Seminar and Workshop

Dynamics and Relaxation in Complex Quantum and Classical Systems and Nanostructures

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The international Seminar and Workshop Dynamics and Relaxation in Complex Quantum and Classical Systems and Nanostructures was devoted to quantum transport and field theories of quantum disorder, a fast-growing field of charge and spin dynamics in nanostructures (including manipulation of multi-qubit systems and spins in quantum dots), and to theories of disordered and strongly interacting classical systems.

The programme started with a **three-week Workshop** focused on the theory of phase coherence and de-coherence in qubits, interaction and localization in one and two dimensions and fundamental issues in classical disordered systems.

The recent progress in the field theory of pinning and its relation to chaos, random fields and fermions, as well as to the new results on non-integrable quantum field theories and disordered classical systems have been brought up by Miguel Ortuño (Murcia), Pierre Le Doussal (ENS Paris), Kay Wiese (ENS Paris) and Giuseppe Mussardo (SISSA Trieste). They have shown spectacular theoretical results in this field, which were confirmed by the extensive numerical simulations by Alan Middleton (Syracuse). Igor Lerner (Birmingham) has shown how to apply statistical field theory methods to study critical phenomena in computer networks (in application to email traffic and distribute computing). Finally, Igor Aleiner (Columbia Univ NY) and Denis Basko (Princeton) have presented the new theory of the interactions-driven localisation transition in disordered systems. The issue of decoherence has been discussed in relation to a very broad range of complex quantum systems and devices, ranging from Luttinger liquid formed on the edge of a two-dimensional quantum Hall effect system [Yuval Gefen (Weizmann Inst), Dima Feldman Brown University), Ady Stern (Weizmann Inst)], superconducting and quantum dot spin qubits [Yuri Galperine (Oslo), Rosario Fazio (Pisa), Valery Pokrovsky (Univ Texas), Baruch Horovitz (Haifa), Elisabetta Paladino(Catania)], quantum wires and dots [Leonid Glazman (Minneapolis), Alessandro Silva (ICTP Trieste), Björn Kubala (Bochum), John Jefferson (Qinetiq)].

During the middle part of the Seminar, the main attention has been given to the spin-related effects in quantum nanostructures. Naoto Nagaosa (Tokyo Univ), Arturo

Tagliacozzo (Naples), Yaroslav Tserkovnyak (UCLA), Leon Balents (UCSB) discussed theories related to the spin-orbit coupling in 2D electron gases and quantum dots, with one week fully dedicated to the discussion of the spin Hall effect. Alexander Tartakovskii (Sheffield) has reported an amazing observation of the bistable behaviour of nuclear polarisation in optically pumped quantum dots, with the theory of this new effect developed by Alan Russell and Vladimir Falko (Lancaster).

The culmination of the Seminar was in the one-week **Graphene Conference**. In 2004, the group of A. Geim at Manchester has separated individual graphene flakes (atomically thin graphitic monolayers and bilayers) from pyrolitic graphite crystals and produced the first graphene-based field-effect transistor. Since then, Geim's group and P. Kim and H. Stormer at Columbia University NY have processed individual graphene flakes into microstructures and measured their transport characteristics while varying the carrier density in graphene sheets from the electron (n) to the hole (p) channels. The most recent technological development in graphene has been that of E. Rotenberg (Lawrence Berkeley National Lab) who have grown monolayer and bilayer graphene on a silicon carbide substrate and performed angle-resolved photoemission measurements confirming the features of the electronic band structure of these materials.

All these and other more recent developments have been reported by the world leaders in the field: Andre Geim (Manchester), Philip Kim (Columbia University NY), Walter de Heer (Georgia Tech), Eli Rotenberg (Berkeley). The recently performed measurements of Raman spectra have been reported by Klaus Ensslin (ETH Zurich) and Andrea Ferrari (Cambridge). Alberto Morpurgo (TU Delft) has shown the results on the first operational graphene-based Josephson proximity effect transistor. The advancement of theory has been described by the repsentatives of most of the groups involved in graphene research. Edward McCann (Lancaster), Alexander Altland (Koln) Igor Aleiner (Columbia University), Matthew Foster (UCSB), Igor Gorny (Karlsruhe), and Vadim Cheianov (Lancaster) formed the complete picture of the quantum interference effects in graphene. Vladimir Falko (Lancaster), Fracisco Guinea (Madrid) and Antonio Castro Neto (Boston) reviewed the most unusual properties of this new material derived from its band structure. Vladimir Falko, Louis Brey (ICMM Madrid) and Herbert Fertig (Univ. of Indiana – Bloomington) delivered the peculiar theories of quantum Hall effect in graphene, which Janis Pachos (Leeds) and Yasuhiro Hatsugai (University of Tokyo) related to the index theorem in application to this two-dimensional crystal.

The Graphene Conference was great success. It attracted a lot of interest from community (55 participants came to Dresden on a very short notice). This was the first Conference entirely dedicated to this new material, and, now, it will be followed by the focused workshop in KITP in Santa Barbara (January 2007) and possibly by the ESF Conference in 2008.

All components of the Seminar have been productive and met their goals. Half of the Seminar participants were junior researchers who collaborated with the senior participants and engaged themselves in numerous discussions. The atmosphere of the meeting was informal, with a lot of open fruitful discussions.