XV SCHOOL ON GEOMETRY AND PHYSICS

Białystok, Poland

22 June - 26 June 2026

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LIST OF COURSES

1. **Suvrajit BHATTACHARJEE** — *University of Białystok, Poland*

   Groups, C^*-algebras and K-theory

   Consider the first object in the title above, i.e., a group G, and suppose that there is a torsion element in G, i.e., an element g of finite order, say, $n > 1$. For an n-th root of unity ω, i.e., $\omega^n = 1 \in \mathbb{C}$, the element
   $$p = \frac{1}{n} \sum_{i=0}^{n-1} \omega^i g^i$$
   is an idempotent in the complex group algebra $\mathbb{C}G$, i.e., $p^2 = p$. One then has the following conjecture which dates back at least to the first half of the last century: if G is torsion free, i.e., if G has no torsion element other than e, then $\mathbb{C}G$ has no idempotent other than 0 and 1. This seemingly algebraic statement is in fact of a deep geometric and analytic nature and providing the conjecture its natural home – which is the goal of this lecture series – will lead us to the rest of the objects in the title above. We will therefore spend the first one-third of the lectures in reviewing and collecting necessary information from the theory of C^*-algebras. We will equally spend another one-third of the lectures in doing the same for K-theory and K-homology. Having gathered the required background, the rest of the lectures will be devoted to the conjecture itself and in conveying the geometry hiding underneath.

   We do not know whom the algebraic statement should be attributed to but its C^*-analogue is usually called the Kadison–Kaplansky conjecture. The geometric form – which is our aim for these lectures – is due, among many others, to Baum, Connes, Kasparov and Mishchenko, and, most importantly, Novikov.

   Last but not the least, we will assume nothing more than rudimentary functional analysis for these lectures.

2. **Eduardo CHIUMIENTO** — *University of La Plata, Argentina*

   Infinite Grassmanians and operator theory

   The Grassmannian of an infinite-dimensional Hilbert space is the set consisting of all the closed subspaces. From an operator theoretic perspective, it may be identified with the set of all orthogonal projections on the Hilbert space. Thus, its connected components become homogeneous spaces, which can be endowed with a Finsler metric by using the operator norm on tangent spaces.

   In these lectures we will present old and new results on the differential and metric properties of the Grassmannian of a Hilbert space. Then we will consider the geometric structure of other Grassmannians obtained by imposing restrictions on the subspaces such as restricted Grassmannians, projections with compact commutator, etc. Also we will discuss the relation with other infinite dimensional manifolds such as manifolds of idempotents, manifolds of partial isometries and abstract homogeneous spaces. We will emphasize the interplay between geometric aspects of infinite Grassmannians and operator theory.

   It is based on a joint work with Esteban Andruchow and Gustavo Corach.

3. **Manuel GADELLA** — *University of Valladolid, Spain*

   Contact potentials in quantum mechanics

   Along these lectures, we introduce a new series of solvable models in quantum mechanics, focusing on the one dimensional models either relativistic or non-relativistic. In the one dimensional models with contact potentials (or potential supported on a dot, such as Dirac delta interactions), we use different type of constructions as listed below. We analyze several aspects of the problem giving some relevance to scattering. We also study one another model that we may classify as *singular*, for which the potential is the one dimensional Coulomb. Models are intended to be treated with due mathematical rigor and include:

- Contact potentials defined through self adjoint extension of symmetric operators.
- Same with a distributional method.
- The Salpeter Hamiltonian decorated with N deltas and Heat Kernel regularization.
- The Schrödinger equation with N delta potentials.
- One dimensional Dirac equation with two centers and given symmetry.
- The Birman–Schwinger method applied to the one dimensional Coulomb potential.

4. **Krzysztof MARCINIAK** — *Linköping University, Sweden*

   Stäckel systems, soliton hierarchies and Painlevé-type systems

   The aim of this lecture series is to present a completely new perspective on the relationships between three major classes of integrable systems: classical separable (in the sense of Hamilton–Jacobi theory) Stäckel systems, soliton hierarchies, and Painlevé-type systems.

   I begin by examining how deformations of Stäckel-separable systems, constructed via suitable algebras of Killing tensors, give rise to both known and new Painlevé-type equations. I then demonstrate – using the coupled Korteweg–de Vries hierarchy as a guiding example – how appropriate autonomous constraints reduce a soliton hierarchy to a corresponding Stäckel system, highlighting the way in which the geometric structures inherent in the hierarchy manifest themselves in the resulting Stäckel system. Finally, (this part is not yet published), I discuss how suitable non-autonomous constraints allow one to reduce a soliton hierarchy to a Painlevé-type system. Thus, a new and complete picture of relations between these three large classes of integrable systems emerges.

   The lectures will be self-contained and will include all necessary definitions and background information.

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