François Bentosela

Bloch Oscillations in Semiconductor Superlattices

More than 80 years after Bloch pointed out that electrons in crystals submitted to a static homogeneous electric field would be oscillating in space, there is still a lot of activity around this subject. The oscillations have been observed in semiconductor superlattices , but the oscillations have they sufficiently large lifetime so that these man made materials could be used as electromagnetic emitters in particular in the Terra-Hertz range? Supposing that the electron sees a potential which is the sum of the periodic potential created by the ions and the linear potential created by an external electric field chosen perpendicular to the surfaces of growth of the superlattice, one can use the bi-periodicity in the directions parallel to the surface of growth to decompose the Hamiltonian in a direct integral. One can prove that in each fiber the reduced Hamiltonian has pure a.c spectrum and presents resonances which form ladders parallel to the real axis. Then the total Hamiltonian presents bands of resonant states. This is the first step to see the relationship between the lifetime of the Bloch oscillators and the parameters which define the superlattice structure.

Horia Cornean

On the Peierls Substitution for (Non)Constant, Weak Magnetic Fields

Consider an isolated spectral band of a real periodic Bloch Hamiltonian in either two or three dimensions. Assume that the system is weakly perturbed by a smooth and bounded magnetic field. We show that the perturbed spectral projector admits an exponentially localized orthonormal basis and we construct a magnetic matrix which is unitary equivalent with the perturbed band Hamiltonian. If the magnetic field is constant, our magnetic matrix is Harper-like. This is ongoing work with M.H. Brynildsen, I. Herbst, G. Nenciu and R. Purice.

Pavel Exner

Narrowing channels, or Schrödinger operators mixing different dimensions

In this talk I am going to discuss several examples of Schrödinger operators describing particle motion localized to narrowing channels, either in form of potential "valleys" or Dirichlet boundaries; the aim is to show they can exhibit unexpected spectral properties, in particular, they may have a discrete spectrum although the corresponding phase space volume is infinite. The first example concerns the well-known model of the x^2y^2 potential to which a negative potential term is added; we will see that the spectrum may be purely discrete even for potentials unbounded from below and that it may show a transition to a below unbounded one as the coupling constant changes. A similar behaviour can be observed in a regular version of the so-called Smilansky model. In the last example, I consider Dirichlet Laplacians in cusp-shaped regions and derive inequalities of Lieb-Thirring type showing how they depend on the geometry of the regions. The results come from a common work with Diana Barseghyan.

Dan Radu Grigore

Group Theoretical Aspects of the Standard Model in the Causal Approach; the Higgs Sector

We consider the electro-weak sector of the standard model up to the second order of the perturbation theory (in the causal approach) and derive the most general form of the interaction Lagrangian for an arbitrary number of Higgs fields. The analysis is done in a purely quantum setting. If more than one Higgs field is considered, the values of the Weinberg is not fixed uniquely.

Bernard Helffer

On Harper's Equation for the Kagome Lattice

If the first mathematical results were obtained more than 30 years ago with the interpretation of the celebrated Hofstadter butterfly, more recent experiments in Bose-Einstein theory suggest new questions in particular on the Kagome lattice. I will discuss more recent questions related to generalized butterflies (Dalibard and co-authors, Hou, Kerdelhué, Royo-Letelier). These new questions are strongly related to Harper on triangular or hexagonal lattices (in connexion with the now very popular graphene). Joint work with Philippe Kerdelhué and Jimena Royo-Letellier.

Ira Herbst

Decay of Eigenfunctions of Elliptic PDEs

We study exponential decay rates of eigenfunctions of self-adjoint higher order elliptic operators on $\mathbb{R}^d$. We are particularly interested in decay rates as a function of direction. We show that the possible decay rates are to a large extent determined algebraically. This is joint work with Erik Skibsted.

