PROGRAM AND ABSTRACT BOOKLET

WORKSHOP ON CORRELATIONS AND COHERENCE IN QUANTUM MATTER

Évora, Portugal, 10-14 November 2008

This workshop is dedicated to the memory of Kazumi Maki

On 10 September 2008 Kazumi succumbed to a long battle with cancer. He was among an elite group of Japanese physicists who fostered the development of physics as a science during the 20th century. After earning his Ph.D. in physics at Kyoto University, Kazumi arrived in the United States in the 1960s and worked as a research associate with the famous physicist Yoichiro Nambu, who was just awarded the 2008 Nobel Prize in Physics, at the University of Chicago. He joined the University of Southern California in Los Angeles in 1974. He dedicated his life to researching superconductors, charge density wave, and spin density wave systems. Stephan Haas, his friend and colleague, said Maki loved to laugh; he loved life, and He was easily excitable mostly about science. He had many passions, but science was his life. Kazumi was an invited speaker of the first international conference on correlated systems held in Évora, in May and June 1989.

The Workshop

An intensive exchange of ideas between related fields of theoretical physics allows for a rapid spreading of new concepts and of new methods among different research directions. This should be particularly true for the topics chosen for the planned workshop on Correlations and Coherence in Quantum Matter: quantum-many-body theory, statistical mechanics, quantum field theory and quantum computation. This workshop will provide an excellent setting for the promotion of this cross-fertilization, through a well-balanced menu of talks by leading experts, through lively poster sessions and through numerous informal discussions. The past experience of the organizers has amply proven that the city of Évora offers a unique environment for this kind of workshop.

Special attention will be given to recent advances in the fractional quantum Hall effect, quantum phase transitions, magnetic chains and ladders, atomic gases on optical lattices with reduced dimensions, quantum computation (for instance the topological protection of quantum bits), the many facets of graphene (such as the minimal conductivity, the anomalous quantum Hall effect, or the connection to special relativity and gravity), metal-insulator transitions, spin liquids, fractional charge and statistics, and transport through quantum dots. Both analytical and numerical methods will be discussed, for instance exact solutions by the Bethe Ansatz (which now allows for the calculation of correlation functions), bosonization, techniques of conformal field theory, new approaches for treating non-equilibrium phenomena, the use of gauge fields to take into account certain constraints, the (numerical) Density Matrix Renormalization Group, and matrix product states that allow to formulate promising variational many-body wave functions.

No fee required for participation in this event. Limited number of grants available for young researchers. Contributed talks will be selected by the organizing committee.

Location
The CCQM will take place at:

Anfiteatro 131-A
Edifício do Espirito Santo
Universidade de Évora.

International Organizing Committee

Miguel A. N. Arajo (vora, Portugal)

Dionys Baeriswyl (Fribourg, Switzerland)

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Contacts and Information

CCQM
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Sponsors

- ISTAS - Portugal

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(project PTDC/FIS/64926/2006)

Universidade do Minho - Centro de Fsica

- Câmara Municipal de Évora

PROGRAM

Talks by invited speakers are 40 min. long plus 5 min. for discussion; Contributed talks are 15 min. long plus 5 min. for discussion.

Monday, November 10

8:20 - 8:50 Registration

8:50 - 9:00 Welcome

9:00 - 9:45 Invited talk: **J. M. B. Lopes dos Santos**
"Graphene in a magnetic field and a superlattice potential"

9:45 - 10:30 Invited talk: **N. M. R. Peres**
"On the electronic properties of graphene and its bilayer: gaps, edge states and optical conductivity"

10:30 - 10:50 Contributed talk: **V.M. Pereira**
"Coulomb impurities in graphene"

10:50 - 11:20 Coffee break

11:20 - 12:05 Invited talk: **A. H. Castro Neto**
"Graphene deconstructed"

12:05 - 12:50 Invited talk: **M. Vozmediano**
"General relativity and graphene"

12:50 - 15:00 Lunch break

15:00 - 15:45 Invited talk: **G. Mussardo**
"Spectrum of the two-dimensional O(3) non-linear sigma model with topological coupling"

15:45 - 16:05 Contributed talk: **R. Roldan**
"Strong magnetic field collective modes in graphene and in a standard 2D electron gas"

16:05 - 16:25 Contributed talk: **S. V. Kusminskiy**
"Electron-electron interactions and Dirac liquid behavior in graphene bilayers"

16:25 - 16:55 Coffee break

16:55 - 17:40 Invited talk: **M. Zvonarev**
"Spin dynamics in a one-dimensional Bose ferromagnet"

17:40 - 18:00 Contributed talk: **F. Heidrich-Meisner**
"The expansion of strongly interacting fermions in one-dimensional optical lattices"

18:00 - Poster session I

Tuesday, November 11

9:00 - 9:45 Invited talk: **D. Arovas**
"New directions in valence bond solid antiferromagnets"

9:45 - 10:30 Invited talk: **L. Balents**
"Spin liquid states in frustrated antiferromagnets"

10:30 - 10:50 Contributed talk: **C. Karrasch**
"Josephson current and singlet-doublet phase transitions of a quantum dot Josephson junction"

10:50 - 11:20 Coffee break

11:20 - 12:05 Invited talk: **N. Andrei**
"Quantum impurities out of equilibrium"

12:05 - 12:50 Invited talk: **M. Cazalilla**
"Quantum wires coupled to dissipative environments"

12:50 - 15:00 Lunch break

15:00 - 15:45 Invited talk: **G.I. Japaridze**
"Metal-insulator transitions in one-dimensional electron system with next-nearest-neighbor hopping"

15:45 - 16:05 Contributed talk: **M. Goldstein**
"Interacting resonant level coupled to a Luttinger liquid"

16:05 - 16:25 Contributed talk: **A. Imambekov**
"Universal theory of nonlinear Luttinger liquids"

16:25 - 16:55 Coffee break

16:55 - 17:40 Invited talk: **J. I. Latorre**
"Exact quantum circuits for strongly correlated systems"

17:40 - 18:00 Contributed talk: **A. Tokuno**
"Transport phenomena for bosons in Y-junction and its related systems"

18:30 - Reception at the City Hall

Wednesday, November 12

9:00 - 9:45 Invited talk: **F. Verstraete**
"Aspects of real-space renormalization group methods"

9:45 - 10:05 Contributed talk: **D. L. Kovrizhin**
"Multiparticle inerference in electronic Mach-Zehnder interferometers"

10:05 - 10:25 Contributed talk: **H. S. Sim**
"*Electron coherence in a finite-length Luttinger liquid and in an electronic Mach-Zehnder interferometer"*

10:22 - 10:45 Contributed talk: **D. Urban**
"Interaction-induced beats of Friedel oscillations in quantum wires"

10:45 - 11:15 Coffee break

11:15 - 12:00 Invited talk: **S. J. Gu**
"Fidelity susceptibility and quantum phase transitions"

12:00 - 12:20 Contributed talk: **A. Crépieux**
"The AC conductance and non-symmetrized noise at finite frequency in quantum wires and carbon nanotubes"

12:20 - 12:40 Contributed talk: **M. Kollar**
"Relaxation dynamics of isolated many-body systems"

12:40 - Lunch

14:00 – 20:00 Social Program

20:00 - Banquet

Thursday, November 13

9:00 - 9:45 Invited talk: **G.V. Shlyapnikov**
"Gapped 1D systems in an external harmonic potential"

9:45 - 10:30 Invited talk: **I. Bouchoule**
"Transition towards quasi-BEC in a weakly interacting elongated Bose gas"

10:30 - 10:50 Contributed talk: **B. Öztop**
"Quantum entanglement of spin-1 atoms in an optical lattice"

10:50 - 11:20 Coffee break

11:20 - 12:05 Invited talk: **J. T. Mendonça**
"Collective processes in the ultra-cold gas"

12:05 - 12:50 Invited talk: **J. Eschner**
"Single cold atoms for quantum optics and quantum information processing"

12:50 - 15:00 Lunch

15:00 - 15:20 Contributed talk: **M. Sato**
"Spontaneous rotation in trapped one-dimensional Bose gases"

15:20 - 15:40 Contributed talk: **S. D. Huber**
"Dynamically generated double occupancy as a probe of cold atom systems"

15:40 - 16:25 Invited talk: **J.-S. Caux**
"Correlations and quenches in integrable systems"

16:25 - 16:55 Coffee break

16:55 - 17:15 Contributed talk: **P. Barmettler**
"Quantum spin systems far from equilibrium"

17:15 - 17:35 Contributed talk: **M. Moeckel**
"Interaction quench in the Hubbard model"

17:40 - Poster session II

Friday, November 14

9:30 - 10:15 Invited talk: **S. Viefers**
"Quantum Hall hierarchy wave functions from conformal field theory"

10:15 - 10:35 Contributed talk: **H. Hansson**
"Conformal field theory approach to Abelian and non-Abelian quantum Hall quasielectrons"

10:35 - 10:55 Contributed talk: **A. Jellal**
"Anomalous Quantum Hall Effect on Sphere"

10:55 - 11:20 Coffee break

11:20 - 12:05 Invited talk: **E. Ardonne**
"*Interferometry in the quantum Hall effect"*

12:05 - 12:50 Invited talk: **V. Ponomarenko**
"Splitting electrons into quasiparticles with fractional edge-state interferometers"

12:50 - 15:00 Lunch

15:00 - 15:45 Invited talk: **G. Sierra**
"An exactly solvable pairing model with p + ip wave symmetry"

15:45 - 16:30 Summary and concluding remarks

POSTERS

Session I – 10/11/2008

	Name	Title
1	A. Cortijo	Competition between instabilities in doped graphene
2	F. de Juan	Electronic properties of strongly disordered graphene
3	R. M. Ribeiro	Inducing energy gaps in graphene monolayer and bilayer
4	M. Mucha-Kruczynski	Characterization of graphene through anisotropy of constant-energy maps in angle-resolved photoemission
5	T. Stauber	Optical conductivity of graphene beyond the Dirac cone approximation: Making the fine-structure visible
6	A. I. Tóth	Dynamical correlations in the spin-half two-channel Kondo model
7	V. R. Vieira	Application of the stereographic projection for the simulation of macrospin dynamics
8	P. Waechter	The conductance through Luttinger liquids: towards experimental setups
9	D. Bercioux	Electron tunneling into a quantum wire in the Fabry-Pérot regime
10	C. Neuenhahn	Dephasing by electron-electron interactions in a ballistic Mach-Zehnder interferometer
11	Y. Arredondo-Léon	Study of the charge correlation function in one-dimensional Hubbard heterostructures
12	F. Franchini	Hydrodynamic description of the spin Calogero-Sutherland model

