The Abdus Salam
International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

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Workshop on
Localization Phenomena in Novel Phases of Condensed Matter
(17 - 23 May 2010)

(Miramare, Trieste - Italy)

ORGANIZERS:

Ferdinand EVERS	FZK, Karlsruhe, Germany
Victor KAGALOVSKY	SCE, Beer-Sheva, Israel
Igor LERNER	University of Birmingham, U.K.

LOCAL ORGANIZER:

Vladimir E. KRAVTSOV	the Abdus Salam International Centre for Theoretial Physics, Trieste, Italy

BOOK OF ABSTRACTS

web-page: http:agenda.ictp.trieste.it/smr.php?2144

CONTENTS

PREFACE

The phenomena of localization - delocalization transitions (LDT) have been a central topic in condensed matter physics for the last 50 years. Recently, very interesting phenomena related to the LDT were predicted and discovered in various systems. Examples of new systems include topological insulators in electron gases with spin-orbit scattering; cold atoms localization in one-dimensional optical lattices, multifractal systems in the vicinity of the superconductor - insulator transition and many others.

The topics to be covered by invited talks are -

New topological phases of disordered electron systems (including topological insulators, graphene etc);

Effects of disorder in systems with special symmetries (e.g. comprising disorder and Griffiths effects);

Localization/delocalization physics in systems of cold matter and atomic matter (including dynamical localization in atomic matter, localization in 1d-systems of cold atoms etc);

Localization/delocalization in superconducting and (strongly) correlated systems (including localization and related effects in Luttinger liquids, quantum dots and wires, etc).

The goal of the Workshop is to create the atmosphere facilitating open discussions of the current status of the localization problem and related phenomena. In a broader context, the Workshop will look at the perspectives for identifying new localization physics in novel phases of matter and will foster closer collaboration between the theoretical and experimental groups working in this and related fields. The timetable given below assumes 40-min. talks with 10 min. left for discussions. There are no late afternoon talks, leaving plenty of time for free discussions.

The Organizers wish you a most exciting and enjoyable Workhsop.

Ferdinand EVERS
Victor KAGALOVSKY
Igor V. LERNER
Vladimir E. KRAVTSOV
Doreen M. SAULEEK

P R O G R A M M E

(as of 10 May 2010)

The Abdus Salam
International Centre for Theoretical Physics

Workshop on Localization Phenomena in Novel Phases of Condensed Matter

Organizer(s): Directors: F. Evers, V. Kagalovsky and I.V. Lerner. Local Organizer: V.E. Kravtsov
Trieste - Italy, 17 - 23 May 2010

Venue: Adriatico Guest House Kastler Lecture Hall

Preliminary Programme

MONDAY, 17 MAY 2010 (Room:Adriatico Guest House Kastler Lecture Hall)

17 May 2010

08:30 - 09:30 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- REGISTRATION / ADMINISTRATION FORMALITIES ---
(subsequently, in the Secretariat office no.1)

09:30 - 10:20 **Andreas LUDWIG** / *University of California, U.S.A.*
Classification of Topological Insulators and Superconductors - the "Ten-Fold" Way

10:20 - 10:50 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

10:50 - 11:40 **Alexander MIRLIN** / *Karlsruhe Institute of Technology, Germany*
Topological Insulators: Disorder, Interaction and Quantum Criticality of Dirac Fermions

11:40 - 12:30 **Joel MOORE** / *University of California, U.S.A.*
Topological Insulators: Magnetoelectric and Disorder Effects

12:30 - 14:00 (Room: Adriatico Guest House Cafeteria)
--- LUNCH BREAK ---

14:00 - 14:50 **Felix von OPPEN** / *Freie Universitaet Berlin, Germany*
Synthetic Electric Fields in Graphene and Carbon Nanotubes

14:50 - 15:40 **Igor GORNYI** / *Karlsruhe Institute of Technology, Germany*
Anderson (de)Localization of Dirac Fermions in Disordered Graphene

15:40 - 16:10 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

16:10 - 17:00 **Khandker MUTTALIB** / *University of Florida, U.S.A.*
Asymmetric Metal-Insulator Transition in Ferromagnetic Films

17:00 - 18:00 **DISCUSSIONS**

18:30 - 20:30 (Room: Adriatico Guest House (Terrace))
--- WELCOME RECEPTION ---

TUESDAY, 18 MAY 2010 (Room:Adriatico Guest House Kastler Lecture Hall)

18 May 2010

09:30 - 10:20 **Charles MARCUS** / *Harvard University, U.S.A.*
Title to be confirmed

10:20 - 10:50 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

10:50 - 11:40 **Peter WOELFLE** / *Karlsruhe Institute of Technology, Germany*
Quantum Corrections to the Conductivity of Disordered Fermi Systems Interacting by Gauge Fields

11:40 - 12:30 **Yuval GEFEN** / *The Weizmann Institute of Science, Rehovot, Israel*
Interplay of Spin and Charge in Quantum Dots: The Effect of Disorder

12:30 - 14:00 (Room: Adriatico Guest House Cafeteria)
--- LUNCH BREAK ---

14:00 - 14:50 **Alexander ALTLAND** / *Institute of Theoretical Physics, Cologne, Germany*
Localization Phenomena in the Quantum Kicked Rotor

14:50 - 15:40 **Piet BROUWER** / *Freie Universitaet Berlin, Germany*
Anderson Localization from Classical Trajectories

15:40 - 16:10 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

16:10 - 17:00 **to be confirmed**
Title to be confirmed

17:00 - 18:00 **DISCUSSIONS**

18:00 - 19:00 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
POSTER SESSION 1 - with refreshments

WEDNESDAY, 19 MAY 2010 (Room:Adriatico Guest House Kastler Lecture Hall)

19 May 2010

09:30 - 10:20 **John CHALKER** / *Oxford University, U.K.*
Quantum and Classical Localization Transitions

10:20 - 10:50 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

10:50 - 11:40 **Dominique DELANDE** / *Universite Pierre et Marie Curie, Paris, France*
Experimental Observation of the Critical Regime of the Anderson Transition with Cold Atoms

11:40 - 12:30 **Alex KAMENEV** / *University of Minnesota, U.S.A.*
Dynamics of Quantum Impurities in Bose Condensates

12:30 - 14:00 (Room: Adriatico Guest House Cafeteria)
--- LUNCH BREAK ---

14:00 - 17:00 --- FREE TIME IN THE AFTERNOON ---

THURSDAY, 20 MAY 2010 (Room:Adriatico Guest House Kastler Lecture Hall)

20 May 2010

09:30 - 10:20 **Laurens MOLENKAMP** / *University of Wuerzburg, Germany*
Dirac Fermions in HgTe Quantum Wells

10:20 - 10:50 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

10:50 - 11:40 **Yasuhiro HATSUGAI** / *University of Tsukuba, Ibaraki, Japan*
Dirac Fermions, Chern Numbers and Bulk-Edge Correspondence in Graphene with Randomness

11:40 - 12:30 **Dmitry IVANOV** / *EPFL, Lausanne, Switzerland*
Localization in Quasi-One-Dimensional Wires: Correlations of the Local Density of States

12:30 - 14:00 (Room: Adriatico Guest House Cafeteria)
--- LUNCH BREAK ---

14:00 - 14:50 **Alain ASPECT** / *Institut d'Optique, Palaiseau, France*
Title to be confirmed

14:50 - 15:40 **Dimitri GANGARDT** / *University of Birmingham, U.K.*
Dark Solitons: a Model of Impurity-Phonon Interactions in Quantum Liquids

15:40 - 16:10 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

16:10 - 17:00 **Vladimir YUDSON** / *RAS, Institute of Spectroscopy, Troitsk, Russia*
Delocalization by Disorder in Layered Conductors

17:00 - 18:00 **DISCUSSIONS**

18:00 - 19:00 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
POSTER SESSION II - with refreshments

