PROGRAM AND ABSTRACT BOOKLET

WORKSHOP ON CORRELATIONS AND COHERENCE IN QUANTUM SYSTEMS

University of Évora, Portugal, 8-12 October 2012

This workshop is dedicated to the memory of Adilet Imambekov and Zlatko Tesanovic, speakers of previous workshops held in Évora.

In Memoriam - Adilet Imambekov (Speaker in the Workshop on Correlations and Coherence in Quantum Matter Évora, Portugal, 10-14 November 2008)

An outstanding young physicist, Adilet Imambekov, passed away on July 18, 2012 on Khan Tengri mountain in Kyrgyzstan. Adilet was only 30. Despite his short career, Adilet's presence in quantum condensed matter and cold atoms communities was prominent. His work had a strong impact on non-equilibrium physics of low-dimensional systems, and was widely recognized by colleagues. One of his recent remarkable contribution is the universal theory of nonlinear Luttinger liquids. Adilet received his B.Sc. degree summa cum laude from Moscow Institute of Physics and Technology in 2002. He did his PhD at Harvard University with Prof. Demler, working on cold atoms and exactly solvable models. Following a two-year postdoc at Yale, Adilet took a position of assistant professor at Rice University in 2009. Adilet was a highly interactive, warm, and genuinely kind person. He was among the key participants of many conferences and workshops, and had many close friends both in physics and in climbing communities.

In Memoriam - Zlatko Tesanovic (Invited speaker in the Workshop on Quantum coherence and correlations in condensed-matter and cold-atom systems, Évora, Portugal, 11-15 October 2010)

Zlatko Tesanovic passed away on July 26, 2012 of an apparent heart attack. A leading theoretical condensed matter physicist, Zlatko's work primarily concerned high temperature superconductors and related materials. In particular, he worked on the theory and phenomenology of iron- and copper-based high temperature superconductors. He also studied the quantum Hall effect, and other manifestations of strong correlations and emergent behavior in quantum many-particle systems. Zlatko leaves behind a wife physicist, Ina Sarceviv (University of Arizona, Tucson), and a daughter, Rachel Sarcevic-Tesanovic, undergraduate student at The Johns Hopkins University. Among his many interests he kept a web page for visitors and interested people called "Zlatko's Best Places to Eat in Baltimore", was eloquent and had a sharp wit and will be missed. Zlatko published more than 125 papers, and received numerous honors and fellowships. He was a leader in his department and worked diligently to attract stellar faculty and students to Johns Hopkins.

The Workshop

The workshop is promoted by several projects and European and Chinese research centers. Our main aim is to generate a lively exchange of ideas between researchers working in the different but nevertheless related fields such as unconventional superconductivity, spin quantum liquids, application of AdS/CFT to condensed matter, ultra-cold atoms, and quantum information.

Workshops in Évora have a long tradition. The beautiful medieval town offers an ideal setting for bringing together people working in different but related fields. In the past, discussions often continued after the last session of the day and sometimes outlasted the closing hours of the bars scattered around the center of town. The month of October is an ideal period for visiting the Alentejo region, where excursions to the surroundings of Évora and its megalithic monuments can be made at moderate temperatures.

Location

The workshop will take place at:

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

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Contacts and Information

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PROGRAM

The lengths of both invited and contributed talks include at least 5 minutes of discussion.

Monday, October 8

9:00 - 9:10 Welcome

9:10 - 9:40 Invited: **Hans-Peter Büchler**
Anomalous behavior of spin systems with dipolar interactions

9:40 - 10:10 Invited: **Marcos Rigol**
Dynamics and description after relaxation of disordered quantum systems after a sudden quench

10:10 - 10:30 Contributed: **Marcus Cramer**
Thermalization under randomized local Hamiltonians

10:30 - 11:00 Coffee break

11:00 - 11:30 Invited:: **Jun-Peng Cao**
Exactly solvable models in the cold atomic systems

11:30 - 12:00 Invited: **Johannes Hecker-Denschlag**
A trapped ionic impurity in a sea of ultracold neutral atoms