Session II – 13/11/2008

	Name	Title
1	P. V. Buividovich	Entanglement entropy in gauge theories and the holographic principle for electric strings
2	L. Fidkowski	Topological quantum computation with anyonic excitations
3	J. M. Vilaplana	Extraction of entangled states in a 1D XY ring by local projective measurements
4	J. Sabio	Interaction quench in the sine-Gordon model
5	M. Eckstein	Adiabatic ramping of correlated fermions
6	N. Ciobanu	Collective resonance fluoresence of a system of cold atoms in the standing wave cavity
7	D. M. Otajanov	Nonlinear dynamics of atoms in a cavity: the role of finite temperature effects
8	J. Viana Gomes	Towards the establishment of two cold atom experiments in Portugal
9	O. Poplavskyy	Local density of states of electron-solid phases in the quantum Hall regime
10	A. K. Pan	Contextuality within quantum mechanics in terms of subensemble statistics

Monday, November 10

GRAPHENE IN A MAGNETIC FIELD AND A SUPERLATTICE POTENTIAL

J.M. B. Lopes dos Santos[1], N. M. R. Peres[2], A. H. Castro Neto[3]

1 CFP and Departamento de Física, Faculdade de Ciências, Universidade do Porto, P-4169-007, Porto, Portugal
2 Centro de Física and Departamento de Física, Universidade do Minho, P-4710-057 Braga, Portugal
3 Department of Physics, Boston University, 590 Commonwealth Avenue, Boston, Massachusetts 02215, USA

9h00 Mon 1

It has been recently been shown that a small angle twist between layers is a common defect in few layer graphene, giving rise to Moiré patterns observed in STM studies[1,2]. We showed that the low energy description of a bilayer with a twist is that of two massless Dirac fermion system coupled by a spatially modulated perturbation[3]. This leads to an electronic spectrum quite distinct from the one observed in AB stacked bilayer. We also address the problem of massless Dirac fermions in the simultaneous presence of a superlattice modulation and a magnetic field, as all these ingredients will be present in a bilayer with a twist in a magnetic field.

[1] F Varchon *et. al* Phys. Rev. B. 77 165415 (2008)
[2] J. Hass. *et. al* arXiv:0706.2134v1 [cond-mat.mtrl-sci]
[3] JMB Lopes dos Santos, NMR Peres and AH Castro Neto, Phys. Rev. Lett. 99, 256802 (2007)

THE ELECTRONIC PROPERTIES OF GRAPHENE AND ITS BILAYER

N. M. R. Peres[1]

1 Centro de Física and Departamento de Física, Universidade do Minho, P-4710-057 Braga, Portugal

9h45 Mon 2

We present a discussion of some of the physical properties of graphene and its bilayer. In particular, we focus our attention on the calculation of the transparency of graphene and on the dependence of the energy gap of the biased graphene bilayer on the electronic density. We show that the transparency of graphene is controlled by the value of the fine structure constant over a frequency range from the infra-red to the ultraviolet. We derive the dependence of the energy gap of the graphene bilayer on the external applied electric field.

1. A. H. Castro Neto, F. Guinea, N. M. R. Peres, K. S. Novoselov, and A. K. Geim, accepted for publication in Review of Modern Physics; arXiv:0709.1163v2.

COULOMB IMPURITIES IN GRAPHENE

Vitor M. Pereira[1]

1 Department of Physics, Boston University, 590 Commonwealth Avenue, Boston, Massachusetts 02215, USA

Charged (Coulomb) impurities play an important role in the transport characteristics of graphene samples. They can come from the environment, or selectively added through ion beam irradiation. The Coulomb potential for Dirac fermions in 2D is peculiar in many ways. One of them arises from the fact that the 1/r decay is critical, allowing for a bound spectrum with infinitely deep states beyond a certain strength the potential [1]. In this so-called supercritical regime, screening of the Coulomb center by the Dirac fermions is highly non-trivial and not accessible through perturbative methods. Since graphene is characterized by a rather large effective fine structure contant, low valence impurities should, in principle, suffice to attain the supercritical regime. I will discuss some of the effects associated with supercritical impurities and their consequences for transport in graphene. In gapped graphene the phenomenology of a supercritical Coulomb impurity is connected with the long standing QED problem of the charged vacuum for supercritical nuclei [2,3]. The prospects of observing such features in graphene samples will be critically analyzed.

10h30
Mon
3

1. Vitor M. Pereira *et al.*, Phys. Rev. Lett. **99**, 166802 (2007).
2. Vitor M. Pereira *et al.*, Phys. Rev. B **78**, 085101 (2008).
3. Valeri N. Kotov *et al.*, Phys. Rev. B **78**, 075433 (2008).

GRAPHENE DECONSTRUCTED

A. H. Castro Neto[1]

1 Department of Physics, Boston University, 590 Commonwealth Ave., Boston, MA 02215, USA

We will summarize the latest developments in the field of graphene research.

11h20
Mon
4

GENERAL RELATIVITY AND GRAPHENE

M. A. H. Vozmediano[1],F. de Juan[1], A. Cortijo[1]

1 Instituto de Ciencia de Materiales de Madrid,
CSIC, Cantoblanco, E-28049 Madrid, Spain.

The graphene samples used in the experiments show corrugations that can influence the transport properties of the system. The low energy excitations of the system are relativistic Dirac fermions. This fact calls for the possibility of using general relativity techniques to study the influence of the curvature of the background sheet on the electronic properties of the samples. Topological defects in graphene give rise to singular metrics: Disclinations mimic cosmic strings and dislocations introduce torsion in the space, a rare property in general relativity that can result in a feedback for cosmologists. These defects give rise to long range correlated disorder that give rise to non-universal minimal conductivity of the samples.

12h05
Mon
5

1. A. Cortijo and M. A. H. Vozmediano, Nucl. Phys. B **293**, 763 (2007).
2. F. de Juan, A. Cortijo and M. A. H. Vozmediano , Phys. Rev. B **76**, 165409 (2007) .
3. A. Cortijo and M. A. H. Vozmediano, arXiv:0709.2698 (2007).

SPECTRUM OF THE TWO-DIMENSIONAL O(3) NON-LINEAR SIGMA MODEL WITH TOPOLOGICAL COUPLING

Giuseppe Mussardo[1]

1 SISSA, Trieste, Italy

15h00 Mon 6

The O(3) sigma model with topological term is a non-integrable quantum field theory associated to the continuum limit of quantum spin chain. We discuss the spectrum of its excitations and other physical consequences using the Form Factor Perturbation Theory.

STRONG MAGNETIC FIELD COLLECTIVE MODES IN GRAPHENE AND IN A STANDARD 2D ELECTRON GAS

R. Roldán[1], J.-N. Fuchs[1], M.O. Goerbig[1]

1 Laboratoire de Physique des Solides, Univ. Paris-Sud, CNRS, UMR 8502, F-91405 Orsay Cedex, France.

15h45 Mon 7

We consider a graphene layer in a strong perpendicular magnetic field in the integer quantum Hall regime. The particle-hole excitation spectrum is calculated from both the dynamical polarizability as well as from semiclassical methods. We find that the elementary neutral excitations in graphene in a magnetic field are better described in terms of dispersive magneto-zero-sound phonons, instead of the usual magneto-excitons that appear in the two-dimensional electron gas. Including long-range Coulomb interaction, we also study the magneto-plasmon mode and screening within the random phase approximation.

ELECTRON-ELECTRON INTERACTIONS AND DIRAC LIQUID BEHAVIOR IN GRAPHENE BILAYERS

S. Viola Kusminskiy[1], D. K. Campbell[1], A. H. Castro Neto[1]

1 Department of Physics, Boston University, Boston, MA

16h05 Mon 8

We study the effect of electron-electron interactions in the quasiparticle dispersion of a graphene bilayer within the Hartree-Fock-Thomas-Fermi theory. We find that the electronfluid can be described in terms of an effective Lorentz invariant theory with renormalized mass and velocity, the Dirac liquid. We show that the Dirac liquid can quantitatively describe recent cyclotron resonance experiments in this system.

1. S. Viola Kusminskiy, Johan Nilsson, D. K. Campbell and A. H. Castro Neto, Phys. Rev. Lett. **100**, 106805 (2008).
2. S. Viola Kusminskiy, D. K. Campbell and A. H. Castro Neto, preprint at arXiv:0805.0305 (2008).

SPIN DYNAMICS IN A ONE DIMENSIONAL BOSE FERROMAGNET

M. Zvonarev[1], T. Giamarchi[1], V. Cheianov[1]

1 DPMC, University of Geneva, Quai Ernest Ansermet 24, 1211 Geneva, Switzerland

We investigate the propagation of spin excitations in a one dimensional ferromagnetic Bose gas. While the spectrum of longitudinal spin waves in this system is soundlike, the dispersion of transverse spin excitations is quadratic, making a direct application of the Luttinger liquid theory impossible. By using a combination of different analytic methods we derive the large time asymptotic behavior of the spin-spin dynamical correlation function for strong interparticle repulsion. The result has an unusual structure associated with a crossover from the regime of trapped spin wave to an open regime.

16h55 Mon 9

THE EXPANSION OF STRONGLY INTERACTING FERMIONS IN ONE-DIMENSIONAL OPTICAL LATTICES

Fabian Heidrich-Meisner[1], Marcos Rigol[2], Alejandro Muramatsu[3], Adrian E. Feiguin[4], Elbio Dagotto[5]

1 Institut für Theoretische Physik C, RWTH Aachen University, Germany
2 Department of Physics, University of California, Santa Cruz, CA, USA
3 Institut für Theoretische Physik III, Universität Stuttgart, Germany
4 Microsoft Q, University of California, Santa Barbara, CA, USA
5 Materials Science Division, ORNL, and University of Tennessee, Knoxville, TN, USA

Both the recent experimental progress in cold atom gases realizations and developments in computational techniques have fueled interest in nonequilibrium properties of strongly correlated systems. Here we study the expansion of fermions in a one-dimensional lattice after released from a trap. Using the time-dependent density matrix renormalization group method, we analyze properties of the one-particle density matrix as well as the evolution of spin and density correlations [1]. A comparison of particles escaping from a metallic region as compared to a Mott-insulating one shows that memory on the initial state is preserved during the expansion. For instance, in the case of the expansion from a Mott insulating state, the momentum distribution function has a maximum at roughly $\pi/2$. We further address the question to what extent correlation functions measured during the expansion and thus in a genuine nonequilibrium situation resemble those of appropriately chosen reference systems in equilibrium. The main result of our work is that, indeed, such reference systems provide for an excellent approximation to correlation functions of the expanding cloud. We discuss limitations of this mechanism and finally investigate the validity of the reference system description in nonintegrable systems.