20:00 - 23:00 --- SOCIAL DINNER ---
Details to be confirmed

FRIDAY, 21 MAY 2010 (Room:Adriatico Guest House Kastler Lecture Hall)

21 May 2010

09:30 - 10:20 **Mahmood ZAHID HASAN** / *Princeton University, U.S.A.*
Experimental Discovery of Several Classes of Topological Insulators and Related Superconductors using Spin-Sensitive Novel Spectroscopic Methods

10:20 - 10:50 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

10:50 - 11:40 **Ilya GRUZBERG** / *University of Chicago, U.S.A.*
Quantum Hall Transitions and Conformal Restriction

11:40 - 12:30 **Akira FURUSAKI** / *RIKEN, Saitama, Japan*
Conformal Invariance and Boundary Multifractality at Anderson Transition in Two Dimensions

12:30 - 14:00 (Room: Adriatico Guest House Cafeteria)
--- LUNCH BREAK ---

14:00 - 14:50 **Oleg YEVTUSHENKO** / *LMU, Munich, Germany*
Critical Scaling at the Anderson Localization Transition in the Strong Multifractality Regime

14:50 - 15:40 **Igor BURMISTROV** / *Landau Institute for Theoretical Physics, Moscow, Russia*
Dephasing at the Integer Quantum Hall Transitions: Short-Ranged Interaction in the Singlet Channel

15:40 - 16:10 (Room: Adriatico Guest House - Kastler Lecture Hall Area (Lower Level 1))
--- COFFEE BREAK ---

16:10 - 17:00 **Alexander CHUDNOVSKIY** / *University of Hamburg, Germany*
Spin-Flip Scattering at Quantum Hall Transition

17:00 - 18:00 **DISCUSSIONS**

SATURDAY, 22 MAY 2010 (**Saturday**)

22 May 2010

00:00 - 00:00 **DISCUSSION DAY**

ABSTRACTS

OF

INVITED TALKS

(in order of presentation, as per Programme updated 10 May 2010)

MONDAY, 17 MAY 2010

(updated as of 10 May 2010)

web-page: http://agenda.ictp.trieste.it/smr.php?2144

Classification of Topological Insulators and Superconductors: the "Ten-Fold Way"

Andreas LUDWIG
University of California
Santa Barbara
U.S.A.

Topological insulators and superconductors are Fermionic states with a bulk gap, possessing extended modes at their surface which cannot be Anderson localized for topological reasons. An exhaustive classification of these systems is obtained by classifying those problems of Anderson localization, in one dimension less (at the surface), which entirely avoid Anderson localization. We find that in each spatial dimension there exist precisely five distinct classes of topological insulators (superconductors). The different topological sectors within a given such class can be labeled, depending on the case, by an integer winding number, or by a "binary" Z_2 quantity. One of the five classes of topological insulators is the "quantum spin Hall" (or: Z_2-topological) insulator in d=2 and d=3 dimensions, which has been experimentally observed in HgTe/(Hg,Ce)Te semiconductor quantum wells (d=2), and in BiSb alloys and Bi_2 Se_3 (d=3). The other four classes of topological insulators (superconductors) are new. For each spatial dimension d, the five classes of topological insulators are shown to correspond to a certain subset of five of the ten generic symmetry classes of Hamiltonians introduced more than a decade ago by Altland and Zirnbauer in the context of disordered systems (generalizing the three well-known "Wigner-Dyson" symmetry classes). - Besides providing an overview of the classification, we will also discuss the novel (surface) disorder physics of some of these states.

References:

- A.P. Schnyder, S. Ryu, A. Furusaki, A.W.W. Ludwig, Phys. Rev. B 78. 195125 (2008).

- A.P. Schnyder, S. Ryu, A. Furusaki, A.W.W. Ludwig, AIP Conf. Proc. 1134, 10 (2009). (Proceedings of the L.D. Landau Memorial Conference "Advances in Theoretical Physics").

- A.P. Schnyder, S. Ryu, A.W.W. Ludwig, Phys. Rev. Lett. 102, 196804 (2009).

- A.P. Schnyder, S. Ryu, A. Furusaki, A.W.W. Ludwig, "Topological insulators and superconductors: ten-fold way and dimensional hierarchy", arXiv:0912.2157; to appear.

Topological Insulators: Disorder, Interaction and Quantum Criticality of Dirac Fermions

Alexander MIRLIN
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GERMANY

Topological insulators represent an emergent research field attracting a lot of attention of experimentalists and theoreticians. These are bulk insulators with delocalized (topologically protected) states on their surface. In this talk, I will first review a full symmetry classification of topological insulators. I will then focus on 2D and 3D topological insulators (and on topologically protected metals on their boundaries) in systems with strong spin-orbit interaction ("symplectic symmetry class"). I will analyze the field theories of these systems in the presence of disorder. A non-trivial topological nature of these theories leads to topological protection of boundary states from Anderson localization. I will also discuss an analogy with graphene where the same topological protection is operative as long as the intervalley scattering can be neglected.

Further, I will analyze the effect of Coulomb interaction on transport in topological insulators. While the Coulomb interaction does not affect the topological protection, it leads to emergence of a novel quantum critical state with a conductivity ~e^2/h on the surface of a 3D topological insulator. Remarkably, this critical state emerges without any adjustable parameters. Such a ``self-organized quantum criticality'' is a novel concept in the field of interacting disordered systems. Finally, we predict a quantum spin-Hall transition between the normal and topological insulator phases in 2D that occurs via a similar (or identical) quantum critical point.

Topological insulators: magnetoelectric and disorder effects

Joel E. MOORE
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U.S.A.

"Topological insulators" are insulating in bulk but have protected metallic surface states as a result of topological properties of the electron wavefunctions. Several examples have been discovered recently in ARPES experiments that directly probe the surface state, including its spin structure. One way to characterize the topological insulator is through its magnetoelectric response in a weak applied field: it generates an electrical polarization in response to an applied magnetic field, and a magnetization in response to an applied electrical field. This talk first reviews the origin of this response and its generalization to other insulators and topological states. A complete formula for the orbital contribution to the magnetoelectric polarization is given. It includes a topological part that is the only contribution in topological insulators.

We then discuss some features of disordered topological insulators, concentrating on the two-dimensional case and on thin films of three-dimensional topological insulators. These features should be observable in charge transport and optical experiments.

Synthetic Electric Fields in Graphene and Carbon Nanotubes

Felix von OPPEN
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GERMANY

Within the Dirac theory of the electronic properties of graphene, smoothly varying lattice strain affects the Dirac carriers through a synthetic gauge field. For static lattice strain, the gauge field induces a synthetic magnetic field which is known to suppress weak localization corrections by a dynamical breaking of time-reversal symmetry. When the lattice strain is time dependent, as in connection with phononic excitations, the gauge field becomes time dependent and the synthetic vector potential is also associated with an electric field. In this talk, I discuss observable consequences of this synthetic electric field.

Anderson (de)Localization of
Dirac Fermions in Disordered Graphene

Igor GORNYI
Universität Karlsruhe
Institut für Theorie der Kondensierten Materie
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76021 Karlsruhe
GERMANY

I will discuss electronic transport in disordered graphene at the Dirac point for various types of disorder. In particular, I will address in detail the Anderson localization problem for the case of resonant scatterers (strong impurities or vacancies).

Asymmetric Metal-Insulator Transition in Ferromagnetic Films

K.A. MUTTALIB
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U.S.A.