Arne Jensen

Resolvent Expansions for the Discrete One Dimensional Schrödinger Operator

I will present results on asymptotic expansion of the resolvent of the one dimensional discrete Schrödinger operator with a general class of sufficiently short range interactions. A major part of the result is a complete classification of the (generalized) solutions corresponding to the thresholds 0 and 4. I will focus on this part in the talk. Joint work with K. Ito, Kobe University, Japan.

Alain Joye

Spectral Properties of Non-Unitary Band Matrices

We consider families of random non-unitary contraction operators defined as deformations of CMV matrices which appear naturally in the study of random quantum walks on trees or lattices. We establish several results about the location and nature of the spectrum of such non-normal operators as a function of their parameters. We relate these results to the analysis of certain random quantum walks, the dynamics of which can be studied by means of iterates of such random non-unitary contraction operators. This is joint work with Eman Hamza.

Călin Iuliu Lăzăroiu

Supersymmetry, Foliated G-structures and Non-Commutative Geometry

I discuss a class of geometric models arising in compactifications of supergravity for which the supersymmetry conditions are realized through Stefan-Sussmann (singular) foliations carrying longitudinal G-structures. Among such models are certain eight-dimensional geometries which can be viewed respectively as "deformations" of Spin(7) manifolds and of Calabi-Yau fourfolds, in a sense different from generalizations considered before by Hitchin and collaborators. The physical excitations in such backgrounds (which determine the fields appearing in the action of the low energy theory) are governed by differential operators associated with the foliation and can be interpreted though noncommutative geometry.

Claude-Alain Pillet

The Landauer Principle in Quantum Statistical Mechanics

In a celebrated 1961 paper, Landauer formulated a fundamental lower bound on the energy dissipated by computation processes. Since then, there has been many attempts to formalize, generalize and contradict Landauer's analysis. The situation became even worse with the advent of quantum computing. In a recent enlightening article, Reeb and Wolf sets the game into the framework of quantum statistical mechanics, and finally gave a precise mathematical formulation of Landauer's bound. I will discuss parts of this analysis and present some extensions of it that were obtained in a joint work with V. Jaksic.

Emil Prodan

The Non-Commutative Geometry of the Complex Classes of Topological Insulators

Alain Connes' Non-Commutative Geometry program has been recently carried out for the entire A- and AIII-symmetry classes of topological insulators, in the regime of strong disorder where the insulating gap is completely filled with dense localized spectrum. In this talk I will highlight the methods of Non-Commutative Geometry involved in these studies. Specifically, I will discuss odd and even families of Fredholm-modules for homogeneous disordered systems, the algebra of localized observables, the Chern characters of the families of Fredholm-modules over this algebra, together with local formulas and the corresponding index theorems. The final products are morphisms from the K-groups of the localized algebra into group of integers, which define the classifying topological invariants for the topological insulators from the complex symmetry classes. Among some of the physical implications of these results is the stability of the topological phases at strong disorder and the existence of an Anderson localization-delocalization transition between any distinct topological phases.

Erik Skibsted

Scattering Theory on Riemannian Manifolds

We introduce a notion of scattering theory on Riemannian manifolds endowed with a certain "escape function". A typical example is provided by a distance function on the manifold (measuring the distance to a submanifold) with a certain convexity property, covering for example the Euclidean and hyperbolic models. We study time-dependent as well as stationary theory. The latter includes optimal resolvent bounds and characterization of spaces of generalized eigenfunctions. This is joint work with Kenichi Ito.

Jakob Yngvason

Incompressibility Estimates for Many-Body Wave Functions in the Laughlin Phase

When quantum particles are submitted to a sufficiently strong magnetic field the motion becomes two-dimensional and restricted to the Lowest Landau Level. Strong repulsive interactions can then lead to highly correlated states, descending from the Laughlin wave function. We investigate the response of such strongly correlated ground states to variations of an external potential. This leads to a family of variational problems of a new type. Our main results are rigorous energy estimates demonstrating strong rigidity of the response. In particular we obtain estimates indicating that there is a universal bound on the maximum local density of these states in the limit of large particle number. We refer to these as incompressibility estimates. This is joint work with Nicolas Rougerie.