17h40 Mon 10

1. Heidrich-Meisner, Rigol, Muramatsu, Feiguin, and Dagotto, Phys. Rev. A **78**, 013620 (2008).

Tuesday, November 11

NEW DIRECTIONS IN VALENCE BOND SOLID ANTIFERROMAGNETS

Daniel P. Arovas[1]

1 Department of Physics, University of California at San Diego, La Jolla CA 92093 USA

Valence bond solid (VBS) quantum antiferromagnets, first discussed by Affleck, Kennedy, Lieb, and Tasaki, have provided a useful paradigm for Haldane gap systems, quantum paramagnets, and matrix/tensor product states. They also provide interesting parallels to the physics of the fractional quantum Hall effect (FQHE). I will briefly review the properties of these states and then discuss several recent developments associated with them, including extensions to 'simplex solids', phase transitions between Néel antiferromagnets and quantum paramagnets each described by VBS states, and fermionic extensions which continuously interpolate between VBS and resonating valence bond (RVB) states, establishing a connection which parallels that between the Laughlin and Pfaffian states of the FQHE.

9h00
Tue
1

1. I. Affleck, T. Kennedy, E. H. Lieb, and H. Tasaki, *Phys. Rev. Lett.* **59**, 799 (1987); *Comm. Math. Phys.* **115**, 477 (1988)
2. D. P. Arovas, A. Auerbach, and F. D. M. Haldane, *Phys. Rev. Lett.* **60**, 531 (1988)
3. D. P. Arovas, *Phys. Rev. B* **77**, 104404 (2008)
4. S. A. Parameswaran, S. L. Sondhi, and D. P. Arovas, `cond-mat/0807.3189`
5. D. P. Arovas, K. Hasebi, X.-L. Qi, and S.-C. Zhang (in preparation, 2008)

SPIN LIQUID STATES IN FRUSTRATED ANTIFERROMAGNETS

L. Balents [1]

1 Kavli Institute of Theoretical Physics, University of California, Santa Barbara, CA

Spin liquids are magnets in which spins are strongly correlated but fluctuating and not ordered. The fluctuations can be sustained by thermal energy, zero point energy, or both, and are generally enhanced by frustration, or competing interactions. I will describe a number of sightings of spin liquid states in magnetic materials of recent interest, and discuss their theoretical interpretation.

9h45
Tue
2

1. G. Chen, and L. Balents, Phys. Rev. B **78**, 094403 (2008).
2. M. Lawler, A. Paramekanti, Y.-B. Kim and L. Balents, arXiv.org:0806.4395 (2008).
3. M. Kohno, O. A. Starykh, and L. Balents, Nature Physics **3**, 790 (2007).
4. D. Bergman, J. Alicea, E. Gull, S. Trebst and L. Balents, Nature Physics **3**, 487 (2007).
5. G. Chen, A. Schnyder, and L. Balents, arXiv:0810.0577 (2008).

JOSEPHSON CURRENT AND SINGLET-DOUBLET PHASE TRANSITIONS OF A QUANTUM DOT JOSEPHSON JUNCTION

C. Karrasch[1]

1 RWTH Aachen, Physiczentrum, 52056 Aachen

10h30 Tue 3

We study the low-energy physics of a quantum dot embedded between two superconductors. The system is modeled as a single Anderson impurity coupled to BCS leads, and the functional and numerical renormalization group frameworks are employed to treat the local Coulomb interaction. We reestablish the picture of a singlet-doublet quantum phase transition occurring if the ratio between the Kondo temperature T_K and the BCS energy gap Δ or, at appropriate T_K/Δ, the phase difference or the impurity energy is varied. Introducing a direct link between the superconductors leads to a phase boundary which depends non-monotonously on the coupling strength t_d, and the system can exhibit re-entrance behavior. We present accurate zero- as well as finite-temperature data for the Josephson current J, particularly settling a dispute raised about its magnitude at $t_d = 0$. For the Aharonov-Bohm situation $t_d \neq 0$, we demonstrate that the Coulomb interaction can cause J to become negative in the singlet phase.

QUANTUM IMPURITIES OUT OF EQUILIBRIUM

Natan Andrei[1]

1 Rutgers University

11h20 Tue 4

We develop an exact non-perturbative framework to compute steady state properties of quantum-impurities connected to leads subject to ?nite bias. We show that the steady-state physics of these systems is captured by non-equilibrium scattering eigenstates de?ned on the in?nite open line with boundary conditions set by the leads (open system limit). Introducing the Scattering Bethe Ansatz (SBA), a generalization of the traditional Bethe Ansatz to open systems, we show how to explicitly construct the fully interacting, current-carrying and entropy producing scattering eigenstates. As examples we derive exact results for the non-equilibrium steady state properties of the Interacting Resonance Level model and the Anderson model and discuss the Kondo effect out of equilibrium.

QUANTUM WIRES COUPLED TO DISSIPATIVE ENVIRONMENTS

M. A. Cazalilla[1]

1 Centro de Fisica de Materiales CSIC-UPV/EHU, Avenida de Tolosa, 72, 20018 San Sebastian

12h05 Tue 5

We study quantum phase transitions in a one dimensional (1D) quantum fluid (such like electrons in an armchair carbon nanotube) coupled to a dissipative environment. In particular, we show that electrostatic coupling of a 1D quantum wire with nearby metallic gate acts like an ohmic environment, which can drive a quantum phase transition where a (fluctuating) 1D Wigner crystal is pinned. The resulting pinned phase exhibits true long range order at zero temperature as well as diffusive plasmon excitations. Other possible physical realizations will be also discussed as well as the consequences for different kinds of physical systems.

[1] M. A. Cazalilla, F. Sols, and F. Guinea, Phys. Rev. Lett 97, 076401 (2006).

METAL-INSULATOR TRANSITIONS IN ONE-DIMENSIONAL ELECTRON SYSTEM WITH NEXT-NEAREST-NEIGHBOR HOPPING

G.I. Japaridze[1]

1 Andronikashvili Institute of Physics, Tbilisi, Georgia

We study the quantum phase transition from an insulator to a metal in the ground state of the half-filled $t - t'$ repulsive Hubbard model, using the continuum-limit bosonization approach and density matrix renormalization group calculations. An effective low-energy Hamiltonian that describes the insulator-metal transition is derived. We find that the gross features of the phase diagram are well-described by the standard theory of commensurate-incommensurate transitions in a wide range of parameters. We also obtain an analytical expression for the insulator-metal transition line line $t'_c(U, t)$. [1]
In the presence of a staggered ionic potential Δ we find, that the gross features of the ground state phase diagram and in particular the behavior of the charge sector can be described by a quantum double-frequency sine-Gordon model with topological term. We have shown that with increasing on-site repulsion, for various values of the parameter t'_c the model shows the following sequences of phase transitions: Band insulator - Ferroelectric Insulator - Mott Insulator; Band Insulator - Nonmagnetic Metal - Ferroelectric Insulator and Non-magnetic Metal - Ferroelectric Insulator. [2]
The magnetic field induced insulator to metal transition in the ground state of the $t - t'$ ionic-Hubbard model is also discussed.

15h00
Tue
6

1. G.I. Japaridze, R.M. Noack, D. Baeriswyl and L. Tincani, Phys. Rev. B **76**, 115118 (2007).
2. G.I. Japaridze, R. Hayn, P. Lombardo and E. Müller-Hartmann, Phys. Rev. B **75**, 245122 (2007).

INTERACTING RESONANT LEVEL COUPLED TO A LUTTINGER LIQUID

Moshe Goldstein[1], Yuval Weiss[1], Richard Berkovits[1]

1 The Minerva Center, Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel

We consider the problem of a single level quantum dot coupled to a one-dimensional Luttinger liquid wire by both a hopping term and interactions. We first discuss the case where the level is connected to the end of the wire. Using bosonization and a Coulomb gas mapping we show that thermodynamic properties of the level, in particular – its occupation, depend on the interactions only through the a single combination – the corresponding Fermi edge singularity exponent [1]. The latter can be calculated exactly for a particular model of the lead using boundary conformal field theory arguments and the Bethe ansatz. However, dynamical properties, such as the level density of states, depend in a different way on each type of interaction. Hence, we can construct different models with the same Fermi edge singularity exponent, which have the same population curve, although it originates from very different level densities of states. The latter may either be regular or show a power-law suppression or enhancement at the Fermi energy. These predictions are verified to a high degree of accuracy using the density matrix renormalization group algorithm to calculate the dot occupation, and classical Monte-Carlo simulations on the corresponding Coulomb-gas model to extract the level density of states. We then turn to the case where the dot is side-coupled to the wire. Using similar methods we show that an exact duality exists between this problem and that of resonant tunneling through a quantum dot connecting the edges of two wires with the inverse Luttinger liquid parameter g. In particular, the transport properties of the two models, both in and out of equilibrium are complementary: when one is conducting the other is insulating, and vice-versa. Using this results, as well as an exact solution by refermionization at $g = 2$ and Monte-Carlo simulations on the Coulomb gas model, we fully characterize the conductance of the system. The latter exhibits an anti-resonance as a function of the level energy, whose width vanishes (so that transport is enhanced) as a power law for low temperatures and source-drain voltages whenever $g > 1$, while it diverges (and transport is suppressed) for $g < 1$.