I will present experimental data and a theoretical interpretation of conductivity σ of thin Gd films as a function of temperature (T ~ 5 - 50 K) and disorder (sheet resistance R_0 ~ 4 – 40 kΩ) across the metal-insulator transition. While a fractional power law in T allows us to obtain the dynamical critical exponent z ~ 2.5, the collapse of the conductivity data σ (T, R_0) on to two finite-temperature scaling curves allows us to extract critical exponents for the correlation lengths as well. The best fit values for the correlation length exponents turn out to be distinctly different on the two sides of the transition, ν' ~ 1.4 for the correlation length on the metallic side and ν ~ 0.8 for the localization length on the insulating side. [See R. Misra, A.F. Hebard, K.A. Muttalib and P. Wölfle, cond-mat arXiv:1003.4195.]

TUESDAY, 18 MAY 2010

(updated as of 10 May 2010)

web-page: http://agenda.ictp.trieste.it/smr.php?2144

Mesoscopic Hyperfine Systems:
Open Problems Motivated by Recent Experiments

Charles MARCUS
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Cambridge, MA 02138
U.S.A.

I will present recent experiments on 13C nanotubes, GaAs quantum point contacts, and GaAs few-electron quantum dots in which, in each case, a small number of electrons couples to a larger number of nuclear spins. In all three cases, the behavior is only partly understood: some aspects make sense, others are not understood. I will try in this talk to draw attention to those aspects that are less well understood.

This work is supported by the US Department of Defense, IARPA, NSF-NRI, and Microsoft. Device fabrication was done at the Harvard Center for Nanoscale Systems.

Quantum Corrections to the Conductivity of Disordered Fermi Systems Interacting by Gauge Fields

Peter WÖLFLE
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GERMANY

We calculate the Altshuler-Aronov-type quantum corrections to the conductivity of fermions in two-dimensional disordered systems, subject to a transverse gauge field. One example for such a system is the fractional quantum Hall effect near half-filling, where the system of composite fermions interacts strongly with a Chern-Simons gauge field. Wheras the exchange contribution is found to be localizing [1], the Hartree contribution may be delocalizing [2]. A recent finding that the Hartree contribution is dominant, and therefore may lead to a metallic state [3] is shown to be incorrect. We find that both, decoherence effects and vertex corrections, play an important role. Surprisingly, it appears that the gauge field is regularized by the presence of disorder, such that a controlled strong coupling analysis is possible.

[1] A. D. Mirlin and P. Wölfle, Phys. Rev. B 55, 5141 (1997)
[2] T. Ludwig, I.V. Gornyi, A.D. Mirlin, and P. Wölfle, Phys. Rev. **B 77**, 235414 (2008)
[3] V. M. Galitski, Phys. Rev. B **72**, 214201 (2005).

INTERPLAY OF SPIN AND CHARGE IN QUANTUM DOTS: THE EFFECT OF DISORDER

Yuval Gefen,[1] I. S. Burmistrov,[2,3] and M. N. Kiselev[4]

[1] *Department of Condensed Matter Physics, The Weizmann Institute of Science, Rehovot 76100, Israel*
[2] *L.D. Landau Institute for Theoretical Physics RAS, Kosygina street 2, 119334 Moscow, Russia*
[3] *Department of Theoretical Physics, Moscow Institute of Physics and Technology, 141700 Moscow, Russia*
[4] *International Center for Theoretical Physics, Strada Costiera 11, 34014 Trieste, Italy*

The inclusion of charging and spin-exchange interactions (of continuous symmetry) within the Universal Hamiltonian description of quantum dots is challenging as it leads to a non-Abelian action. This is in sharp contrast to Ising-like spin exchange which leads to an Abelian action [1]. We have recently obtained an exact analytical solution to the former [2], in particular, in the vicinity of the Stoner instabilty point. I will report on the calculation of the tunneling density of states (TDOS) and the spin susceptibility. Near the instability point the TDOS exhibits a non-monotonous behavior as function of the tunneling energy (in accordance with perturbation theory [3]) even at temperatures higher than the exchange energy. Our approach is generalizable to a broad set of observables, including the a.c. susceptibility and the absorption spectrum for anisotrpic spin interaction. I will show how the introduction of disorder to the single electron Hamiltonian , with different classes of disorder symmetries, affects the results.

The work is supported by RFBR Grant No. 09-02-92474-MHKC, the Council for grants of the Russian President Grant No. MK-125.2009.2, the Dynasty Foundation, RAS Programs "Quantum Physics of Condensed Matter", "Fundamentals of nanotechnology and nanomaterials", CRDF, SPP 1285 "Spintronics", Minerva Foundation, German-Israel GIF, Israel Science Foundation, and EU project GEOMDISS

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[1] B. Nissan-Cohen, Y. Gefen, M. N. Kiselev, and I. V. Lerner, to be published.
[2] I. S. Burmistrov, Y. Gefen, and M. N. Kiselev, cond-mat/0912.3185.
[3] M. N. Kiselev and Y. Gefen, Phys. Rev. Lett. **96**, 066805 (2006).

Localization Phenomena in the Quantum Kicked Rotor

Alexander ALTLAND
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The quantum kicked rotor (QKR) is a paradigm of driven chaotic dynamics. In spite of its nominal simplicity, this system displays a wealth of quantum interference phenomena, including strong Anderson localization. Recent advances in experimentation have made it possible to observe QKR quantum interference in the context of atom optics. In this talk, I will discuss an analytic theory of quantum interference and Anderson localization in the QKR. It will be shown that the system can be effectively mapped onto the theory of a disordered metallic ring subject to an Aharonov-Bohm flux (the persistent current problem). Building on this correspondence, quantitative and non-perturbative results for the system's localization properties can be obtained. We will also discuss analogies as well as a number of striking differences to the physics of disordered metals.

Anderson Localization from Classical Trajectories

Piet BROUWER
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GERMANY

Anderson localization in quasi-one dimensional conductors with ballistic electron dynamics, such as an array of ballistic chaotic cavities connected via ballistic contacts or an antidot lattice, can be understood exclusively in terms of classical electron trajectories. At large length scales, an exponential proliferation of trajectories of nearly identical classical action generates an abundance of interference terms, which eventually leads to a suppression of transport coefficients. We quantitatively describe this mechanism using an explicit description of transition probabilities in terms of interfering trajectories.

POSTER SESSION I

Adriatico Guest House

lower level

(outside the Kastler Lecture Hall)

WEDNESDAY, 19 MAY 2010

(updated as of 10 May 2010)

web-page: http://agenda.ictp.trieste.it/smr.php?2144

Quantum and Classical Localisation Transitions

J. T. Chalker[1]

[1] *Theoretical Physics, Oxford University,*

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Localisation of a particle moving in a random environment may occur both quantum mechanically and with classical dynamics, but the phenomenon is very different in the two cases. I will discuss a class of quantum-mechanical localisation problems for which some physical quantities can be expressed exactly in terms of averages taken in a classical counterpart. The equivalence holds despite the fact that interference effects dominate the behaviour of the quantum systems. The models are network models belonging to class C in Zirnbauer's classification, and the classical problem involves random walks that are self-avoiding but also self-attracting. The equivalence was first discovered in the context of the spin quantum Hall effect by Gruzberg, Ludwig and Read [Phys. Rev. Lett. **82**, 4524 (1999)], and the results I will describe were obtained in collaboration with Beamond and Cardy [Phys Rev B **65**, 214301 (2002) and with Ortuño and Somoza [Phys. Rev. Lett. 102, 070603 (2009)]. In the case of the spin quantum Hall effect, the equivalent classical problem is related to percolation in two dimensions, for which many exact results are known. In case of three dimensional systems, we have no exact results for the classical problem, but the mapping makes high-precision numerics possible. I will describe results from these calculations and also efforts to relate the self-avoiding, self-attracting random walks in three dimensions to other classical problems.