12:00 - 12:20 Contributed: **Gergely Szirmai**
Spin liquid phases of alkaline earth atoms at finite temperatures

12:20 Lunch break

15:00 - 15:30 Invited: **Pedro Schlottmann**
Phase separation and FFLO phases in ultra-cold gas of fermionic atoms with attractive potential in a one-dimensional trap

15:30 - 16:00 Invited: **Giovanni Modugno**
Disordered ultracold bosons in one dimension

16:00 - 16:30 Invited: **Masaki Tezuka**
Dynamics of interacting fermions on a bichromatic optical lattice

16:30 - 17:00 Coffee break

17:00 - 17:30 Invited: **Yusuke Nishida**
Efimov effect in quantum magnets

17:30 - 17:45 In memorian by Daniel Arovas
Adilet Imambekov

17:45 - 18:00 In memorian by Pedro Sacramento
Zlatko Tesanovic

Tuesday, October 9

09:00 - 09:30 Invited: **Jorge Dukelsky**
Integrable pairing models in mesoscopic physics

09:30 - 10:00 Invited: **Emil Yuzbashyan**
Quantum integrability in systems with finite number of levels

10:00 - 10:20 Contributed: **Alexandre Faribault**
Decoherence in the central spin model

10:20 - 10:50 Coffee break

10:50-11:20 Invited: **Monique Combescot**
BEC-BCS crossover in an excitonic system

11:20 - 11:40 Contributed: **Pedro Ribeiro**
Superconductivity in nanostructures

11:40 - 12:20 Invited: **Jan Zaanen**
Quantum criticality, superconductivity and the AdS/CFT correspondence

12:20 - 15:00 Lunch break

15:00 - 15:30 Invited: **Nicolas Garcia**
Graphite is a narrow band semiconductor

15:30 - 16:00 Invited: **Pablo Esquinazi**
Evidence for superconductivity at graphite interfaces

16:00 - 16:30 Invited: **Pedro Sacramento**
Anomalous Hall effect in superconductors with spin-orbit interaction

16:30 - 16:50 Coffee break

16:50 - 17:25 Poster presentations (2 minutes each)

17:25 Poster session I

Wednesday, October 10

09:00 - 9:30 Invited: **Amir Caldeira**
Cats, Decoherence and Quantum Measurement

09:30 - 10:00 Invited: **Karlo Penc**
Long-range ordering in SU(3) and SU(4) Heisenberg models

10:00 - 10:30 Invited: **Carlo Di Castro**
Ferronematic order in underdoped cuprates

10:30 - 11:00 Coffee break

11:00 - 11:40 Invited: **Anders Sandvik**
Exploring quantum fluctuations and quantum phase transitions in spin models

11:40 - 12:40 Invited: **Patricia Conde Muiño**
(Multidisciplinary Colloquium): Overview of recent Higgs searches results

12:40 Lunch break

14:30 Bus excursion to megalithic monuments about 6 000 years old.

20:00 Banquet *

Restaurant *Fanatismo*
Praça do Giraldo, 69
7000-872 Évora

* For the young workshop participants who were awarded a grant the banquet will be for free. For the remaining participants, a partial contribution of 7:50 Euros is requested. Please, pick up your banquet ticket at the workshop secretariat.

Thursday, October 11

09:00 - 09:30 Invited: **Henrik Johannesson**
Electrical control of the Kondo effect in a helical edge liquid

09:30 - 10:00 Invited: **Kai Chang**
Quantum transport in topological edge states

10:00 - 10:20 Contributed: **Eduardo V. Castro**
Topological phases driven by electron interactions in certain two-dimensional lattices

10:20 - 10:40 Contributed: **Dmitri Ivanov**
Phase transitions in full counting statistic

10:40 - 11:10 Coffee break

11:10 - 11:30 Contributed: **Edina Szirmai**
Exotic magnetic orders for high spin ultracold fermions

11:30 - 12:00 Invited: **Jian-Qiang You**
Quantum open system in a fermionic bath: A quantum trajectory approach

12:00 - 12:20 Contributed: **Daniel Arovas**
Visibility of the amplitude (Higgs) mode in condensed matter

