At the confluence of Analysis, Geometry and Modern Mathematical Physics

Beirut, February 15-17, 2018

Titles and Abstracts

Paolo Aschieri (University of Piemonte Orientale, Italy)

Title : *Noncommutative differential geometry*
Abstract : Deformation quantization of algebras can be efficiently studied in the context of representation theory. This leads to deformations of vector bundles and principal bundles and of their geometry. We present an overview of these topics considering in particular deformations via Drinfeld twists and the corresponding gravity theory on noncommutative spacetime.

Isabelle Chalendar (University of Paris-Est, France)

Title : *Discrete and continuous semigroups of composition operators on various spaces of analytic functions*
Abstract : Composition operators on spaces of holomorphic functions have been a subject which attracted attention for more than 50 years and it is still a very active research area. In this talk we will underline their universal character and emphasize why they are so interesting in operator theory and semigroup theory.

Viveka Erlandsson (University of Bristol, United Kingdom)

Title : *Counting curves on surfaces*
Abstract : It is a classical problem to try to count the number of closed curves on (hyperbolic) surfaces with bounded length. Due to people such as Delsart, Huber, and Margulis it is known that the asymptotic growth of the number of curves is exponential in the length. On the other hand, if one only looks at simple curves the growth is polynomial. Mirzakhani proved that the number of simple curves on a hyperbolic surface of genus g of length at most L is asymptotic to L^{6g-6}. Recently, she extended her result to also hold for curves with bounded self intersection, showing that the same polynomial

growth holds. In this talk I will discuss her results and some recent generalizations.

Ayman Kachmar (Lebanese University, Lebanon)

Title : *New estimates of the Ginzburg-Landau order parameter*
Abstract : This talk addresses the celebrated Ginzburg-Landau model for type II superconductivity. The superconducting properties of a type II superconductor material are encapsulated by a complex-valued wave function, the Ginzburg-Landau order parameter, which minimizes the non-linear Ginzburg-Landau functional. After presenting a short background on the physical aspects of superconductivity, I will discuss a celebrated result by Sandier-Serfaty on the L^4-norm of the Ginzburg-Landau order parameter. I will terminate the talk by presenting my joint work with B. Helffer on estimating the L^2-norm of the Ginzburg-Landau order parameter.

Ines Kath (University of Greifswald, Germany)

Title : *Compact quotients of Cahen-Wallach spaces*
Abstract : Indecomposable symmetric Lorentzian manifolds of non-constant curvature are called Cahen-Wallach spaces. Their isometry classes are described by continuous families of real parameters. We derive necessary and sufficient conditions for the existence of compact quotients of Cahen-Wallach spaces in terms of these parameters (joint work with Martin Olbrich).

Semyon Klevtsov (University of Köln, Germany)

Title : *Geometry and large N asymptotics in Quantum Hall states*
Abstract : Quantum Hall effect (QHE) is a remarkable phenomenon in condensed matter physics, where precise integer or fractional quantization of the conductance is exhibited in materials with imprecise characteristics. Laughlin states are N-particle wave functions, which successfully describe QHE when the conductance is quantized in terms of simple fractions. It was understood early on, that much can be learned about the theory of QHE when Laughlin states are considered on a Riemann surface. I will define the Laughlin states on a compact Riemann surface of arbitrary genus and talk about recent progress in understanding their geometric properties and relation to physics. Mathematically, it is interesting to know how do Laughlin states depend on an arbitrary Riemannian metric, magnetic potential function, complex structure moduli, singularities and compute the corresponding Chern classes on moduli spaces for a large number of particles N. I give a

user-friendly introduction into the subject and review the results, conjectures and further questions in this area, and relation to topics such as Coulomb gases/beta-ensembles, Bergman kernels for holomorphic line bundles, Quillen metric, zeta determinants.

David Lannes (University of Bordeaux, France)

Title : *On the dynamics of floating structures*
Abstract : The goal of this talk is to derive some equations describing the interaction of a floating solid structure and the surface of a perfect fluid. This is a double free boundary problem since in addition to the water waves problem (determining the free boundary of the fluid region), one has to find the evolution of the contact line between the solid and the surface of the water. The so-called floating body problem has been studied so far as a three-dimensional problem. Our first goal is to reduce it to a two-dimensional problem that takes the form of a coupled compressible-incompressible system. We will also focus our attention on the analysis of the force exerted on the fluid and show how to recover important phenomenon such as Archimedes force, added mass, inviscid damping, etc.