Experimental observation of the critical regime of the Anderson transition with cold atoms

Dominique Delande

Laboratoire Kastler-Brossel, Case 74, Université Pierre et Marie Curie, 4 Place Jussieu, F-75252 Paris Cedex 05, France

(Dated: April 16, 2010)

We realize experimentally an atom-optics quantum chaotic system, the quasiperiodic kicked rotor, which is equivalent to a 3D disordered system, that allows us to demonstrate the Anderson metal-insulator transition. Sensitive measurements of the atomic wavefunction dynamics and the use of finite-size scaling techniques make it possible to extract the critical parameters and the critical exponent of the transition, experimentally measured for the first time for non-interacting matter waves. The critical exponent is universal, i.e. independent of the detailed values of the parameters, and equal to the one numerically obtained for the 3D Anderson model. We also study the spatio-temporal evolution of the wavefunction at the critical point, and show that it is well described by self-consistent theory of localization.

Dynamics of Quantum Impurities in Bose Condensates

Alex KAMENEV
Fine Theoretical Physics Institute
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U.S.A.

Recent progress in investigation of cold atomic gases in optical lattices made it possible to focus on the dynamics of isolated quantum impurities. Such impurities may be created by e.g. spin flipping of one or few particles and may be selectively accelerated by magnetic or gravitational fields. The talk will review dynamics of such quantum impurities, moving through a Bose condensed media. The main aspects of the dynamics include: Cherenkov radiation by supersonic particles, as well as Raman scattering of thermal phonons by subsonic particles, which results in friction and dissipation. Another aspect, associated with the non-linearity of the media, is formation of polarons, which modify dispersion relation of the impurities. Dynamics of such polarons under the influence of force, applied to the impurity, is the central topic of the talk.

THURSDAY, 20 MAY 2010

(updated as of 10 May 2010)

web-page: http://agenda.ictp.trieste.it/smr.php?2144

Dirac Fermions in HgTe Quantum Wells

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Narrow gap HgTE quantum wells exhibit a band structure with linear dispersion at low energies and thus are very suitable to study teh physics of the Dirac Hamiltonian in a solid state system. In comparison with graphene, they boast higher mobilities and, moreover, by changing the well width one can tune the effective Dirac massfrom positive, through zero, to negative.

Negative Dirac mass HgTe quantum wells are 2-dimensional topological insulators and, as a result, exhibit the quantum spin Hall effect, where a pair of spinfull helical edge channels develops when the bulk of material is insulting, leading to a quantized conductance.

In this talk, I will give an overview of our recent work on the quantum spin Hall effect that develops when the HgTe samples are gated into the gap, as well as the Dirac Fermion physics we observe when the wells are metallic.

Dirac fermions, Chern numbers and bulk-edge correspondence in graphene with randomness

Y. Hatsugai
Institute of Physics, University of Tsukuba, Tsukuba, 305-8571 Japan

Massless Dirac fermions which are experimentally realized in graphene have rather long history. We focus on their topological properties and symmetry in this talk. A zero gap semiconductor implies that the effective low energy Hamiltonian has a chiral symmetry. On the contrary, the chiral symmetry of the crystal implies topologically protected doubling of Dirac cones. It is a two-dimensional analogue of the Nielsen-Ninomiya theorem in four-dimensions [1]. This chiral symmetry plays important roles in many aspects of graphene such as the anomalous quantum Hall effect and the boundary physics. By the bulk-edge correspondence, it implies that the boundary physics of graphene reflects non-trivial topological structure of the bulk and has to be rich [2]. Actually an appearance of characteristic edge states is confirmed even experimentally. As is well known, the chiral symmetry also plays a fundamental role in the Anderson localization. We have numerically demonstrated crucial roles of the chiral symmetry in graphene with a stress on its spatial correlation of the bond/gauge disorder. It may be a good model for ripples of a free standing single layer graphene. Especially for the N=0 Landau level where special role of the zero energy is apparent since the chiral symmetry implies a particle-hole symmetry of the spectrum. Only when the special correlation of the bond disorder exceeds lattice spacing, the N=0 Landau level is extremely sharp even with the chiral symmetric disorder, which is consistent with the index theorem prediction [3, 4].

The Hall conductance of the graphene that is given by the sum of the Chern numbers of filled Landu levels inevitably includes contribution of Dirac sea. It brings numerical difficulty in calculation of each Chern number separately especially for disordered graphene. Then use of the non-Abelian Berry connection defined by a multiplet of the filled Landau levels is essential for the consistent calculation. We have demonstrated numerical validity of the non-Abelian Berry connection [1,3,4]. Effects of the next nearest neighbor hopping, which does not respect a naive chiral symmetry is discussed as well [4]. The work has been done in collaboration with T. Kawarabayashi T. Morimoto and H. Aoki.

References

[1] Y. Hatsugai, T. Fukui and H. Aoki, Phys. Rev. B 74, 205414 (2006), Eur. Phys. J. Special Topics 148, 133 (2007).
[2] Y. Hatsugai, Solid State Commun. 149, 1061 (2009).
[3] T. Kawarabayashi, Y. Hatsugai and H. Aoki, Phys. Rev. Lett. 103, 156804 (2009).
[4] T. Kawarabayashi, T. Morimoto, Y. Hatsugai, H. Aoki, Graphene Week 2010, Maryland USA April 19-23 (2010) and to be published.

Localization in quasi-one-dimensional wires: correlations of the local density of states

Dmitry IVANOV
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We address the problem of Anderson localization in quasi-one-dimensional wires, which, in the limit of a large number of channels may be described in terms of a supersymmetric non-linear sigma model. In the unitary symmetry class, we report a calculation of the correlation function of the local density of states, at different spatial positions and at a small energy difference. The result is expressed as a "quasiclassical" expansion in energy difference, which involves both energy and its logarithm. To the leading order, we find the universal behavior coinciding with the known result for strictly one-dimensional chains: the statistics of a single localized wave function at short distances, and level repulsion at the Mott scale. Corrections at finite energy difference are, however, non-universal: they differ from the strictly one-dimensional expressions.

Ref: D.A.Ivanov, P.M.Ostrovsky, and M.A.Skvortsov,
PRB 79, 205108 (2009).

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Dark solitons: a model of impurity-phonon interactions in quantum liquids

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Understanding of interactions between quantum liquids and impurities is important for studying superfluid flow in disordered media in 1d. Impurities create nonlinear disturbances in the quantum liquid with a complicated dynamics. For low enough temperatures and velocities of the liquid the description can be simplified and leads to an universal Hamiltonian describing interactions of the dressed impurities with long wavelength phonons. The phenomenological parameters of this Hamiltonian can be determined semiclassically in the case of weak interactions. In this talk we review this method and apply it to study dissipative dynamics of dark solitons, which may be regarded as mobile impurities. Our main findings are as follows.

Unless protected by the exact integrability, solitons are subject to dissipative forces, originating from a thermally fluctuating background. At low enough temperatures T background fluctuations (phonons) should be considered as being quantised. Since the soliton velocity V is always smaller than the speed of sound c, emission of a single phonon is forbidden by the energy and momentum conservation, *i.e.* by Landau criterion. The leading allowed process is the Raman two-phonon scattering, where one thermal phonon is absorbed and another one reemitted. This enables us to calculate finite lifetime of the solitons $\tau \sim T^{-4}$. We show that the prefactor in the expression for the life-time depends crucially on integrability properties of the quantum liquid model. We also find that the coherent nature of the quantum fluctuations leads to enhanced mutual friction of solitons due to the superradiation of phonons.

Our results are of relevance to current experiments with ultracold atoms, while the approach may be extended to solitons in other media.

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[2] D. M. Gangardt and A. Kamenev, accepted for publication in Phys. Rev. Lett.