12:20 - 15:00 Lunch break

15:00 - 15:30 Invited: **André A. Pasa**
Determination of the spin diffusion length in silicon at low temperatures

15:30 - 16:00 Invited: **Chang-Qin Wu**
A quantum entanglement induced effect: Magneto-mobility in organic semiconductors

16:00 - 16:20 Coffee break

16:20 - 16:50 Invited: **Sandro Sorella**
Recent advances in the numerical simulation of the Hubbard model

16:50 - 17:10 Contributed: **Enrico Arrigoni**
Variational cluster approaches for correlated quantum many-body systems out of equilibrium

17:10 - Poster session II

Friday, October 12

09:00 - 09:40 Invited:: **Gora Shlyapnikov**
Novel macroscopic quantum states in dipolar systems

09:40 - 10:00 Contributed: **Nikola Paunkovi**
Fidelity spectrum and characterization of different phases of quantum systems

10:00 - 10:20 Contributed: **Xi Chen**
Shortcuts to adiabaticity: Theory and application

10:20 - 10:40 Contributed: **Fabrizio Illuminati**
Factorization, frustration and entanglement order parameters in complex quantum systems

10:40 - 11:10 Coffee break

11:10 - 11:40 Invited:: **Zhi-Guo Wang**
Artificial acoustic atom and crystal

11:40 - 12:20 Invited: **Paolo Zanardi**
Quantum entanglement for typical and less typical states

12:20 Summary and closing remarks

POSTERS

Poster Session I (9/10/2012) and II (11/10/2012)

	Name	Title
1	Luis Miguel Martelo	Exact solution for a boson-fermion model and application to ultra-cold atoms
2	Michael Tomka	Dynamics of the rotated Dicke model
3	Balazs Hetényi	Current response as a geometric phase: Interpretation of conductivity in projected variational wave functions
4	Yue Ban	Fast and robust spin manipulation in a quantum dot
5	Elena Canovi	DMRG study of transport in quantum dots out of equilibrium
6	Ana Ballestar	Field-effect superconductivity in multigraphene
7	Omar El Araby	Fidelity susceptibility of the reduced BCS Hamiltonian
8	Ling-Feng Zhang	Unconventional vortex states in nanoscale superconductors due to shape-resonated inhomogeneity of the Cooper-pair condensate
9	Hua Bi Zeng	Mean-field properties of the holographic superconductor –
10	Hai-Qing Zhang	On the Holographic Josephson Junction
11	Alexandre Miguel A. Lopes	Itinerant interacting spinless fermions in the AB2 chain
12	Alexander Moreno	Charge and spin fractionalization beyond the Luttinger Liquid paradigm
13	Christina Psadouraki	Magnetic excitations in the spin-1 anisotropic antiferromagnet $NiCl_2$-$4SC(NH_2)_2$
14	Luca Tocchio	Spin-liquid versus spiral-order phases in the anisotropic triangular lattice
15	Dennis Manuel Heim	Concept of tunable qubit based on a molecule of two fractional Josephson vortices
16	Luca Taddia	Estimating quasi-long-range order via Renyi entropies

ABSTRACTS OF THE INVITED AND CONTRIBUTED TALKS

Monday, October 8

ANOMALOUS BEHAVIOR OF SPIN SYSTEMS WITH DIPOLAR INTERACTIONS

H.P. Büchler

Institute for theoretical physics III, University of Stuttgart, Germany

9h10 Mon 1

We study the properties of spin systems realized by cold polar molecules interacting via dipole-dipole interactions in two dimensions. Using a spin wave theory, that allows for the full treatment of the characteristic long-distance tail of the dipolar interaction, we find several anomalous features in the ground state correlations and the spin wave excitation spectrum, which are absent in their counterparts with short-range interaction. The most striking consequence is the existence of true long-range order at finite temperature for a two-dimensional phase with a broken U(1) symmetry.

