

However, when there is a Lie group G acting on M by local diffeomorphisms, P. Lecomte and V. Ovsienko defined a G-equivariant quantization as a linear bijection from the space of symbols to the space of differential operators that exchanges the actions of G on these spaces.

The first example of such equivariant quantization was given by Lecomte and Ovsienko, who considered the case of the projective group $PGL(m+1,\mathbb{R})$ acting on the manifold $M=\mathbb{R}^m$ by linear fractional transformations.

Together with C. Duval, they then considered the conformal group $SO(p+1,q+1)$ acting on the space $\mathbb{R}^{p+q}$ or on a manifold endowed with a flat conformal structure.

In both cases, they obtained results of existence and uniqueness of equivariant quantizations, up to normalization.

These results were followed by a series of papers dealing with other types of differential operators or other groups of equivariance.

The first generalization of these works was formulated by P. Lecomte. He conjectured the existence of a quantization procedure depending on a torsion-free connection, that would be natural (in all arguments) and that would be left invariant by a projective change of connection : a projectively invariant quantization.

The existence of such a quantization procedure was proved by M. Bordemann for differential operators acting on densities, using the notion of Thomas-Whitehead connections.

These results were generalized by S. Hansoul using Thomas whitehead connections. At the same time, together with F. Radoux, we provided new and easier proofs of the existence results using Cartan connections.

In this talk, I will give a review of equivariant and invariant quantizations starting from the very beginning. Then I will focus on recent developments that use the theory of Cartan connections in order to settle the existence problem of projectively invariant quantizations.

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November 2007

6 November 2007, at 5 pm **Room 3.04 bs**

Georges Habib
Max Planck Institute, Leipzig

A new lower bound for eigenvalues of the Dirac operator

Abstract

In this talk, we give a new estimate for the eigenvalues of the Dirac operator on a compact spin manifold in terms of an appropriate endomorphism E^ψ of the tangent bundle associated with an eigenspinor ψ. We then show that, for isometric immersions and Riemannian flows (local Riemannian submersions), the limiting case could be achieved. In this case, the tensor E^ψ is identified with the second fundamental form of the immersion while it is identified with the O'Neill tensor of the flow.

13 November 2007, at 5 pm **Room 3.04 bs**

Anne Pichereau
Centre de Recerca Matemàtica, Barcelona

Formal deformations of Poisson structures in low dimensions

Abstract

As in the classical cases of associative or Lie brackets, there is a cohomology that governs the existence of formal deformations and the existence of extensions of deformations of

Poisson structures. This cohomology is the so-called Poisson cohomology. In this talk, we consider a family of Poisson structures on the affine space of dimension 3, F^3, and a family of singular Poisson surfaces in F^3, both families being associated to weight-homogeneous polynomials that admit an isolated singularity. We then explain how we obtain an explicit formula for all formal deformations of these Poisson structures, using some results of Poisson cohomology. We also give some interesting properties for these deformations.

20 November 2007, at 5 pm **Room 3.04 bs**

Giovanni Peccati
University Paris 6

High-frequency asymptotics on the sphere and Clebsch-Gordan random walks

Abstract

We discuss high-frequency central limit theorems on homogeneous spaces, and how they can be expressed in terms of convolutions of Clebsch-Gordan coefficients. These coefficients appear in unitary matrices connecting reducible representations of $SO(3)$. This allows reinterpreting part of our results in terms of coupling of angular momenta in a quantum mechanical system. An important motivation for our research comes from the probabilistic representation and the statistical analysis of the Cosmic Microwave Background (CMB) radiation.

This is based on joint works with D. Marinucci (Rome).

27 November 2007, at 5 pm **Room 3.04 bs**

Michel Emery
University of Strasbourg

Elementary spectral properties of some 3-tensors

Abstract

As everyone knows, any symmetric matrix diagonalizes in an orthonormal basis, and several symmetric matrices commute with each other if and only if they share a common diagonalization.

We shall discuss similar properties for some symmetric tensors with three indices instead of two.

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December 2007

12 December 2007, at 2 pm **Room 2.04 bs**

Jean-Marie Couveignes
University of Toulouse 2

Rational torsion classes in the Picard group of algebraic curves and the computation of modular Galois representations

Abstract

Take a prime ℓ and a finite field F_q with characteristic $p \neq \ell$ and a curve C over F_q. Let J/F_q be the Jacobian of C. We want to compute a basis $(g_1, \ldots, g_I)$ for $J/F_q[\ell]$, the rational part of the ℓ-torsion in J. Each g_i is given as a divisor on C in the corresponding class. I will show how to solve this problem in probabilistic polynomial time in $\log q$ and the genus of C. I will explain why this is useful for computing Galois representation attached with modular forms with even weight and the coefficients of these forms, following the program developed by Edixhoven to answer a question raised by René Schoof.

Please note that this talk—jointly organized by the LACS and the IMATH—will be given on **Wednesday** at **2 pm**, in room **2.04 bs**.

18 December 2007, at 5 pm **Room 3.04 bs**

Willy Sarlet
Ghent University

Decoupling second-order ordinary differential equations

Abstract

The general field for this talk is *applied differential geometry* and more particularly the *geometry of second-order dynamics*.

I shall start from the following concrete question: given an arbitrary (coupled) system of second-order differential equations, how can we figure out whether it is possible to change coordinates in such a way that the transformed equations decouple into single equations? To tackle this question, one needs to know about general tangent bundle geometry and the geometry of second-order equation fields. It will be argued that efficient tools for studying geometrical aspects of second-order dynamics are provided by the calculus of derivations of forms along the tangent bundle projection $\tau : TM \to M$. After a brief survey of this theory, which involves various notions of connections, I will present the full solution of the separability question. Finally, if time permits, I will briefly dwell on some related issues, such as the 'separable case' in Douglas's treatment of the inverse problem of the calculus of variations, and recent work on so-called 'submersive cofactor systems'.