Delocalization by Disorder in Layered Conductors

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Conductivity of many layered materials is more anisotropic than it is predicted by the band theory and Drude model. To understand this anomaly, we consider a model with two kinds of the disorder: a "planar" disorder - due to the presence of randomly spaced ``wrong" planes, and a weak "bulk" disorder caused by isotropic impurities located randomly in the bulk of the material. This model has been solved numerically and analytically, with the use of an exact solution for the conductivity of a strictly one-dimensional (1D) disordered system. Bulk disorder destroys 1D localization along the c-axis (perpendicular to the layers) which would be in the absence of the bulk disorder. Hence, the conductivity along the c-axis is finite and is proportional to the weak scattering rate by bulk impurities, i.e., it is manifestly of a non-Drude form. This may result in a much stronger anisotropy of the conductivity than it follows from the band theory for systems with only a bulk disorder.

POSTER SESSION II

Adriatico Guest House

lower level
(outside the Kastler Lecture Hall)

FRIDAY, 21 MAY 2010

(updated as of 10 May 2010)

web-page: http://agenda.ictp.trieste.it/smr.php?2144

Experimental Discovery of several classes of Topological Insulators and related Superconductors using Spin-sensitive novel spectroscopic methods

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The topological insulator is a fundamentally new phase of quantum matter, which exhibits exotic quantum-Hall-like behavior even in the absence of an applied magnetic field and unlike the quantum Hall liquids can be turned into superconductors [1]. In this talk, I will briefly review the first experimental discovery and realization of the topological insulator in Bi-Sb [2,3], and then report our discovery a new generation of topological insulators with order-of-magnitude larger bulk band gaps and a single spin-helical surface Dirac cone [4,5,6] and experimentally demonstrate *all* defining properties of topological insulators such as (1) Topological Spin-Textures [3,5,6], (2) Spin-momentum helical locking [3,6], (2) Non-trivial Berry's phases [3,6], (3) Absence of backscattering or no U-turn [5,7], (4) Protection by time-reversal symmetry [1,5], (5) Room temperature topological order [6], (6) Superconductivity and Magnetism in doped topological insulators [8,9].

[1] *"Topological Insulators"* M. Z. Hasan, C. L. Kane; arXiv:1002.3895 Rev. of Mod. Phys. (2010).
[2] *`A topological Dirac insulator in a quantum spin Hall phase"*, D. Hsieh et al., NATURE 452, 970 (2008).
[3] *`Observation of unconventional quantum spin textures in topological insulators"*, D. Hsieh et al., SCIENCE 323, 919 (2009).
[4] *`Observation of a large-gap topological-insulator (Bi_2Se_3) class with a single Dirac cone on the surface"*, Y. Xia et al., NATURE PHYSICS 5, 398 (2009).
[5] *`Observation of time-reversal-protected single-Dirac-cone topological-insulator states in Bi_2Te_3 and Sb_2Te_3"*, D. Hsieh et al., Phys. Rev. Lett., 103, 146401 (2009).
[6] *``A tunable topological insulator in the spin helical Dirac transport regime"*, D. Hsieh et al., NATURE 460, 1101 (2009).
[7] *"Topological Surface States Protected From Backscattering by Chiral Spin Texture"* P. Roushan et.al., (Yazdani, Hasan) NATURE 460, 1106 (2009).
[8] *"Observation of unconventional band topology in a superconducting doped topological insulator, Cu_x-Bi_2Se_3: Topological or non-Abelian superconductor?"* L. Wray et.al., arXiv:0912.3341 (2009).
[9] *"The development of ferromagnetism in the doped topological insulator $Bi_{2-x}Mn_xTe_3$"* Y. S. Hor et.al., arXiv:1001.4834 (2010).

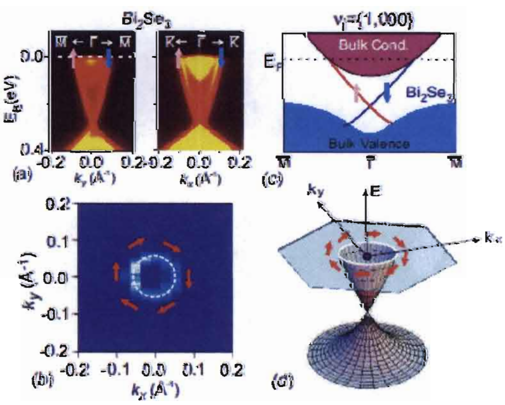

Figure 1: First direct measurement of Z_2 Topological Order : Helical Dirac fermions with spin-textures and p Berry's phase observed at 300K (room temperature) in the largest gap topo. insulator Bi_2X_3 (X=Se/Te).

Quantum Hall Transitions and Conformal Restriction

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Disordered electronic systems exhibit continuous quantum phase transitions between insulating and conducting phases (Anderson transitions). The nature of the critical state at and the critical phenomena near such a transition are of great current interest. A famous example is the integer quantum Hall (IQH) plateau transition. Recent experiments have provided very clear evidence for critical behavior near an IQH transition, and gave rather precise values of critical exponents. In spite of much effort over several decades, an analytical treatment of most of the critical states in disordered electronic systems has been elusive. We propose to use the recently developed rigorous theory of conformal restriction and Schramm-Loewner evolutions to study the IQH and other Anderson transitions in two dimensions, assuming conformal invariance at these critical points. We consider the so-called point contact conductances (PCC) and obtain, for the first time, exact analytical results for PCC's in the presence of a variety of boundary conditions at the IQH and similar critical points.

Conformal invariance and boundary multifractality at Anderson transition in two dimensions

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At Anderson (metal-insulator) transitions critical wave functions show multifractal scaling behavior. It turns out that the multifractal spectra of critical wave function amplitudes at boundaries are different from those in the bulk. Recent numerical studies of boundary multifractal spectra has indicated that there exists emergent conformal symmetry at Anderson transitions in two dimensions. I will give an overview of these recent studies on boundary multifractality and conformal invariance: (i) angle dependence of corner multifractal spectra and (ii) universal relation between ¥alpha_0 and normalized localization length in quasi-1D geometry. These results are illustrated for the metal-insulator transition in the symplectic (spin-orbit) class and also for the integer quantum Hall plateau transition.

Reference:

H. Obuse, A.R. Subramaniam, A. Furusaki, I.A. Gruzberg, and A.W.W. Ludwig, Phys. Rev. Lett. 98, 156802 (2007); Physica E 40, 1404 (2008); Phys. Rev. Lett. 101, 116802 (2008); arXiv:0911.5443.

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Critical Scaling at the Anderson Localization Transition in the Strong Multifractality Regime

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We study dynamical scaling (DS) in disordered systems at (or close to) the point of the Anderson localization transition. Wave functions of such systems are fractal. DS is connected to strong spatial correlations of the wave functions. These correlations are particularly nontrivial in the strong fractality regime where fractals are very sparse. It has been conjectured [1] that there exists an exact relation between the exponent of DS and the 2nd fractal dimension. To the best of our knowledge, neither existence of DS nor the relation between the exponents were checked analytically.

We study DS and the critical exponents in the strong fractality regime using the model of almost diagonal random matrices with fractal eigenstates [2] by analyzing asymptotic behavior of the return probability in the long time limit. Since the nonlinear \sigma-model cannot be solved in the strong fractality regime we use an alternative field theoretical method: the SuSy virial expansion in a number of interacting energy levels [3].

We have proven the DS to hold true up to the leading terms of 2nd loop of RG. We discuss necessary conditions for the exact relation between the critical exponents.

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Dephasing at the Integer Quantum Hall Transitions: Short-Ranged Interaction in the Singlet Channel"

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I.V. GORNYI, A.D. MIRLIN, S. BERA, F. EVERS
(Karlsruhe Institute of Technology)

The temperature dependence of conductances at the integer quantum Hall transitions is determined by the exponent (kappa) which is the ratio of the localization length exponent (nu) and the dephasing length exponent (p), kappa=p/2nu. Contrary to the localization length exponent which has been intensively studied [1], the dephasing length exponent has attracted much less attention. In Refs. [2] and [3] the dephasing length has been estimated numerically under conjec4ture that the exponent is determined by an anomalous dimension of the irrelevant operator which is involved in the inverse participation ratio. In the present work we analytically demonstrate for short-ranged electron-electron interaction in singlet channel that this conjecture is true for the case of Anderson transition in the unitary class in 2+epsilon dimensions. Our results for 2+epsilon dimensions as well as our numerical calculations of anomalous dimensions of irrelevant operators at the integer quantum Hall transitions provides strong support in favor of this conjecture. Together with known numerical results for the localization length exponent, our numerical results for the dephasing length exponent allows to determine the temperature behavior of the conductances (exponent kappa) at the integer quantum Hall transitions for the case the short-ranged interaction in the singlet channel.