DYNAMICS AND DESCRIPTION AFTER RELAXATION OF DISORDERED QUANTUM SYSTEMS AFTER A SUDDEN QUENCH

Marcos Rigol

Department of Physics, Georgetown University, Washington, DC 20057, USA, and
Physics Department, The Pennsylvania State University, University Park, Pennsylvania 16802, USA

9h40 Mon 2

After a sudden quench, the dynamics and thermalization of isolated quantum systems are topics that have generated increasing attention in recent years. This is in part motivated be the desire of gaining a deeper understanding of how statistical behavior emerges out of the unitary evolution in isolated quantum systems and in part by novel experiments with ultracold gases. Several studies have found that while unitary dynamics in generic systems lead to thermal behavior of observables after relaxation, the same is not true for integrable systems. The latter need to be described using generalized ensembles, which take into account the existence of relevant sets of conserved quantities. In this talk, we discuss how delocalization-to-localization transitions in integrable [1] and nonintegrable [2] disordered quantum systems change the picture above. We find that the relaxation dynamics, whenever relaxation takes place, is close to power law in those systems. In addition, statistical mechanics descriptions (standard or generalized) break down in the localized regimes. We discuss how this relates to the failure of eigenstate thermalization in the presence of localization.

1. C. Gramsch and M. Rigol, arXiv:1206.3570 (2012).
2. E. Khatami, M. Rigol, A. Relaño, and A. M. García-García, Phys. Rev. E **85**, 050102(R) (2012).

THERMALIZATION UNDER RANDOMIZED LOCAL HAMILTONIANS

M. Cramer[1]

1 Institut für Theoretische Physik, Albert-Einstein Allee 11, Universität Ulm, Germany

Recently, there have been significant new insights concerning conditions under which closed systems equilibrate locally. The question if subsystems thermalize—if the equilibrium state is independent of the initial state—is however much harder to answer in general. In this talk, I will present a setting in which thermalization can be addressed: A quantum quench under a Hamiltonian whose spectrum is fixed and basis is drawn from the Haar measure. If the Fourier transform of the spectral density is small, almost all bases lead to local equilibration to the thermal state with infinite temperature. This allows to show that, under almost all Hamiltonians that are unitarily equivalent to a local Hamiltonian, it takes an algebraically small time for subsystems to thermalize.

10h10
Mon
3

1. M. Cramer, New J. Phys. **14**, 053051 (2012).

EXACTLY SOLVABLE MODELS IN THE COLD ATOMIC SYSTEMS

Y. Jiang[1], L. Yang[2], J. Cao[1,2], H.-Q. Lin[1]

1 Beijing Computational Science Research Center, Beijing, China
2 Institute of Physics, Chinese Academy of Sciences, Beijing, China

In this talk, I present our efforts on study of anisotropic exactly solvable models in the cold atomic systems. Firstly, I will introduce a two-component spin-1/2 exactly solvable model, which has both the anisotropic spin-exchanging and the contact interaction. It is found that the system has a spontaneous magnetization. The critical points from fully polarized state to partially polarized state are obtained analytically in the strong repulsive limit. The elementary excitations and the finite temperature properties are studied. The universal scaling behavior near the critical point of the system is also discussed. Secondly, I will introduce an anisotropic spin-1 solvable model for cold atomic systems. The exact solution of the system is obtained by using the Bethe ansatz method. The ground state phase diagram and the phase transitions are discussed. Thirdly, I will introduce an integrable spin-3/2 fermionic gas model. The system has the $U(1) \otimes SO(4)$ symmetry. The ground state phase diagram and the pairing in the system are discussed. In last part of this presentation, I will introduce an exactly solvable models with spin-orbit coupling.

11h00
Mon
4

1. Y. Jiang, J. Cao, H.-Q. Lin, Exactly solvable anisotropic models in the cold atomic systems, in preparation.
2. L. Yang, J. Cao, H.-Q. Lin, Exactly solvable models with spin-orbit coupling, in preparation.