15h45
Tue
7

1. M. Goldstein, Y. Weiss and R. Berkovits, arXiv:0808.0849 (2008).

UNIVERSAL THEORY OF NONLINEAR LUTTINGER LIQUIDS

Adilet Imambekov[1], Leonid I. Glazman[1]

1 Department of Physics, Yale University, New Haven, Connecticut

16h05 Tue 8

One-dimensional quantum fluids are conventionally described within the Luttinger liquid paradigm: as the principal simplification, a generic spectrum of the constituent particles is replaced by a linear one. Here, we show that keeping the nonlinearity of the generic spectrum introduces a new energy scale $\sim p^2/(2m_*) \ll vp$ into the spectral function $A(p,\omega)$, and changes it near the edge $\omega \approx vp$ drastically. Spectral function $A(p,\omega)$ develops new power-law singularities at energies $\omega = \pm vp \pm p^2/(2m_*)$. Remarkably, the corresponding new exponents for short-ranged interactions depend only on the Luttinger liquid parameter K. We also find the universal crossover of $A(p,\omega)$ to the Luttinger liquid theory predictions valid at energies $\gg p^2/(2m_*)$ away from the edge. The theory developed in this article is applicable to fermionic, bosonic, and spin systems. It can be probed in electron tunneling, cold atoms, and neutron scattering experiments, and provides a stringent test for numerical simulations of quantum dynamics of one-dimensional liquids.

1. Adilet Imambekov and Leonid I. Glazman, arXiv:0806.4779v1.

EXACT QUANTUM CIRCUITS FOR STRONGLY CORRELATED SYSTEMS

J. I. Latorre[1]

1 Department d'Esctructura i Constituents de la Matèria, Diagonal 647, 08028 Barcelona

16h55 Tue 9

We present the exact quantum circuits that build up the dynamics of the quantum Ising model. As a particularly simple instance, the full dynamics of a one-dimensional Quantum Ising model in a transverse field with four spins is shown to be reproduced using a quantum circuit of only six local gates. This opens up the possibility of experimentally producing strongly correlated states, their time evolution at zero time and even thermal superpositions at zero temperature.

1. F. Verstraete, J. I. Cirac and J. I. Latorre, arXiv:0804.1888

TRANSPORT PHENOMENA FOR BOSONS IN Y-JUNCTION AND ITS RELATED SYSTEMS

A. Tokuno[1], M. Oshikawa[2], E. Demler[3]

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2 Institute for Solid State Physics, University of Tokyo, Kashiwa 227-8581, Japan
3 Department of Physics, Harvard University, Massachusetts 02138, MA

Recent, guiding of atoms in a low-dimensionally magnetic trap has been actively studied. It provides an opportunity to study real-time dynamics of quantum many-body systems. In particular, Y-shaped trapped system analogous to three way junction system called Y-junction is important for designing a beam splitter for guided atoms. Indeed, there are experimental efforts for it.[1]

17h40 Tue 10

We study real-time dynamics of one-dimensional Bose liquids in a single Y-junction. [2] According to analysis based on Tomonaga-Luttinger liquid, an excitation packet on the Bose liquid filled in a whole system should experience a negative density reflection: A dip in density is reflected back if a bump in density moves through one of branch to the junction.

In addition, we also extend the discussion on the single-junction problem to that of transport of a packet in a ring-type interferometer that is equivalent to a system combining two Y-junctions symmetrically. We assume existence of (effective) flux contained in the ring. Then, the transport is completely insensitive to the flux in contrast to the Aharonov-Bohm effect of a single particle in the same geometry.

1. D. Cassettari *et al.*, Phys. Rev. Lett. **85**, 5483 (2000).
2. A. Tokuno, M. Oshikawa and E. Demler, Phys. Rev. Lett. **100**, 140402 (2008).

Wednesday, November 12

ASPECTS OF REAL-SPACE RENORMALIZATION GROUP METHODS

F. Verstraete[1]

1 University of Vienna, Boltzmanngasse 5, 1190 Viena

9h00 Wed 1

We will summarize recent progress on real-space renormalization group methods, and highlight their connections with the theory of entanglement.

MULTIPARTICLE INTERFERENCE IN ELECTRONIC MACH-ZEHNDER INTERFEROMETERS

D.L. Kovrizhin[1], J.T. Chalker[1]

1 Oxford University, 1 Keble Road, OX1 3NP Oxford, UK

9h45 Wed 2

I present the results of our theoretical investigation of the recently observed phenomena of voltage dependent current oscillations of the Aharonov-Bohm interference in the electronic Mach-Zehnder interferometer constructed from the two chiral quantum Hall edge states by a group from Weizmann institute [1]. This unexpected behavior was believed to arise because of the interactions, but no clear explanation of this phenomenon was presented so far. We argue that the destructive interference of the paths with different number of particles in the interferometer arms is responsible for this behavior. Using perturbation theory in interactions and the exact solution of the problem we propose our theoretical explanation of this phenomenon.

[1] I. Neder, M. Heiblum, Y. Levinson, D. Mahalu and V. Umansky, "Unexpected Behavior in a Two-Path Electron Interferometer", Phys. Rev. Lett. 96 016804 (2006)

ELECTRON COHERENCE IN A FINITE-LENGTH LUTTINGER LIQUID AND IN AN ELECTRONIC MACH-ZEHNDER INTERFEROMETER

H.-S. Sim[1]

1 Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon 305-701, Korea

10h05 Wed 3

I will discuss two nontrivial effects of electron-electron interactions on electron coherence.
It has been commonly hypothesized that as a particle travels more distance, its coherence decays due to scattering with other particles, and that the decay is characterized by a single coherence length. I will first show [1] that the coherence of an electron does not follow the hypothesis in a one-dimensional quantum wire with finite length. The decay is characterized by multiple coherence lengths, applied from region to region, even though the wire is homogeneous, and the coherence can even revive after the decay. This counterintuitive behavior is due to the interaction-induced fractionalization of electrons [2,3,4] and the finite-size-induced recombination of the fractions.
Second, I will consider an electronic Mach-Zehnder interferometer, recently realized using integer quantum Hall edge states. Recent experiments on it have shown a puzzling lobe structure of interference visibility and phase jumps by π as a function of bias voltage [5]. I will propose a possible origin of the puzzle [6]. The shot noise at the beam splitter of the interferometer generates an ensemble of nonequilibrium electron density configurations and electron interactions induce configuration-specific phase shifts of an interfering electron. The nonequilibrium ensemble average of the resulting interference signals gives rise to the lobe structure and the phase jumps by π.

1. J. U. Kim, W.-R. Lee, H.-W. Lee, and H.-S. Sim, preprint (2008).
2. K.-V. Pham, M. Gabay, P. Lederer, Phys. Rev. B **61**, 16397 (2000).
3. H. Steinberg *et al.*, Nature Phys. **4**, 116 (2008).
4. K. Le Hur, Phys. Rev. Lett. **95**, 076801 (2005).
5. I. Neder et al., Phys. Rev. Lett. **96**, 016804 (2006).
6. S.-C. Youn, H.-W. Lee, and H.-S. Sim, Phys. Rev. Lett. **100**, 196807 (2008).

INTERACTION-INDUCED BEATS OF FRIEDEL OSCILLATIONS IN QUANTUM WIRES

D. F. Urban[1], A. Komnik[2]

1 Physikalisches Institut, Albert-Ludwigs-Universität, Hermann-Herder-Str. 3, D-79104 Freiburg, Germany
2 Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 19, D-69120 Heidelberg, Germany

10h25 Wed 4

We analyze the spectrum of electron density oscillations in an interacting one-dimensional electron system with an impurity. The system's inhomogeneity is characterized by different values of Fermi wave vectors $k_F = k_{L/R}$ on left/right side of the scatterer, leading to a Landauer dipole formation. We demonstrate, that while in the noninteracting system the Friedel oscillations possess only one periodicity related to the local k_F, say k_L on the left side, the interplay of the interactions and the Landauer dipole generates an additional peak in the spectrum of density oscillations at the counterpart k_R. Being only present in correlated systems, the position and shape of this spectral feature, which in coordinate space is observable as a beating pattern in the Friedel oscillations, reveals many important details about the nature of interactions. Thus it has a potential to become an investigation tool in condensed matter physics.

FIDELITY SUSCEPTIBILITY AND QUANTUM PHASE TRANSITIONS

Shi-Jian Gu[1]

1 Department of Physics and Institute of Theoretical Physics, The Chinese University of Hong Kong, Hong Kong, China

Quantum phase transitions of a many-body system at zero temperature are characterized by the change of the ground state properties as model parameter g in the system Hamiltonian H(g) is varied across the transition point gc. This primary observation motivates people to explore the role of fidelity, a concept emerging from quantum information theory, in critical phenomena. Since the fidelity measures the similarity between states, the change of the ground state structure around the quantum critical point should result in a dramatic change in the fidelity across the critical point. In this talk, we will introduce the role of leading term in the fidelity, i.e. the fidelity susceptibility, in the quantum phase transitions occurred in several strongly correlated systems, such as the one-dimensional asymmetric Hubbard model, the Lipkin-Meshkov-Glick Model, the Kitaev honeycomb model, etc. We argue that the fidelity susceptibility can be used to describe the critical phenomena in its own way.

11h15
Wed
5

1. W. L. You, Y. W. Li, and S. J. Gu, Phys. Rev. E **76**, 022101 (2007).
2. S. Chen, L. Wang, S. J. Gu, and Y. Wang, Phys. Rev. E **76** 061108 (2007).
3. S. J. Gu, H. M. Kwok, W. Q. Ning, and H. Q. Lin, arXiv:0706.2495.
4. W. Q. Ning, S. J. Gu, C. Q. Wu, and H. Q. Lin, arXiv:0708.3178.
5. H. M. Kwok, W. Q. Ning, S. J. Gu, and H. Q. Lin, arXiv:0710.2581.
6. S. Yang, S. J. Gu, C. P. Sun, and H. Q. Lin, arXiv:0803.1292.

THE AC CONDUCTANCE AND NON-SYMMETRIZED NOISE AT FINITE FREQUENCY IN QUANTUM WIRES AND CARBON NANOTUBES

Adeline Crépieux[1], Cristina Bena[2,3], Inès Safi[2]

1 Centre de Physique Théorique, Université de la Méditerranée, 163 avenue de Luminy, 13288 Marseille, France
2 Laboratoire de Physique des Solides, Université Paris-Sud
3 Institut de Physique Théorique, CEA/Saclay, CNRS, URA 2306, Orme des Merisiers, F-91191 Gif-sur-Yvette, France

We calculate the AC conductance and the finite-frequency non-symmetrized noise in interacting quantum wires and single-wall carbon nanotubes in the presence of an impurity. We observe a strong asymmetry in the frequency spectrum of the non-symmetrized excess noise, even in the presence of the metallic leads. We find that this asymmetry is proportional to the differential AC conductance of the system [1]. The asymmetry disappears for a linear system (in the absence of interactions). In the quantum regime, for temperatures much smaller than the frequency and the applied voltage, we find that the emission noise is exactly equal to the impurity partition noise. Moreover the noise exhibits oscillations with respect to frequency, whose period is inversely proportional to the value of the interaction parameter g, and whose envelope is given by the noise in an infinite Luttinger liquid with the same value of g.