[1] F. Evers and A.D. Mirlin, Rev. Mod. Phys. 80, 001355 (2008).
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[3] Z. Wang, M.P.A. Fisher, S.M. Girvin, and J.T. Chalker, Phys. Rev. B 61, 8326 (2000).

Spin-Flip Scattering at Quantum Hall Transition

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We formulate a generalized Chalker--Coddington network model that describes the effect of nuclear spins on the two-dimensional electron gas in the quantum Hall regime. We find exact analytical expression for the transmission coefficient of a charged particle through a saddle point potential in presence of perpendicular magnetic field that takes into account spin-flip processes.

Spin-flip scattering creates a metallic state in a finite range around the critical energy of quantum Hall transition. As a result we find that the usual insulating phases with Hall conductance $\sigma_{xy}=0, 1, 2$ are separated by novel metallic phases.

SATURDAY, 22 MAY 2010

(updated as of 10 May 2010)

DISCUSSION DAY

web-page: http://agenda.ictp.trieste.it/smr.php?2144

A B S T R A C T S

O F

P O S T E R S

(in alphabetical order of author name as of 10 May 2010)

Thermodynamical Variations in a Condensed Binary Bose-Fermi System

AYODO Kennedy, Khanna Mohan & Sakwa Thomas

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Specific heat capacity, internal energy and entropy for a condensed binary Bose-Fermi system have been investigated. The derived equations in terms of the statistical partition function were applied to a Bose-Fermi system of liquid $^{4}_{2}He - ^{3}_{2}He$. For this system, negative specific heat values were obtained giving an indication that the system rejects increasingly more heat as temperature is lowered from 2.3K to 2.0K. Internal energy showed a remarkable discontinuity at about 2.16K which is reminiscent of the λ - transition that occurs in liquid $^{4}_{2}He$ at 2.176K. Entropy values increased with temperature as expected. Total energy for the $^{7}_{3}Li - ^{6}_{3}Li$ Bose-Fermi mixture exhibited values with different signs on the different sides of the potential trap suggesting a shift of atoms. This showed that the atoms can be taken from the attractive to repulsive regimes. The sign of the atomic interactions is found to vary in a Bose-Einstein condensate. The Gross-Pitaevskii (GP) analysis for a $^{41}_{19}K - ^{40}_{19}K$ system indicated that the energy distribution is dependent on the sign of the scattering length between atoms. The total energy decreases with increase in condensate radius for the positive scattering length that normally denotes repulsion between the atoms. Negative scattering length due to attraction between the particles resulted in increase in energy with the condensate radius. Studies about the influence of atomic interactions on energy distribution on the $^{87}_{37}Rb - ^{40}_{19}K$ system, gave nearly similar results. However, the $^{41}_{19}K - ^{40}_{19}K$ system exhibited a critical condensate radius of about 6.0 oscillator units at which there is spontaneous transition from the attractive to the repulsive regime and vice versa. Particle density distribution is greatly dependent on the strength of the atom – atom interactions. Thomas-Fermi approximation (TF) showed that the distribution of particles as well as the energy profile are dependent on a finite interaction range. The density of particles depicts to have a cubic dependence on the Thomas-Fermi radius R. For R = 0, only one type of particles is found to exist indicating a completely separated regime. The energy of the fermions and bosons showed a singularity in the energies at R= 0 which depicts a point for phase separation for the two types of particles.

Key words: Bosons, fermions, Bose-Einstein condensates (BECs), scattering lengths, oscillator lengths, GP equations, TF equations

Out-of-equilibrium Aharonov-Bohm spectroscopy with quantum Hall edge states

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Motivated by a series of recent experiments we consider the influence of the long range Coulomb interaction on the quantum coherence in Mach-Zehnder and Fabry-Perot electronic interferometers realized with integer quantum Hall edge states. We propose a simple physical model which enables to explain an experimentally observed unusual non-monotonic dependence of the visibility of the interference pattern. The origin of this effect stems from the combination of an electrostatic Aharonov-Bohm effect, related to the charge imbalance on different arms of the interferometer, and a non-equilibrium dephasing, suppressing the Aharanov-Bohm oscillations of conductance with an increase of voltage. One finds that dephasing rate is proportional to the shot-noise power of the quantum point contacts (QPC's) which define the interferometer and originates from the emission of non-equilibrium plasmons in course of inelastic electron tunneling. The role of the edge-state reconstruction on the formation of the interference pattern is also discussed.

In collaboration with S. Ngo Dinh, M. Schneider and A. Mirlin

Effects of Short Range Interaction on the Integer Quantum Hall Transition

Authors: **S. BERA**, I. S. Burmistrov, F. Evers, I. Gornyi, A. D. Mirlin.

To understand the effect of the Coulomb interaction is one of the most challenging problems in the context of Anderson localization and the quantum Hall effect.

In our study we address this question by doing a perturbation theory in the interaction near the non-interacting fixed point. In each order diagrams appear which contain correlation functions characterizing the fluctuation properties of wavefunctions at the (non-interacting) critical fixed point. It turns out that correlators combine in a way such that the leading multifractal powerlaws cancel; the subleading terms govern the interaction corrections. We present a numerical study based on the Chalker-Coddington network, in which we determine quantitatively the subleading multifractal exponents of the salient wavefunction correlators.

Universal Critical Conductivity in the Anderson Insulator to Metal Transition in Two Dimensions

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We demonstrate, through extensive quantum Monte Carlo simulations, the existence of a universal critical conductivity in an Anderson insulator to metal transition in two dimensions. The universality of the critical conductivity across various models of disorder is presented, thus pointing to the existence of a quantum critical point in these systems with universal properties. We also present the behaviour of the compressibility and magnetic susceptibilities across the transition and compare the results to experimental data and analytical renormalization group investigations.

Co-authors:

(1) Krzysztof Byczuk, Institute of Theoretical Physics, University of Warsaw, ul. Hoza 69, PL-00-681, Warszawa, Poland.

(2) Dieter Vollhardt, Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute for Physics, University of Augsburg, D-86135, Augsburg, Germany.

The Landau Fermi-liquid Parameters of Unitary Fermions System with a Quasi-Linear Approximation Method

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In recent years, considerable efforts for understanding the strongly interacting fermions physics with ultra-cold atomic Fermi gases have been made. The two-body interaction strength can be tuned with the Feshbach resonance. At unitarity, the divergent scattering length with a zero energy bound state can manifest the thermodynamic universal properties. To interpret the exotic phase separation properties observed in the trapped polarized fermions system, the Landau effective fermion mass becomes the key dynamical parameter. Theoretically, fixing the Landau parameters of interacting fermions system with these conventional technique is a formidable task.

Recently, we have made a non-perturbative attempt to understand the novel strongly correlating physics. A nonlinear transformation approach is formulated for the correlated fermions' thermodynamics through a medium-scaling effective action. Through an effective chemical potential, the correlation effects are incorporated in the grand partition function. The low temperature expansions with the Sommerfeld lemma give the Landau Fermi-liquid parameters F_0^s and F_1^s. At unitarity, the effective mass ratio as a universal constant is ${m^*}/m=\frac{10}9$. The result agrees with the previous numerically theoretical/experimental fitting attempts.