A SINGLE ION AS A THREE-BODY REACTION CENTER IN AN ULTRACOLD ATOMIC GAS

Johannes Hecker Denschlag

Institut für Quantenmaterie and
Center of Integrated Quantum Science and Technology IQST,
Universität Ulm

11h30
Mon
5

We report on three-body recombination of a single trapped Rb^+ ion and two neutral Rb atoms in an ultracold atom cloud [1]. We observe that the corresponding rate coefficient K_3 depends on collision energy and is about a factor of 1000 larger than for three colliding neutral Rb atoms. In the three-body recombination process large energies up to several 0.1eV are released leading to an ejection of the ion from the atom cloud. It is sympathetically recooled back into the cloud via elastic binary collisions with cold atoms. Further, we find that the final ionic product of the three-body processes is again an atomic Rb^+ ion suggesting that the ion merely acts as a catalyzer, possibly in the formation of deeply bound Rb2 molecules.

1. A. Härter, A. Krükow, A. Brunner, W. Schnitzler, S. Schmid, J. Hecker Denschlag, Phys. Rev. Lett. **109**, 123201 (2012).

SPIN LIQUID PHASES OF ALKALINE EARTH ATOMS AT FINITE TEMPERATURES

P. Sinkovicz[1], A. Zamora[2], E. Szirmai[1], G. Szirmai[1] and M. Lewenstein[1,2]

1 Wigner Research Centre of the Hungarian Academy of Sciences, Budapest
2 ICFO – The Institute of Photonic Sciences, Barcelona

12h00
Mon
6

Mott insulator phases of lattice systems composed of fermions with internal states are characterized by frozen charge dynamics. However, the spin degrees of freedom remain dynamical, and actually they are governed by a Heisenberg like Hamiltonian with antiferromagnetic coupling. It was pointed out that such multicomponent systems in 1 and 2 dimensions and at zero temperature realize states without breaking the spin rotation symmetry when the number of components is large enough [1-3]. The low energy fluctuations on top of these so called spin liquid states are described by various gauge theories whose character depend on the symmetries of the mean-field solution [4]. Therefore high spin, ultracold, fermionic alkaline earth metal atoms loaded into optical lattices can serve as simulators of quantum gauge theories. Since in experiments with ultracold atoms it is a hard task to go to sufficiently low temperatures it becomes important to study the effects of finite temperature. We carry out the stability analysis of the mean-field solution and calculate the free energy at finite temperature to determine the phase diagram relevant for experiments.

1. J. B. Marston, and I. Affleck, Phys. Rev. B **39**, 11538, (1989).
2. M. Hermele, V. Gurarie, and A. M. Rey, Phys. Rev. Lett. **103**, 135301 (2009).
3. G. Szirmai, E. Szirmai, A. Zamora, and M. Lewenstein, Phys. Rev. A 84, 011611 (2011).
4. X.-G. Wen, *Quantum Field Theory of Many-Body Systems* (Oxford University Press, 2004).

PHASE SEPARATION AND FFLO PHASES IN ULTRA-COLD GAS OF FERMIONIC ATOMS WITH ATTRACTIVE POTENTIAL IN A ONE-DIMENSIONAL TRAP*

P. Schlottmann

Department of Physics and NHMFL, Florida State University, Tallahassee, Florida 32306, USA

A gas of ultracold ^{6}Li atoms (effective spin 1/2) confined to an elongated trap with one-dimensional properties is a candidate to display three different phases: (i) fermions bound in Cooper-pair-like states, (ii) unbound spin-polarized particles, and (iii) a mixed phase in which Cooper bound states and unpaired particles coexist.[1] It is of great interest to extend these studies to fermionic atoms with higher spin, e.g., for neutral ^{40}K, ^{43}Ca, ^{87}Sr or ^{173}Yb atoms. We investigated the μ vs. H phase diagram (μ is the chemical potential and H the external magnetic field) for $S = 3/2, \cdots, 9/2$ for the ground state using the exact Bethe *ansatz* solution of the one-dimensional Fermi gas with an attractive δ-function interaction potential.[2] There are $N = 2S + 1$ fundamental states: The particles can be either unpaired or clustered in bound states of two, three, $\cdots$, $2S$ and $2S + 1$ fermions. The rich phase diagram consists of these N states and various mixed phases in which combinations of the fundamental states coexist. Bound states of N fermions are not favorable in high magnetic fields, but always present if the field is low. Possible scenarios for phase separation due to the harmonic confinement along the tube are explored within the local density approximation for $S = 3/2$ and 5/2.
In an array of tubes with weak Josephson tunneling superfluid order may arise.[3] We study the response functions determining the type of superfluid order of the generalized Cooper clusters for $S = 3/2$ and 5/2 using conformal field theory and the exact Bethe *ansatz* solution.[4] The correlation functions consist of a power law with distance times a sinusoidal term oscillating with distance. The wavelength of the oscillations is related to the periodicity of a generalized Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state for higher spin particles. All the relevant states are analyzed for $S = 3/2$ and 5/2.