12h00
Wed
6

1. I. Safi, C. Bena, and A. Crépieux, arXiv:0805.3932.

RELAXATION DYNAMICS OF ISOLATED MANY-BODY SYSTEMS

Marcus Kollar[1]

1 Theoretical Physics III, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

12h20
Wed
7

If an isolated quantum-mechanical many-body system is suddenly forced out of thermal equilibrium, does it relax to a new steady state or does it keep oscillating? How does the final state depend on the initial state? Recently it has become possible to investigate such fundamental questions in experiments with ultracold atomic gases. Here we study two models of interacting fermions, the Falicov-Kimball model in dynamical mean-field theory [1] and a Hubbard chain with long-range hopping [2]. We obtain the exact real-time dynamics after a sudden change of the Hubbard interaction, starting from a metallic or a Mott-insulating initial state. We observe relaxation to a new steady state, showing that the presence of the Mott gap does not inhibit relaxation. The steady-state properties are described by generalized Gibbs ensembles which take all constants of motion into account. We discuss under which conditions such ensembles provide the correct statistical description of integrable systems [2].

1. M. Eckstein and M. Kollar, Phys. Rev. Lett. **100**, 120404 (2008).
2. M. Kollar and M. Eckstein, Phys. Rev. A **78**, 013626 (2008).

Thursday, November 13

GAPPED 1D SYSTEMS IN AN EXTERNAL HARMONIC POTENTIAL

G.V. Shlyapnikov[1]

1 LPTMS, Universite Paris Sud, 91405 Orsay, France

9h00 Thu 1

One-dimensional (1D) gapped systems are characterized by the Dirac spectrum of excitations, where the momentum dependence of energy of low-energy excitations is quadratic: $\hbar\omega = \Delta + \alpha k^2$. This is in particular the case for spin-gapped fermions, for example for a 1D two-component Fermi gas with attractive intercomponent interaction, or a multicomponent Fermi gas with the density-density attraction. We show that in an external harmonic potential, due to a change in the density of states, this spectrum becomes linear: $\hbar\omega = \Delta + \beta n$, where an integer quantum number n represents an analog of the momentum in free space. I will consider two examples, a multicomponent Fermi gas with the density-density attractive interaction and two coupled 1D Bose gases, and discuss possible consequences for dynamics of (isospin) excitations in experiments with 1D quantum gases/.

TRANSITION TOWARDS QUASI-BEC IN A WEAKLY INTERACTING ELONGATED BOSE GAS

I. Bouchoule[1]

1

9h45 Thu 2

A fascinating branch of research in quantum physics deals with low-dimensional systems, which show strikingly new properties as compared to their three-dimensional counterparts. Fluctuations are enhanced and give rise to remarkable features in the collective behaviour of the fluid. Such low dimensional gases are obtained with ultra-cold atoms confined in highly anisotropic traps where one or two degree of freedom is frozen and these experiments stimulated many theoretical developments. In this talk, we will discuss the case of weakly interacting one-dimensional Bose gases. One-dimensional Bose gas do not present Bose-Einstein condensation phenomena. However, in presence of repulsive interactions, a crossover towards a quasi-bec is expected for homogeneous gases. We will first theoretically discuss this crossover in the case of harmonically confined gases and show that the different regimes of the homogeneous gases may also be observed in such a situation. Then, we will present experimental results obtained on an atom chip experiment. In this experiment, a strong magnetic transverse confinement is realised in the vicinity of a current carrying micro-wire. Analysing noise on in-situ absorption images, we measured the atomic density fluctuations. We clearly observed the bosonic bunching effect, that leads to density fluctuations larger than the shot noise level. At larger densities, we observed a saturation of the density fluctuations, characteristic of the quasi-bec regime. Investigating in detail the atomic cloud shapes, we showed that the cross-over towards the quasi-bec regime could not be explained by the Hartree-Fock theory, which neglect correlations between atoms introduced by interactions. This failure, which is in opposition with the previous experiments performed in 3D situations where the Hartree-Fock theory successfully predicts the apparition of the bec, is due to the enhanced fluctuations in 1D gases.

QUANTUM ENTANGLEMENT OF SPIN-1 ATOMS IN AN OPTICAL LATTICE

B. Öztop[1], M. Ö. Oktel[1], Ö. E. Müstecaplıoğlu[2], L. You[3]

1 Physics Department, Bilkent University, Ankara 06800, Turkey
2 Department of Physics, Koç University, Sariyer 34450, Istanbul, Turkey
3 School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332, USA

In this work, we investigate the system of cold spin-1 atoms in a one dimensional optical lattice in relation with squeezing and entanglement. By using the corresponding Bose-Hubbard Hamiltonian, both superfluid and Mott-insulator phases are studied by using numerical methods in the mean-field approximation. To observe the presence of entanglement, we used a squeezing measure as a criterion for quantum correlations. We further investigate the two interaction regimes, namely ferromagnetic and antiferromagnetic in the case of zero and nonzero but very small angle between the counterpropagating laser beams that form the optical lattice.

10h30
Thu
3

COLLECTIVE PROCESSES IN THE ULTRA COLD GAS

J.T. Mendonça [1]

1 IPFN and CFIF, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal

We discuss the basic oscillations and waves of a cloud of ultra-cold atoms confined in a magneto-optical trap [1]. We use both fluid and kinetic descriptions, where repulsive forces between near by atoms are included. We show that hybrid mode, with properties similar to both plasma and acoustic waves, can exist in this medium. We consider Tonks-Dattner resonances for confined hybrid modes in a spherical cloud. The nonlinear coupling between the dipole resonanc and the hybrid modes, is also considered. Landau damping and quasi-linear diffusion in velocity space are discussed. The possible excitation of solitons in a cylindrical configuration, similar to the Trivelpiece-Gould solitons recently considered by us in quantum plasmas [2], is also analysed.

11h20
Thu
4

1. J.T. Mendonça, R. Kaiser, H. Terças and J. Loureiro, *PRA*, **78**, 013408 (2008).
2. H. Terças, J.T. Mendonça and P.K. Shukla, *Phys. Plasmas*, **15**, 072109 (2008).

SINGLE COLD ATOMS FOR QUANTUM OPTICS AND QUANTUM INFORMATION PROCESSING

Jürgen Eschner[1]

1 ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain

Experiments with single cold atoms and single photons have provided milestone contributions to quantum physics. They have demonstrated such fundamental phenomena as quantum measurement, quantum jumps, photon graininess, and entanglement. Through continuous innovation, such effects have now turned into tools which allow for controlling the interaction of single atoms and single photons at the quantum level. One of the most promising applications of such quantum optical tools is quantum information technology. I will highlight the relation between basic quantum phenomena and possible future applications, focusing on experiments with single and few trapped, laser-cooled atomic ions which are manipulated with coherent light sources, and whose light emission is detected at the single-photon level. Starting from an overview of the achievements in the field of single-ion quantum information processing, I will then describe the current research efforts at ICFO towards the realization of building blocks for quantum networks.

12h05
Thu
5

SPONTANEOUS ROTATION IN TRAPPED ONE-DIMENSIONAL BOSE GASES

Masahiro Sato[1], Akiyuki Tokuno[2]

1 Condensed Matter Theory Laboratory, RIKEN, Wako, Saitama 351-0198, Japan
2 Department of Applied Physics, Hokkaido University, Sapporo 060-8628, Japan

15h00 Thu 6

Cold-atoms systems have been intensively studied for more than a decade. Among them, we focus on harmonically-trapped one-dimensional (1D) atomic Bose gases such as ^{7}Li, ^{23}Na, and ^{39}Na. When we apply a 2D harmonic potential to a 3D Bose-gas system, the radial energy spectrum becomes quantized. Then, if almost all atoms enter in the lowest energy level (band), the Bose gas can be regarded as a 1D system. Actually, so far, many theoretical works of 1D cold atoms have been done under this assumption. However, if we control the strength of the 2D potential, the number of atoms, etc, higher-energy levels must be also occupied by the atoms. As a simple system with higher-band atoms, we theoretically consider the situation that in a trapped 1D Bose gas, the lowest and the doubly-degenerate second lowest bands are occupied. For this system, we show that the repulsive interaction between atoms on the second lowest bands and quantum-fluctuation effects cooperatively induce a spontaneous rotation around the trapping axis [1]. In the workshop, we will explain the mechanism of the spontaneous rotation in detail.

1. A. Tokuno and M. Sato, Phys. Rev. A **78**, 13623 (2008).

DYNAMICALLY GENERATED DOUBLE OCCUPANCY AS A PROBE OF COLD ATOM SYSTEMS

S.D. Huber[1], A. Rüegg[1]

1 Theoretische Physik, ETH Zurich, CH-8093 Zürich, Switzerland

15h20 Thu 7

The experimental investigation of quantum phases in optical lattice systems provides major challenges. Recently, dynamical generation of double occupancy via modulation of the hopping amplitude t has been used to characterize the strongly correlated phase of fermionic atoms. Here, we want to validate this experimental technique with a theoretical study of the driven Hubbard model using analytic methods. We find that conclusive evidence for a Mott phase can be inferred from such a measurement, provided that sufficiently low temperatures $k_B T \ll t$ can be reached.

CORRELATIONS AND QUENCHES IN INTEGRABLE SYSTEMS

Jean-Sébastien Caux[1]

1 Institute for Theoretical Physics, Universiteit van Amsterdam, 1018 XE Amsterdam, The Netherlands

15h40 Thu 8

The application of the theory of integrably models to the calculation of dynamical correlation functions of systems such as quantum spin chains and low-dimensional atomic gases has made much progress in recent years. The first part of this talk will review some recent results on Heisenberg spin chains and bosonic atomic gases, and offer some perspectives on possible future developments. The second part of the talk will be concerned with the nonequilibrium dynamics of interacting quantum systems after a sudden change in one of the system's parameters (quench). We will present a new method based on integrability allowing to study such classes of problems. Focusing on the Richardson model, also known as the 'reduced BCS' theory, we exactly quantify the effects of a quench on the physical properties of the system, and discuss some properties of the nonequilibrium state obtained.