Localization-Delocalization Transition through Graphene Superlattice with Long-Range Correlated Disorder on Potential Barriers

***Hosein CHERAGHCHI*[1] *Amir Hossein Irani*[1], *Seyyed Mahdi Fazeli*[2]**
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Using transfer matrix method, we have solved Dirac equation for chiral particles in graphene supperlattice with long-range correlated disorder on potential barriers. Long range correlated random data is produced by the mid-point method. Because of Klein tunneling, electrons with normal incident can transport without any reflection. The same phenomenon arises when transmission through disordered superlattices is studied. But in large angles incidence to the potential barriers, transmission is suppressed by uncorrelated disorder. However, transport is allowed in wide range of angles when the potential heights are correlated with the correlation strength H (named by the Hurst exponent). As a result, conductance increases with the Hurst exponent. We have provided a phase transition diagram in which critical Hurst exponent depends on the disorder strength. It is also investigated the dependence of conductance to the width and length of the barriers. Energy range of this study has chosen in such way that transport is in its propagating modes.

The 2DES Chemical Potential: Revealing the Link from the Classical to the Quantum Hall Effect Regime

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What happens to the extended states of a system initially in the quantum Hall regime when the temperature is raised? This is of a concern since only in the extended states are transport of charge carriers allowed in the non-ballistic regime.

There are no two-dimensional extended states in zero or weak magnetic fields *B*, the latter being the classical Hall effect case. The (classical) Hall effect is an induced potential difference measured perpendicular to the direction of the current in a conductor, when the conductor is placed in a magnetic field.

On the other hand, quantum Hall effect (QHE), the strong field and low temperature limit of the classical, implies the essential existence of extended states. What happens then to these states as the magnetic field is decreased with the eventual disappearance of the QHE? This implies that there is a critical magnetic field B_c where the extended states vanish. But, not only in the advent of weak *B* does QHE disappear but also with exposure to high enough temperature. When the thermal energy is not small enough, the quantization is also smeared. This is where this paper endeavors to focus into.

Previously, we have shown that at low enough temperature the effect of localization vanishes. This current investigation verifies this result and it further demonstrates the leap to the opposite regime where the extended states vanish.

Assuming a Gaussian form of the density of states, a two-dimensional electron system under a magnetic field was studied numerically particularly the temperature dependence of its chemical potential. For all fillings ν the chemical potential μ saturated to a common value at high temperature T - the classical Hall region. Approaching low T, the quantum Hall regime, μ followed varying paths depending on ν. For the complete fillings, μ showed a knee temperature T_ν pointing to the junction between the two regimes. This crossover, characterized by νT_ν being constant, indicates the balance between the localization and delocalization effects of the magnetic field and temperature, respectively.

For full paper refer to Proceedings of the Samahang Pisika ng Pilipinas (Physics Society of the Philippines) [ISSN 1656-2666] Volume 5, (2008).

Modulational Instability:
Energy Localization in Heisenberg Helimanagnet

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We discuss the process by which energy, initially evenly distributed in a nonlinear lattice, can localize itself into large amplitude excitations. We show that, the standard modulational instability mechanism, which can initiate the process by the formation of small amplitude breathers, is completed efficiently, in the presence of discreteness, by energy exchange mechanisms between the nonlinear excitations which favor systematically the growth of the larger excitations. The modulational instability can generate small breathers and then their interaction leads to the growth of the largest excitations. We investigate the existence of discrete breathers in a Heisenberg ferromagnetic discrete lattice established by the mechanism of modulational instability.

Evidence of gate-tunable topological excitations in two-dimensional systems

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Topological defects are ubiquitous from solid state physics to cosmology, where they drive phase transitions by proliferating as domain walls, monopoles, vortices or cosmic strings. Quantum mechanically they often display fractionally charged excitations and anyonic statistics, and relevant to topologically protected quantum computation schemes. Realizing a controlled physical source for topological excitations has however been challenging, although the 5/2 quantum Hall states or bismuth-based topological insulators are of great interest in this context. Here we report compelling evidence of topological excitations in strongly interacting 2D electron systems (2DES) in GaAs/AlGaAs heterostructures observable even at zero magnetic field. Theoretically, topological defects in this regime was suggested before in connection with melting of pinned two-dimensional (2D) charge density waves such as Wigner crystal, but never clearly observed. In our devices, a gate tunable proliferation of charged topological defects manifests in a Berezinskii-Kosterlitz-Thouless (BKT)-like order-disorder transition that governs the evolution of electrical conductivity at low carrier densities. At low temperatures, zero point fluctuations of these defects lead to delocalization and a remarkable weak temperature dependence of conductivity. Apart from highlighting a new tunable source of topological excitations in semiconductors, our experiments also cast crucial insight on the nature of ground state in strongly interacting 2DESs in the presence of disorder.

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Absence of a metallic phase in charge-neutral graphene with a random gap

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It is known that fluctuations in the electrostatic potential allow for metallic conduction (nonzero conductivity in the limit of an infinite system) if the carriers form a single species of massless two-dimensional Dirac fermions. A nonzero uniform mass M opens up an excitation gap, localizing all states at the Dirac point of charge neutrality. Here we investigate numerically whether fluctuations $\delta M \gg M \neq 0$ in the mass can have a similar effect as potential fluctuations, allowing for metallic conduction at the Dirac point. Our negative conclusion confirms earlier expectations, but does not support the recently predicted metallic phase in a random-gap model of graphene.

Semiclassical spectral correlator in quasi one-dimensional systems

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We investigate the spectral statistics of chaotic clean quasi one-dimensional systems. To do so we represent the spectral correlation function R() through derivatives of a generating function and semiclassically approximate the latter in terms of periodic orbits. In contrast to previous work we obtain both non-oscillatory and oscillatory contributions to the correlation function. Both types of contributions are evaluated to leading order in 1/ for systems with and without time-reversal invariance. Our results agree with predictions from the nonlinear sigma model for disordered systems.

This coincides with the poster I included when registering for the conference. I just shortened the abstract, but I don't mind if the poster appears in the booklet with the old abstract.

Tunneling into Nonequilibrium Luttinger Liquid with Impurity

Stéphane Ngo Dinh, Dmitry A. Bagrets, Alexander D. Mirlin

We evaluate tunneling rates into/from a quantum wire containing a weak backscattering defect and biased by a voltage U. Interacting electrons in such a wire form a true *nonequilibrium* state of the Luttinger liquid (LL). This state is created due to inelastic electron backscattering leading to the emission of nonequilibrium plasmons with typical frequency $\hbar\omega \lesssim U$. The tunneling rates are split in two edges. The tunneling exponent at the Fermi edge is *positive* and equals that of the equilibrium LL, while the exponent at the side edge $E_F - U$ is *negative* if Coulomb interaction is not too strong.

The approach developed here will be useful for the analysis of tunneling and interference in a broad class of nonequilibrium LL structures with impurities and/or tunneling couplings.

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Multifractality and Conformal Invariance of the Conductance at the Integer Quantum Hall Plateau Transition

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We investigate multifractality of the conductance where the two-point contacts attached on the bulk and various boundaries of two dimensional systems at the integer quantum Hall plateau transition. We have shown that power law exponents extracted from the point-contact conductance for the bulk and the reflecting boundary are related to the bulk and reflecting boundary scaling dimensions, respectively, which characterize multifractality of wave functions. We also confirm that the exponent extracted from the conductance for the system imposed absorbing boundaries coincides with an analytical prediction. In addition, we have shown that these exponents can be measured from the two-terminal conductance in the quasi-one dimension due to conformal symmetry. Our results provide a way to observe multifractality by the actual experimental setup.