15h00
Mon
7

*Work done in collaboration with A.A. Zvyagin. The support by the U.S. Department of Energy under grant DE-FG02-98ER45707 is acknowledged.

1. G. Orso, Phys. Rev. Lett. **98**, 070402 (2007).
2. P. Schlottmann and A.A. Zvyagin, Phys. Rev. B **85**, 024535 (2012).
3. K. Yang, Phys. Rev. B **63**, 140511(R) (2001).
4. P. Schlottmann and A.A. Zvyagin, Phys. Rev. B, to appear; Mod. Phys. Lett. B, review article to appear.

DISORDERED BOSONS IN 1D

G. Modugno

LENS and Department of Physics, University of Florence, Italy

I will describe an experimental investigation of the phase diagram of ultracold bosons in 1D disordered (quasiperiodic) lattices. By investigating the correlation function, conductivity and excitation spectrum, we detect two different regimes of a gapless insulator, the Bose glass, which surround a fluid phase. Our measurements reveal the interplay of disorder and interactions in the two limits of weak and strong correlations.

15h30
Mon
8

DYNAMICS OF INTERACTING FERMIONS ON A BICHROMATIC OPTICAL LATTICE

Masaki Tezuka

Department of Physics, Kyoto University, Kyoto, Japan

16h00 Mon 9

We investigate the dynamics around the metal-insulator transition (MIT) in a one-dimensional (1D) Fermi gas with short-range interactions in a quasiperiodic potential, motivated by the experimental realization of such potential in optical lattices. We study the real-time dynamics of interacting spin-1/2 fermions using the numerically exact time-dependent density-matrix renormalization group method. We obtain the time dependence of the width of the particle distribution (mean squared distance) and the number of lattice sites occupied by the particles (inverse participation ratio), close to the boundary of delocalized and localized regions [1] of the ground state phase diagram.

The MIT is not universal because the time evolution, which is described by a process of anomalous diffusion, depends qualitatively on the interaction strength. In the limit of strong interactions theoretical arguments suggest that the critical exponents approach mean-field predictions. We compare the numerically obtained exponents of the time evolution and the localization length with our prediction from scaling ideas [2].

1. M. Tezuka and A. M. García-García, Phys. Rev. A **82**, 043613 (2010).
2. M. Tezuka and A. M. García-García, Phys. Rev. A **85**, 031602(R) (2012).

EFIMOV EFFECT IN QUANTUM MAGNETS

Yusuke Nishida

Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA

17h00 Mon 10

Physics is said to be universal when it emerges regardless of microscopic details. A prominent example is the Efimov effect, i.e., emergence of an infinite tower of three-body bound states obeying discrete scale invariance when particles resonantly interact. Because of its universality and peculiarity, the Efimov effect has been subject to extensive research in chemical, atomic, and nuclear physics for decades. In this talk, after giving a pedagogical introduction to the Efimov effect, I will show that collective excitations in Heisenberg magnets (magnons) also exhibit the Efimov effect by tuning an easy-axis exchange or single-ion anisotropy [1]. I will locate an anisotropy-induced two-magnon resonance, compute binding energies of three magnons, and find that they fit into the universal scaling law. I will also propose several approaches to experimentally realize the Efimov effect in quantum magnets and mention that the emergent Efimov states of magnons can be observed with previously-used spectroscopic measurements. This study thus opens up new avenues for universal few-body physics in solid state systems.

[1] Y. Nishida, Y. Kato, and C. D. Batista, arXiv:1208.6214 [cond-mat.str-el].