QUANTUM SPIN SYSTEMS FAR FROM EQUILIBRIUM

Peter Barmettler[1]

1 University of Fribourg

We study the unitary time evolution of antiferromagnetic order in spin systems that are initially prepared in a pure quantum state far from equilibrium. For the interacting many-body problem our numerical analysis indicates that the order imprinted in the initial state vanishes exponentially. Depending on the anisotropy parameter, oscillatory or non-oscillatory relaxation dynamics is observed. Furthermore, the corresponding relaxation time exhibits a minimum at the critical point, in contrast to the usual notion of critical slowing down, from which a maximum is expected.

16h55 Thu 9

INTERACTION QUENCH IN THE HUBBARD MODEL

Michael Moeckel[1],Stefan Kehrein[1]

1 Department of Physics and Arnold-Sommerfeld-Center for Theoretical Physics, Ludwig-Maximilians-University Munich, Munich, Germany

Motivated by recent experiments in ultracold atomic gases that explore the nonequilibrium dynamics of interacting quantum many-body systems, we investigate the opposite limit of Landau's Fermi liquid paradigm: We study a Hubbard model with a sudden interaction quench, that is the interaction is switched on at time $t = 0$. Using the flow equation method, we are able to study the real time dynamics for weak interaction U in a systematic expansion and find three clearly separated time regimes: i) An initial buildup of correlations where the quasiparticles are formed. ii) An intermediate quasi-steady regime resembling a zero temperature Fermi liquid with a nonequilibrium quasiparticle distribution function. iii) The long time limit described by a quantum Boltzmann equation leading to thermalization of the momentum distribution function with a temperature $T \propto U$.

17h15 Thu 10

1. M. Moeckel and S. Kehrein, Phys. Rev. Lett. **100**, 175702 (2008)

Friday, November 14

QUANTUM HALL HIERARCHY WAVE FUNCTIONS FROM CONFORMAL FIELD THEORY

S. Viefers[1,2], E. Bergholtz[2], H. Hansson[2], M. Hermanns[2], A. Karlhede[2]

1 Department of Physics, University of Stockholm, Sweden
2 Department of Physics, University of Stockholm, Sweden

9h30 Fri 1

It has long been known that Laughlin's wave functions, describing the fractional quantum Hall effect at filling fractions $\nu = 1/(2k+1)$, can be obtained as correlation functions in conformal field theory. We show how to generalize this approach to construct explicit trial wave functions for all states in the quantum Hall hierarchy corresponding to quasiparticle (as opposed to quasihole) condensates, including the recently observed state at $\nu = 4/11$. At the filling fractions $\nu = n/(2np+1)$ this construction exactly reproduces Jain's composite fermion wave functions. An explicit connection is made to Wen's topological classification of FQH states.

1. T.H. Hansson, C.-C. Chang, J.K. Jain, and S. Viefers, Phys.Rev.Lett. **98**, 076801 (2007).
2. T.H. Hansson, C.-C. Chang, J.K. Jain, and S. Viefers, Phys. Rev. **B 76**, 075347 (2007).
3. E.J. Bergholtz, T.H. Hansson, M. Hermanns, A. Karlhede, and S. Viefers, Phys. Rev. **B 77**, 165325 (2008).

CONFORMAL FIELD THEORY APPROACH TO ABELIAN AND NON-ABELIAN QUANTUM HALL QUASIELECTRONS

T. H. Hansson[1], M. Hermanns[1], S. F. Viefers[2]

1 Department of Physics, Stockholm University
2 Department of Physics, Oslo University

10h15 Fri 2

Many prominent Quantum Hall ground state wave functions, as well as their quasihole excitations, can be expressed in terms of rational conformal field theory (RCFT) correlators of operators V and H, describing electrons and quasiholes respectively. Here we present a quasiparticle operator $\mathcal{P}$, which allows for a similar construction of quasielectron excitations. These excitations are obtained by (multiple) insertions of $\mathcal{P}$ in the correlators of any ground state described by a RCFT. In particular this formalism enables us to construct quasielectron wave functions for the non-Abelian Moore-Read Pfaffian state. Moreover, the formalism is powerful enough to allow us to calculate closed expressions for certain hierarchical wave functions; in particular, we can show explicitly that the states in the positive Jain series are hierarchical in nature.

ANOMALOUS QUANTUM HALL EFFECT ON SPHERE

A. Jellal[1]

1 Theoretical Physics Group, Faculty of Sciences, Chouaib Doukkali University, Ibn Machou Road, P.O. Box 20, 24000 El Jadida, Morocco

10h35 Fri 3

We study the anomalous quantum Hall effect exhibited by the relativistic particles living on two-sphere S^2 and submitted to a magnetic monopole. We start by establishing a direct connecion between the Dirac and Landau operators through the PauliSchrodinger Hamiltonian H_s^{SP}. This will be helpful in the sense that the Dirac eigenvalues and eigenfunctions will be easily derived. In analyzing H_s^{SP} s spectrum, we show that there is a composite fermion nature supported by the presence of two efective magnetic fields. For the lowest Landau level, we argue that the basic physics of graphene is similar to that of two-dimensional electron gas, which is in agreement with the planar limit. For the higher Landau levels, we propose a SU(N) wavefunction for diferent filling factors that captures all symmetries. Focusing on the graphene case, i.e. $N = 4$, we give di?erent configurations those allowed to recover some known results.

INTERFEROMETRY IN THE QUANTUM HALL EFFECT

E. Ardonne[1]

1 Nordita, Stockholm, Sweden

11h20 Fri 4

There is ample evidence that the quantum Hall effect observed at filling fraction 5/2 is caused by the formation of the Moore-Read quantum Hall state, which has rather peculiar properties. The most striking property is undoubtedly the non-abelian statistics of the excitations. I will review some of these properties and the recent experiments which confirm the fractional charge e/4 of the excitations. The 'two-state nature' of the Moore-Read state (with four excitations) is the crucial property underlying the non-abelian statistics. It will be shown that this property can be uncovered in by measuring the noise in interferometry experiments.

SPLITTING ELECTRONS INTO QUASIPARTICLES WITH FRACTIONAL EDGE-STATE INTERFEROMETERS

V. V. Ponomarenko[1]

1 Center of Physics, University of Minho, Campus Gualtar, 4710-057 Braga, Portugal

12h05 Fri 5

I will present results of our theoretical study of anyon interference in tunneling between two edges of Quantum Hall liquids (QHL) of different filling factors, $\nu_{0,1} = 1/(2m_{0,1}+1)$, with $m_0 \geq m_1 \geq 0$, through two separate point contacts. In the case of parallel propagation of the edges this set-up is a fractional edge-state version of Mach-Zehnder interferometer [1], while for the antiparallel propagation it is an antidot interferometer. The quasiparticle tunneling models of both interferometers are derived explicitly through the instanton duality transformation of their initial electron models in the limit of strong electron tunneling reached at large voltages or temperatures.

In the Mach-Zehnder interferometer with $m \equiv 1+m_0+m_1 > 1$, the tunneling of quasiparticles of fractional charge e/m leads [2] to non-trivial m-state dynamics of effective flux through the interferometer, which restores the regular "electron" periodicity of the current in flux despite the fractional charge and statistics of quasiparticles. The exact Bethe-ansatz solution available for equal times of propagation between the contacts along the two edges is used to calculate the average tunneling current and to analyze its dependence on the magnetic flux, voltage, and temperature.

Properties of the antidot formed between the antiparallel edges with $m_0 - m_1 \equiv m > 0$ in the strong-tunneling limit are shown [3] to be very different from the $\nu_0 = \nu_1$ case, and include vanishing average total current in the two contacts and quasiparticles of charge e/m. For $m > 1$, as in the Mach-Zehnder case, the quasiparticle tunneling leads to m-state dynamics and restores the regular "electron" periodicity of the current in flux through the anti-dot. In addition, multiple interference in the anti-dot interferometer causes non-perturbative resonant behavior, which is analyzed at low energy.

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AN EXACTLY SOLVABLE PAIRING MODEL WITH P + IP WAVE SYMMETRY

G. Sierra[1]

1

We present the exact Bethe ansatz solution for the two-dimensional BCS pairing Hamiltonian with px + ipy symmetry. From the exact solution we obtain the full phase diagram parameterized by the filling fraction and the coupling constant. It consists of three phases denoted weak coupling BCS, weak pairing and strong pairing. The first two phases are separated by a line where the exact ground state is given by the Moore-Read pfaffian state, while the other two phases are separated by the critical line previously found by Read and Green. We establish a duality relation between the weak and strong pairing phases, whereby low energy states of the weak phase are "dressed" versions of the states of the strong phase by zero energy (Moore-Read) pairs.

15h00
Fri
6

Poster session I

COMPETITION BETWEEN INSTABILITIES IN DOPED GRAPHENE

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The Van Hove singularities in the density of states of graphene can be reached by chemical doping and they have been observed in photoemission measurements [1]. In a recent work [2] some of the authors have been explored the possibility of the existence of a Pomeranchuk instability breaking the lattice point group symmetry and its competition with a ferromagnetic instability [2]. In this work we consider the competition between the Pomeranchuk instability and superconductivity, making emphasis in the order of the transitions between phases and making a possible link to the scenario of a Quantum Critical Point [3].

SI 1

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ELECTRONIC PROPERTIES OF STRONGLY DISORDERED GRAPHENE

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Dirac fermions in a random vector potential are considered as a model for disordered graphene. Within the replica approach to disorder, we compute the electronic properties in the strong-disorder limit. We find a finite density of states at the Dirac point, and a finite minimal conductivity proportional to $g^{-2}(e^{4\pi/g}-1)^{-1}$, where g is the strength of disorder. The role of the chiral symmetry, spontaneous breaking of this symmetry and its relation with diffusion and Anderson localization are addressed in detail.

SI 2

INDUCING ENERGY GAPS IN GRAPHENE MONOLAYER AND BI-LAYER

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In this paper we study the formation of energy gaps in the spectrum of graphene and its bilayer when both these materials are covered with water and ammonia molecules. The energy gaps obtained are within the range 20-30 `meV`, values compatible to those found in experimental studies of graphene bilayer. We further show that the binding energies are large enough for the adsorption of the molecules to be maintained even at room temperature.