Quantum Spin Hall edges and the proximity effect

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We consider a Quantum Spin Hall edge in which a superconducting gap is induced by a proximity effect in a region of finite length. We study the transport properties of this system using a combination of Bogoliubov-de Gennes with the Landauer Buttiker formalism. Because of the helical structure of the edges, crossed Andreev reflection and normal reflection are suppressed. For a long superconducting region, this leads to total Andreev reflection of electrons of energy smaller than the superconducting gap at the normal-superconducting contact. For shorter regions, transmission is possible leading to a current partition noise. For energies higher than the gap, Fabry-Perot resonances are possible.

Multifractal Eigenfunctions in Random Matrix Ensembles

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Random matrix models is an efficient tool to study the Anderson metal-insulator transition. In this poster we focus on two such models: the power-law banded random matrices and the ultrametric random matrices. Using the weak disorder virial expansion we show how the multifractal critical exponents can be calculated analytically. Relations between different critical exponents, universality of the results as well as some open problems are discussed.

Controlling localization of matter waves of cold atoms in a standing-wave field

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Motion of cold atomic wave packets in a standing-wave laser field is interpreted in the dressed-state basis as a propagation in two optical potentials. The wave-packet dynamics depends strongly on the ratio of the squared detuning to the Doppler shift. Varying the strength of the laser field, one can control the wave-packet motion. At small and large detunings, the matter-wave packets are localized in the momentum and position spaces, and their motion is shown to be adiabatic. At intermediate values, the motion is nonadiabatic with a proliferation of wave packets at the nodes of the standing wave [1]. As a result, the matter-wave packets are delocalized in the momentum and position spaces. It is possible under certain conditions to force a single atom to move in the opposite directions along the axis of the optical lattice ot to trap one its part in a well of the optical potential and to force another part to move ballistically. The role of spontaneous emission in localization of atomic matter waves is considered on the basis of Monte Carlo quantum-trajectories method.

1. S.V. Prants. J. Exper. Theor. Phys. V. 109, is. 5. P. 751-761 (2009) [Zh. Eksper. Teor. Fiz. V. 136, is. 5. P. 872-884 (2009)].

Coulomb interaction in graphene: Relaxation rates and transport

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We study electron transport in graphene with Coulomb interaction at finite temperatures by using Keldysh diagrammatics. In the case of clean graphene we obtain the total scattering rate, the transport scattering rate, and the energy relaxation rate at the Dirac point. Since the total scattering rate diverges graphene exhibits a non-Fermi-liquid behavior similar to disordered metals. Unlike metals clean graphene has a finite conductivity due to the Coulomb interaction. For conductivity we obtain the same analytic behavior as was found using the Boltzmann approach[1,2]. We analyze the plasmon spectrum of graphene and formulate quantum kinetic equations to describe transport in the crossover between the Coulomb interaction dominated regime and the disorder dominated regime.

1 L. Fritz et al., Phys. Rev. B 78:085416 (2008)

2 A. Kashuba. Phys. Rev. B 78:085415 (2008)

Electron localization in graphene nanoribbons with a line of defects

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In this work, we study quantum transport properties of a defective graphene nanoribbon (DGNR) attached to two semi-infinite metallic armchair graphene nanoribbon (AGNR) leads. For this reason, a line of defects is considered in the GNR device with different configurations, which affects on energy spectrum of the system. The calculations are based on the tight-binding model and Green's function method, in which localization length of the system is investigated, numerically. By controlling disorder concentration, the extended states can be separated from the localized states in the system. Our results may have important applications for building blocks in the nano-electronic devices based on GNRs.

keywords: Graphene nanoribbon, defects, Ballistic transport, Quantum localization

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Transport in Insulating Josephson Networks and Granulated Superconductors

Authors:
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We study microscopically low-temperature transport in disordered two-dimensional arrays of Josephson junctions and granulated superconductors. The conductivity comes from the motion of charged bosonic excitations. In the whole insulating region of the phase diagram, both in the deep Coulomb-blockade regime and close to the superconductor-insulator transition (SIT), and at arbitrary disorder strength the conductivity shows activational-type behaviour $\propto\exp(-E_g/T)$ with the activation gap E_g independent or nearly independent on the temperature. Also, we derive an effective Ginzburg-Landau functional describing the excitations close to the SIT and show that the transition is always of the first order for most two-dimensional and for all three-dimensional arrays.

TITLES

OF

POSTER

PRESENTATIONS

(in alphabetical order of author name as of 10 May 2010)

The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

Workshop on
Localization Phenomena in Novel Phases of Condensed Matter
(17 - 23 May 2010)

Organizers:
F. Evers, V. Kagalovsky and I. Lerner

Local Organizer:
V.E. Kravtsov

Venue:
Adriatico Guest House - Kastler Lecture Hall (lower level 1)

TITLES of POSTER PRESENTATIONS
(updated as of 18.5.10)

Kennedy AYODO
(Masinde Muliro University of Science & Technology, Kenya)
Thermodynamical Variations in a Condensed Binary Bose-Fermi System

Dmitry BAGRETS (Karlsruhe Institute of Technology, Germany)
Out-of-Equilibrium Aharonov-Bohm Spectroscopy with Quantum Hall Edge States

Soumya BERA (Research Center Karlsruhe, Germany)
Effects of Short Range Interaction on the Integer Quantum Hall Transition

Prabuddha CHAKRABORTY (University of Augsburg, Germany)
Universal Critical Conductivity in the Anderson Insulator to Metal Transition in Two Dimensions

Ji-Sheng CHEN (Central China Normal University, Wuhan, China)
The Landau Fermi-Liquid Parameters of Unitary Fermions System with a Quasi-Linear Approximation Method

Hosein CHERAGHCHI (Damghan Univ. of Basic Sciences, Damghan, Iran)
Localization-Delocalization Transition through Graphene Superlattice with Long-Range Correlated Disorder on Potential Barriers

Rayda GAMMAG (University of the Philippines, Quezon City, Philippines)
The 2DES Chemical Potential: Revealing the Link from the Classical to the Quantum Hall Effect Regime

Louis KAVITHA (Periyar University, Tamilnadu, India)
Modulatinal Instability: Energy Localization in Heisenberg Helimanagnet

Ramadoss KOUSHIK (IIS, Bangalore, India)
Evidence of Gate-Tunable Topological Excitations in Two-Dimensional Systems

Mariya MEDVEDYEVA (Leiden University, The Netherlands)
Absence of a Metallic Phase in Charge-Neutral Graphene with a Random Gap

Sebastian MÜLLER (University of Bristol, U.K.)
Semiclassical Spectral Correlator in Quasi One-Dimensional Systems

Stéphane NGO DINH (Karlsruhe Institute for Technology, Germany)
Tunneling into Noneequilibrium Luttinger Liquid with Impurity

Hideaki OBUSE (Kyoto University, Japan)
Multifractality and Conformal Invariance of the Conductance at the Integer Quantum Hall Plateau Transition

Edmond ORIGNAC (Lab. de Physique de l'ENS Lyon, France
Quantum Spin Hall Edges and the Proximity Effect

Alexander OSSIPOV (University of Nottingham, U.K.)
Multifractal Eigenfunctions in Random Matrix Ensembles

Sergey PRANTS (RAS, Pacific Oceanological Institute, Vladivostok, Russia)
Controlling Localization of Matter Waves of Cold Atoms in a Standing-Wave Field

Abbas Ali SABERI (IPM, Tehran, Iran)
3D Ising Model and Conformal Invariance

Michael SCHÜTT (Karlsruhe Institute for Technology, Germany)
Coulomb Interaction in Graphene: Relaxation Rates and Transport

Reza SEPEHRINIA (IPM, Tehran, Iran)
Irrational Anomolies in One-Dimensional Anderson Localization

A.A. SHOKRI (Payame Noor University, Tehran, Iran)
Electron Localization in Graphene Nanoribbons with a Line of Defects

S.V. SYZRANOV (Ruhr-Universitaet Bochum, Germany)
Transport in Insulating Josephson Networks and Granulated Superconductors