Tuesday, October 9

INTEGRABLE PAIRING MODELS IN MESOSCOPIC PHYSICS

J. Dukelsky

Instituto de Estructura de la Materia, CSIC, Serrano 123, 28006 Madrid, Spain

9h00 Tue 1

The exact solution of the SU(2) pairing Hamiltonian with non-degenerate single particle orbits was introduced by Richardson in the early sixties. Although it passed almost unnoticed, it was recovered in the last decade in an effort to describe the disappearance of superconductivity in ultrasmall superconducting grains. Since then it has been extended to several families of integrable pairing models, the Richardson-Gaudin models. However, only rational the family has been widely applied to mesoscopic systems where finite size effects play an important role. We have recently found two complementary implementations of the hyperbolic family in condensed matter and nuclear physics. The first implementation gives rise to a p-wave pairing describing a gas of spinless fermions in a 2D lattice with $p_x + ip_y$ pairing symmetry [1,2]. Using this new tool we study the quantum phase diagram which unlike the case of s-wave pairing displays a third order quantum phase transition. We make use of the exact solution for finite systems as well as mean-field BCS, which we show to be exact in the thermodynamic limit, to characterize the quantum phase transition and to suggest an experimentally accessible characteristic length scale, associated with the size of the Cooper pairs, that diverges at the transition point. The second implementation leads to a separable pairing Hamiltonian with two free parameters that can be adjusted to give an excellent reproduction of the superfluid properties of heavy nuclei as described by the Gogny force in the Hartree-Fock-Bogoliubov (HFB) approximation [3].

1. M. Ibañez, J. Links, G. Sierra, and S-Y Zhao, Phys. Rev. B **79**, 180501 (2009).
2. S. M. A. Rombouts, J. Dukelsky, and G. Ortiz, Phys. Rev. B **82**, 224510 (2010).
3. J. Dukelsky, S. Lerma H., L. M. Robledo, R. Rodriguez-Guzman, and S. M. A. Rombouts, Phys. Rev. C **84** 061301 (2011).

QUANTUM INTEGRABILITY IN SYSTEMS WITH FINITE NUMBER OF LEVELS

Emil Yuzbashyan

Department of Physics and Astronomy, Rutgers University

9h30 Tue 2

We consider the problem of defining quantum integrability in systems with finite number of energy levels starting from commuting matrices. We argue that if the matrices depend on a (real) parameter, one can provide a definition from this feature alone, leading to specific results such as exact solvability, Poissonian energy level statistics and to level crossings.

DECOHERENCE IN THE CENTRAL SPIN MODEL

Alexandre Faribault, Dirk Schuricht

Institute for Theory of Statistical Physics, RWTH Aachen, 52056 Aachen, Germany

In this presentation, I will discuss how one can numerically exploit the quantum integrability of the central spin model in order to study its decoherence properties. The model describes a single spin, coupled to an external magnetic field and interacting with a spin bath via non-homogeneous hyperfine couplings. It finds a direct application in the description of qubits based on the spin of a single electron trapped in a quantum dot, for which, the interaction with the nuclear spins in the substrate dominates the decoherence. The Algebraic Bethe Ansatz (ABA) provides a way to efficiently compute the exact eigenstates of the model which can be used, in conjunction with a simple Monte Carlo sampling, to compute the time evolution of observables. We specifically study the behavior of the coherence factor and describe the full crossover from the perturbative results at strong magnetic fields down to weak external magnetic fields. In that limit, we evidence and explain the appearance, at long times, of a large completely non-decaying coherent fraction.

10h00
Tue
3

BEC-BCS CROSSOVER IN AN EXCITONIC SYSTEM

Monique Combescot

Institut des NanoSciences de Paris, Université Pierre et Marie Curie, CNRS, Campus Boucicaut, 140 rue de Lourmel, 75015 Paris, France

Through a precise study of spin and orbital degrees of freedom of electrons and holes in semicondutor, we first show how rich the exciton gas is. In the dilute regime, electron-hole pairs form excitons which suffer Bose-Einstein condensation in a linearly polarized dark state. In spite of their dark nature which makes them not directly coupled to light , such excitons can be optically trapped by using standing waves - such a trapping can greatly help "seeing" the condensate ! When the density increases, carrier exchange between dark and bright excitons brings a bright component to the condensate above a density threshold which may fall in the phase separation domaine between exciton gas and electron-hole plasma. BCS condensation of "excitonic Cooper pairs" can take place in the dense plasma, making it superfluid - but not superconductor.