SI 3

1. R. M. Ribeiro et al. , Phys. Rev. B **78**, 075442 (2008).

CHARACTERIZATION OF GRAPHENE THROUGH ANISOTROPY OF CONSTANT-ENERGY MAPS IN ANGLE-RESOLVED PHOTOEMISSION

M. Mucha-Kruczynski[1], O. Tsyplyatyev[1], A. Grishin[1], E. McCann[1], Vladimir I. Fal'ko[1], A. Bostwick[2], E. Rotenberg[2]

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SI 4

We show theoretically how constant-energy maps of the angle-resolved photoemission intensity can be used to test wave function symmetry in graphene [1]. For monolayer graphene, we demonstrate that the observed anisotropy of ARPES spectra is a manifestation of what has been recently branded as electronic chirality. For bilayer graphene, we show that the anisotropy of the constant-energy maps may be used to extract information about the magnitude and sign of interlayer coupling parameters and about symmetry breaking inflicted on a bilayer by the underlying substrate.

1. M. Mucha-Kruczynski, O. Tsyplyatyev, A. Grishin, E. McCann, V. I. Fal'ko, A. Bostwick, and E. Rotenberg, Phys. Rev. B **77**, 195403 (2008).

COMPETITION BETWEEN INSTABILITIES IN DOPED GRAPHENEOPTICAL CONDUCTIVITY OF GRAPHENE BEYOND THE DIRAC CONE APPROXIMATION: MAKING THE FINE-STRUCTURE VISIBLE

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SI 5

We compute the optical conductivity of graphene beyond the usual Dirac cone approximation, i.e., we include non-linear corrections to the density of states. The effect of next nearest neighbour hopping is also discussed. Using the full conductivity of clean graphene, we determine the transmissivity and reflectivity of light that is scattered from two media with different permittivity and graphene at the interface. Our results can explain optical experiments in the visible frequency range.

DYNAMICAL CORRELATIONS IN THE SPIN-HALF TWO-CHANNEL KONDO MODEL

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Dynamical correlations of various local operators are studied in the spin-half two-channel Kondo (2CK) model in the presence of channel anisotropy or external magnetic field. A conformal field theory-based scaling approach is used to predict the analytic properties of various spectral functions in the vicinity of the two-channel Kondo fixed point. These analytical results compare well with highly accurate density matrix numerical renormalization group results. The universal cross-over functions interpolating between channel-anisotropy or magnetic field-induced Fermi liquid regimes and the two-channel Kondo, non-Fermi liquid regimes are determined numerically. The boundaries of the real 2CK scaling regime are found to be rather restricted, and to depend both on the type of the perturbation and on the specific operator whose correlation function is studied. In a small magnetic field, a universal resonance is observed in the local fermion's spectral function. The dominant superconducting instability appears in the composite superconducting channel.

SI 6

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APPLICATION OF THE STEREOGRAPHIC PROJECTION FOR THE SIMULATION OF MACROSPIN DYNAMICS

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We consider the use of the stereographic projection [1] for the study of the Landau-Lifshitz-Gilbert (LLG) equation with the Slonczewski spin-transfer torque term to describe the dynamics of the magnetization of a single domain in the framework of a macrospin approximation [2]. The stereographic projection approach, which includes only two variables and no trigonometric functions, allows much faster calculations in comparison to the usual spherical coordinate representation.
Similar to the midpoint integration technique [3] for LLG equation, the proposed method features unconditional preservation of the magnetization vector magnitude and thus does not require any magnetization re-normalizations, to eliminate numerical inaccuracies. We use the stereographic projection to write the LLG equation in an explicit form, which is simpler for program implementation than the implicit midpoint technique.
The calculations performed demonstrate the successful use of the suggested stereographic projection method for the investigation of the dynamics of the macrospin system and the construction of the corresponding magnetization dynamic diagrams.

SI 7

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THE CONDUCTANCE THROUGH LUTTINGER LIQUIDS: TOWARDS EXPERIMENTAL SETUPS

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SI 8

A major experimental challenge in low-dimensional physics is the doubtless confirmation of Luttinger-Liquid(LL)-behaviour in one-dimensional correlated electron systems. A prominent characteristic property of LL-physics is the scaling of a variety of observables as functions of external parameters with exponents controlled by a single parameter, that is the LL-parameter K. In this work we focus on the scaling of the conductance G as function of the temperature. In particular, we extend the investigation of the LL scaling of G from the mostly considered case of 1d leads connected to the end of a 1d quantum wire to 2d leads coupled arbitrarily to a 1d quantum wire, a geometry often used in experiments. We give numeric results for a variety of configurations as well as some analytical insight to the underlying physical mechanisms.

ELECTRON TUNNELING INTO A QUANTUM WIRE IN THE FABRY-PÉROT REGIME

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2 Scuola Normale Superiore and NEST CNR-INFM, I-56126 Pisa, Italy

SI 9

We study a gated quantum wire contacted to source and drain electrodes in the Fabry-Pérot regime. The wire is also coupled to a third terminal (tip) at an arbitrary position along its length. We allow for an asymmetry of the tunneling amplitudes between right/left moving electrons and the tip. The current-voltage characteristics of this three-terminal set-up is shown to exhibit very rich physical effects. We analyze configurations where the tip acts as an electron injector or as a voltage probe. For a non-interacting wire we find that a tip in the voltage-probe configuration affects the source-drain transport in three different ways, namely by suppressing the conductance, by modulating the Fabry-Pérot oscillations, and by reducing the visibility of the latter. The first two effects of the tip are found to vanish if tunneling between tip and wire is completely asymmetric, independent of the tunneling strength. We then take electron-electron interaction in the wire into account by means of the inhomogeneous Luttinger liquid model. In the interacting case the period of Fabry-Pérot oscillations of the conductance as a function of the source-drain bias differs from the one as a function of the gate bias by a factor that allows for an operative read-out of the Luttinger liquid interaction strength. When the tip is in the electron-injection configuration we find that electron-electron coupling does not affect the ratio of the currents flowing to the source and drain electrodes. This ratio depends only on the asymmetry in tunneling. Nevertheless interaction effects are visible as oscillations in the non-linear tip-source and tip-drain conductances. Important differences emerge with respect to the two-terminal set-up: while in a clean wire adiabatically contacted to source and drain electrodes interaction effects are only detectable by high-frequency ac measurements, the presence of a tip in the voltage-probe configuration allows to observe interaction induced oscillations even with dc measurements. We discuss how these effects are modified by non-adiabatic contacts to the source and drain electrodes.

DEPHASING BY ELECTRON-ELECTRON INTERACTIONS IN A BALLISTIC MACH-ZEHNDER INTERFEROMETER

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1 Arnold-Sommerfeld Center for Theoretical Physics
2 Center for NanoScience and Department of Physics, Ludwig-Maximilians Universit"at M"unchen, Munich, Germany

We consider a ballistic Mach-Zehnder interferometer for electrons propagating chirally in one dimension (such as in an integer Quantum Hall effect edge channel). The Mach-Zehnder interferometer has attracted much attention since its first realization at the Weizman institute in the Heiblum group 2003, as only a fraction of the observed features have been explained by now. In such a system, dephasing occurs when the finite range of the interaction potential is taken into account. Using the tools of bosonization, we discuss the decay of coherence as a function of propagation distance and energy. We supplement the exact solution by a semiclassical approach that is physically transparent and is exact at high energies. In particular, we report on the recently predicted universal power-law decay of the coherence at high energies, where the exponent does not depend on the interaction strength.

SI 10

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STUDY OF THE CHARGE CORRELATION FUNCTION IN ONE-DIMENSIONAL HUBBARD HETEROSTRUCTURES

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1 Physikalisches Institut, Universität Bonn , Germany

The understanding of homogeneous interacting one-dimensional quantum systems is based on the well established theory of the Tomonaga and Luttinger (TL) liquid. This theory describes however only the long wavelength, low energy limit of the system. In the laboratory, realizations of such systems are inherently inhomogeneous, and the crossover between different TL regimes can only be captured by numerical methods because the physics of the strong coupling regime has to be described accurately at high and low energies. One of the most powerful methods for treating such low-dimensional strong correlated systems is the density matrix renormalization group method (DMRG), which combines a variational and a real space renormalization group methods. The DMRG method allows for diagonalization of the Hamiltonian of large one-dimensional lattice systems by selecting a sector out of the complete Hilbert space with a size-manageable basis, yet accurate enough to best describe the state of the systems.
In our work we present a characterization of several inhomogeneous systems in terms of the parameter K_ρ, which describes the decay of the density-density correlation function at large distances. We found that under a specific set of parameters values, a Fermi liquid description is recovered. Our results make it possible to optimize appropriate spatial or chemical parameters which is crucial for the experimental realization of such systems, having direct impact on current research.

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HYDRODYNAMIC DESCRIPTION OF THE SPIN CALOGERO-SUTHERLAND MODEL

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SI 12

The Calogero-Sutherland model describes 1-D particles with an inverse-square interaction. It can be extended to include spin degrees of freedom and retains its integrability when an exchange term is introduced with a dependence on the inverse-square of the distance [1]. We provide a hydrodynamic description of the $SU(2)$ model similar to the one derived in [2], in terms of a charge density and velocity and of spin currents. We study its "semi-classical" limit and soliton solutions, starting with its freezing limit, in which the system is known as the Haldane-Shastry model.

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Poster session II

ENTANGLEMENT ENTROPY IN GAUGE THEORIES AND THE HOLOGRAPHIC PRINCIPLE FOR ELECTRIC STRINGS

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We consider quantum entanglement between gauge fields in some region of space A and its complement B. It is argued that the Hilbert space of physical states of gauge theories cannot be decomposed into a direct product $\mathcal{H}_A \otimes \mathcal{H}_B$ of Hilbert spaces of states localized in A and B. The reason is that elementary excitations in gauge theories - electric strings - are associated with closed loops rather than points in space, and there are closed loops which belong both to A and B. Direct product structure and hence the reduction procedure with respect to the fields in B can only be defined if the Hilbert space of physical states is extended by including the states of electric strings which can open on the boundary of A. The positions of string endpoints on this boundary are the additional degrees of freedom which also contribute to the entanglement entropy. We explicitly demonstrate this for the three-dimensional Z_2 lattice gauge theory both numerically and using a simple trial ground state wave function. The entanglement entropy appears to be saturated almost completely by the entropy of string endpoints, thus reminding of a "holographic principle" in quantum gravity and AdS/CFT correspondence.