Pascal Lefèvre (University of Artois, France)

Title : *Volterra and Cesàro mean operators on L^p spaces*
Abstract : We shall first focus on the Volterra operator $V(f)(x) = \displaystyle\int_0^x f(t)\,dt$. We shall recall several classical properties of this operator $V : L^p \longrightarrow L^q$. Of course, they depend on the choices of $p, q \in [1, +\infty]$ in general. In the extreme case $V : L^1(0,1) \longrightarrow C([0,1]) \subset L^\infty$, we shall prove that although this operator is not compact, it satisfies some weak form of compactness and we shall measure its default of compactness. We shall also consider similar questions for the Cesàro mean operator $\Gamma(f)(x) = \dfrac{1}{x}\displaystyle\int_0^x f(t)\,dt$, and its discrete counterpart.

Farid Madani (University of Frankfurt, Germany)

Title : *Locally conformal Kähler geometry and conformal Kähler metrics*
Abstract : After a short introduction to locally conformal Kähler manifolds, I will discuss the problem of classifying Kähler metrics on a compact conformal Riemannian manifold. The talk is based on joint work with A. Moroianu and M. Pilca.

Olaf Müller (Humboldt University of Berlin, Germany)

Title : *New conformal methods in geometry and analysis*
Abstract : This talk gives an overview of recently developped conformal methods in Riemannian geometry, Lorentzian geometry and global analysis. The topics range from global existence theorems for Dirac-Higgs-Yang-Mills theories (e.g. electrodynamics) and new singularity theorems for Einstein-Maxwell theory to the existence of a metric of bounded geometry in any given conformal class.

Roger Nakad (Notre Dame University, Lebanon)

Title : *Twisted spin structures and CR structures*
Abstract : In a joint work with R. Hererra and I. Tellez (Centro de Investigación en Matemáticas, Guanajuato-Mexico), we develop a spinorial description of CR structures of arbitrary codimension. More precisely, we characterize almost CR structures of arbitrary codimension on Riemannian manifolds by the existence of a spinorial structure carrying a partially pure spinor field. We study the classical integrability of a CR structure as well as those implied by Killing-type conditions on the partially pure spinor field. In the codimension one case, we develop a spinorial description of strictly pseudoconvex CR manifolds, metric contact manifolds and Sasakian manifolds.

Barbara Nelli (University of L'Aquila, Italy)

Title : *The shape of soap films and bubbles*
Abstract : Soap bubbles are the realisation in nature of constant mean curvature surfaces. We describe them in mathematical terms and show how to understand some of their properties. For example : why do soap bubbles have a round shape ? More generally, we deal with constant mean curvature surfaces in Riemannian manifolds.

Nicolas Raymond (University of Rennes, France)

Title : *Magnetic WKB constructions*
Abstract : Consider the semiclassical magnetic Laplacian in two dimensions and assume that the magnetic field has a unique minimum that is positive and non-degenerate.Thanks to normal forms, we can describe the low lying spectrum via the (magnetic) Hamiltonian dynamics. Whats more : when the magnetic field is analytic, we can provide a WKB representation of the ei-

genfunctions, localized near the minimum of the field. I will first recall how we can estimate the spectrum via canonical transformations and the famous Birkhoff normal form (based on a collaboration with S. Vu Ngoc). Then, I will discuss the WKB constructions (joint work with Y. Bonthonneau).

Uwe Semmelmann (University of Stuttgart, Germany)

Title : *Killing tensors on Riemannian manifolds*
Abstract : Killing tensors are symmetric tensors such that the complete symmetrization of the covariant derivative vanishes. This generalizes the equation for Killing vector fields. Killing tensors are well studied in physics, in particular since they define first integrals, i.e. functions constant on geodesics. In my talk I will introduce a formalism for studying Killing and conformal Killing tensors. Using this notation I will discuss the most important properties and mention a few recent results, e.g. the non-existence on compact manifolds with negative sectional curvature and a classification result on Riemannian products. Moreover I will describe several examples of Killing tensors. My talk is based on two joint articles with K. Heil and A. Moroianu.

Theodoros Vlachos (University of Ioannina, Greece)

Title : *Isometric immersions and relative nullity*
Abstract : The theory of isometric immersions in Riemannian geometry is a natural generalization of the classical theory of surfaces in the 3-dimensional Euclidean space. The aim of the theory is to understand geometric invariants of isometric immersions and classify them according to the given data. We discuss minimal isometric immersions with relative nullity. We provide a classification of complete minimal isometric immersions with large index of relative nullity using tools from analysis.