SII
1

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DISORDERED $SU(2)_K$ SPIN CHAINS REALIZE DOMAIN WALL PERMUTATION SYMMETRIC INFINITE RANDOMNESS FIXED POINTS

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It has been demonstrated that disordered spin chains constructed out of non-abelian anyons are a fertile ground for investigating the existence and nature of infinite randomness renormalization group fixed points.
We study spin chains via the strong randomness renormalization group prescription. This procedure is an asymptotically exact method for solving disordered systems in one dimension. Much work has been done on such systems, culminating in the classification of all known universality classes of such fixed points [1], the so-called Damle-Huse, or permutation symmetric, hierarchy, in which the fixed points are indexed by an integer n. In [1] these fixed points are multi-critical points of certain spin systems, reached by tuning dimerization, randomness, and other unspecified parameters.
In this work we study disordered spin chains constructed out of non-abelian anyons. Building on previous work [2], in which we used $SU(2)_3$, or "Fibonacci", anyons, we completely solve the spin chains based on $SU(2)_k$ anyons for all odd k. We show that these spin chains realize the corresponding Damle-Huse fixed points. We do not need to tune any unspecified parameters in the Hamiltonian to achieve these fixed points.

SII 2

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EXTRACTION OF ENTANGLED STATES IN A 1D XY RING BY LOCAL PROJECTIVE MEASUREMENTS

J. M. Vilaplana[1]

1

SII 3

INTERACTION QUENCH IN THE SINE-GORDON MODEL

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There is a renovate interest in the study of non equilibrium phenomena in the context of quantum systems of many particles. A particular problem of recent interest is that of a sudden quench of the interactions [1,2]. In order to deal with these problems, the flow equation approach has proven to be a very insightful tool to get the real time dynamics of the system [3]. In this work we use the flow equation method to study the effect of a sudden quench of interactions in the Sine-Gordon model, in the weak coupling regime.

SII 4

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ADIABATIC RAMPING OF CORRELATED FERMIONS

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SII 5

We obtain the exact time evolution of the fermionic Falicov-Kimball model during a slow variation of the interaction parameter, using dynamical mean-field theory (DMFT) for nonequilibrium. For this purpose we adapt the DMFT equations which were derived for a sudden interaction quench [1] and solve them numerically. We analyze the dependence of the excitation energy on the ramp speed in the adiabatic limit, and find different power-laws when the system is driven within the insulation phase, within the metallic phase, or between the two phases. Possible reasons for this behavior are discussed.

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COLLECTIVE RESONANCE FLUORESCENCE OF A SYSTEM OF COLD ATOMS IN THE STANDING WAVE CAVITY

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SII 6

The cooperative resonance fluorescence from an ensemble of Λtype three-level atoms dressed by standing wave in resonance with coherent field is discussed. It is analyzed the spatial interference effect of fluorescent field as function of the distance between the radiators and relative position of atoms in the standing wave. Taking in to account the dependence of fluorescent spectrum, the spontaneous emission rate on the intensity of external field and its quantum statistical proprieties, the new control possibilities of cooperative spontaneous emission phenomena are investigated. For large values of laser field intensity, the control of spontaneous emission is possible at two frequencies and atom-atom interaction process. The dependence of cvasi-energeticall levels of the atoms on its position in the standing wave and the equations that describe the cooperative effect between two atoms are obtained.

NONLINEAR DYNAMICS OF ATOMS IN A CAVITY: THE ROLE OF FINITE TEMPERATURE EFFECTS

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SII 7

TOWARDS THE ESTABLISHMENT OF TWO COLD ATOM EXPERIMENTS IN PORTUGAL

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There has been little tradition of cutting edge experimental atomic physics or quantum optics in Portugal. With the express goal of changing this situation, two experimental groups have recently joined efforts to work on developing the necessary knowledge and technical capabilities to undertake experiments on cold quantum gases. The near to medium term goals are to have working systems which will enable us to explore the details of light scattering by cold dense atomic ensembles, to create ultra-cold plasmas, and to begin to study ultra-cold bosonic and fermionic atomic systems in reduced dimensions.

SII 8

LOCAL DENSITY OF STATES OF ELECTRON-SOLID PHASES IN THE QUANTUM HALL REGIME

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Within a self-consistent Hartree-Fock approximation [1] for the two-dimensional electron gas restricted to the second Landau level $N = 2$, we calculate the local density of states (LDOS) of the Wigner and electron-bubble crystals [2], which are believed to be responsible for the re-entrant integer quantum Hall effect [3,4]. We show that at the fixed ratio ν_N/M_e (ν_N is the filling factor of the last partially filled Landau level and M_e is the number of electrons per lattice site), and at the same-index peak (counting from the lowest energy position) of the density of states (DOS), the LDOS at different ν_N yield identical real-space patterns. This ν_N/M_e scaling behavior of the LDOS is observed in our numerical calculations up to the fifth DOS peak. While we cannot resolve with good accuracy the next DOS peaks with higher energy, we believe that this correspondence between LDOS at different filling factors remains true in the entire frequency range, and for any Landau level N (we repeated the same calculations also at $N = 1, 3, 4$). The LDOS calculated in this work may be measured in a scanning tunneling microscopy experiment, and may serve as a direct tool to distinguish between different electron-solid phases.

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CONTEXTUALITY WITHIN QUANTUM MECHANICS IN TERMS OF SUBENSEMBLE STATISTICS

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SII 10

For spin-1/2 particles, we argue that it is a direct consequence of the quantum mechanical analysis that the experimentally verifiable subensemble mean values of a spin variable exhibit dependence on the choice of a commeasurable 'path' observable, while the relevant expectation value pertaining to the whole ensemble remains unchanged. This, in turn, enables inferring the context-dependence of an individual measured value, irrespective of the way an outcome is specified using a hidden-variable(realist) model.

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How to get to Évora from Lisbon

Find below the timetables for the connections Lisbon-Évora and Évora-Lisbon both by bus and train.

By bus:

From the **Lisbon International Airport** you should take a taxi or a bus to the bus station in **Sete Rios**, where you can take a direct bus to Évora. The journey will last approximately 1h.40. While there is no metro at the airport, in case you are elsewhere in Lisbon you may take the metro to the bus station (Jardim Zoológico metro station).

This is the address of the Bus Station:

RNE - Rede Nacional de Expressos, Lda
Terminal Rodoviário de Sete Rios
Praça Marechal Humberto Delgado – Estrada das Laranjeiras
1500-423 LISBOA

In the next two pages you will find departure and arrival timetables to and from Évora.

By train:

From the **Lisbon International Airport** you should take a taxi or a bus to the **Oriente Railway Station**, where you can take an intercity train to Évora. The journey will last approximately 1h.40. In case you are elsewhere in Lisbon you may take the metro to the Oriente Railway Station (Oriente metro station).
Below you will find departure and arrival timetables to and from Évora.

TRAIN: LISBOA ⟶ EVORA

	Service	**Departure**Lisboa - Oriente	**Arrival**Evora	**Duration**	**Price1st/2nd**
1.	IC	8h10	10h07	1h57	13,00 10,00
2.	IC	14h10	16h05	1h55	13,00 10,00
3.	IC	18h10	20h14	2h04	13,00 10,00

TRAIN: EVORA ⟶ LISBOA

	Service	**Departure**Evora	**Arrival**Lisboa - Oriente	**Duration**	**Price1st/2nd**
1.	IC	6h44	8h35	1h51	13,00 10,00
2.	IC	13h44	15h35	1h51	13,00 10,00
3.	IC	18h44	20h36	1h52	13,00 10,00

BUS: LISBOA ⟶ EVORA (131 Kms)

	Departure		Arrival		Price		Frequency
	07:00		08:45		11.50		Except Saturdays and Sundays
	08:00		09:30		11.50		Daily
	08:00		09:45		11.50		Saturdays
	08:30		10:15		11.50		Daily
	09:30		11:00		11.50		Daily
	09:30		12:05		11.50		Sundays
	10:30		12:15		11.50		Daily
	11:45		13:35		11.50		Daily
	12:00		13:30		11.50		Daily
	13:00		14:45		11.50		Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
	13:45		15:15		11.50		Daily
	14:15		16:50		11.50		Daily
	15:00		16:30		11.50		Fridays
	15:00		16:40		11.50		Except Sundays
	15:00		16:45		11.50		Sundays
	16:00		17:45		11.50		Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
	17:00		18:45		11.50		Daily
	17:15		19:00		11.50		Daily
	17:45		19:15		11.50		Daily
	18:00		19:30		11.50		Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
	19:00		20:30		11.50		Sundays
	19:00		20:40		11.50		Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
	19:30		21:00		11.50		Daily
	20:00		21:30		11.50		Sundays
	20:30		22:15		11.50		Daily
	21:30		23:15		11.50		Fridays
	22:00		23:45		11.50		Daily
	22:30		00:00		11.50		Sundays

BUS: EVORA ⟶ LISBOA (131 Kms)

	Departure		Arrival		Price		Frequency
	06:00		07:45		11.50		Daily
	07:00		08:30		11.50		Daily
	07:30		09:00		11.50		Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
	08:00		09:45		11.50		Except Sundays
	08:30		10:00		11.50		Daily
	08:30		11:05		11.50		Daily
	09:45		11:30		11.50		Daily
	10:15		11:45		11.50		Daily
	12:45		14:15		11.50		Daily
	13:00		14:45		11.50		Except Saturdays and Sundays
	14:00		15:30		11.50		Daily
	14:45		16:15		11.50		Daily
	15:00		16:45		11.50		Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
	15:00		16:45		11.50		Saturdays
	16:00		17:30		11.50		Fridays
	16:00		17:45		11.50		Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
	17:30		19:00		11.50		Fridays
	17:30		19:05		11.50		Sundays
	17:30		19:15		11.50		Daily
	18:15		19:45		11.50		Daily
	19:00		20:45		11.50		Daily
	19:30		21:15		11.50		Daily
	20:00		21:45		11.50		Daily
	21:00		22:45		11.50		Mondays, Tuesdays, Wednesdays, Thursdays and Fridays and Sundays
	21:30		23:00		11.50		Sundays

Index