10h50
Tue
4

1. Bose-Einstein condensation of excitons: the key role of dark excitons, M. Combescot, O. Betbeder-Matibet, R. Combescot, PRL 99, 176403 (2007).
2. Optical traps for dark excitons, M. Combescot, M. Moore, C. Piermarocchi, PRL 106, 206404 (2011).
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THEORETICAL DESCRIPTION OF SUPERCONDUCTIVITY IN NANO-STRUCTURES AT INTERMEDIATE TEMPERATURES: COMBINED TREATMENT OF COLLECTIVE MODES AND FLUCTUATIONS

Pedro Ribeiro[1], Antonio M. García-García[2]

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11h20
Tue
5

Abstract A rigorous treatment of the combined effect of thermal and quantum fluctuations in a zero dimensional superconductor is considered one of the most relevant and still unsolved problems in the theory of nano-scale superconductors. In this paper we notice that the divergences that plagued previous calculations are avoided by identifying and treating non-perturbatively a low-energy collective mode. In this way we obtain for the first time closed expressions for the partition function and the superconducting order parameter which include both types of fluctuations and are valid at any temperature and to leading order in δ/Δ_0 where δ is the mean level spacing and Δ_0 is the bulk energy gap. Our results paves the way for a quantitative description of superconductivity in nano-structures at finite temperature and pairing in hot nuclei.

QUANTUM CRITICALITY, SUPERCONDUCTIVITY AND THE ADS/CFT CORRESPONDENCE.

J. Zaanen

Instituut Lorentz for Theoretical Physics, Leiden University, Leiden, The Netherlands.

11h40
Tue
6

The understanding of non-Fermi liquids and their habit to turn into superconductors is severely hampered by the inability to describe systems of strongly interactng fermions with the methods of quantum field theory. Remarkably, the AdS/CFT duality of string theory might be the magic bullit. This dualizes the physics of strongly interacting quantum matter into (semi) classical gravitational physics where typically the phenomenological, highly emergent properties of the former are in correspondence with generic properties of special black holes. The highlight is the "AdS2 metal", a non-Fermi-liquid state characterized by local quantum criticality and algebraic pseudogap behavior, dual to a charged black hole [1]. Fermi-liquids are found as instabilities of such metals [2], but also "holographic superconductors" via a mechanism which is a generalization of BCS. This can be tested in the laboratory through a measurement of the pair susceptibility exploiting the second order Jospehson effect [3]. Very recently we discovered that the AdS2 metal reacts in a peculiar way to static periodic potentials [4]: this has a fascinating resemblance to the "nodal-antinodal dichotomy" puzzle in underdoped cuprates.

1] M. Cubrovic, J. Zaanen and K.Schalm, Science **325**, 439 (2009).
[2] M. Cubrovic, Y. Liu, K.Schalm , Y.W, Sun and J. Zaanen, Phys. Rev. D **84**, 086002 (2011).
[3] J.H. She et al., Phys. Rev. B **84**, 144527 (2011).
[4] Y.Liu, K. Schalm, Y.W. Sun and J. Zaanen, arXiv:1205.5227 (2012) .

GRAPHITE IS A NARROW BAND GAP SEMICONDUCTOR

N. García

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Laboratorio e Filmes Fínos e Sperficies, UFSC, Florianópolis, Brazil.

The resistivity of highly oriented pirolitic graphite has many peculiarities depending of the thickness of the position of the electrodes. A same sample can show two different resistivities locating the contacts in different locations of the sample. This resistivity is very low, metallic-like in samples of thickness larger than microns and the concentration of carriers is 1012 carriers/cm2 showing very large values of magnetoresistance. However in our opinion due to large studies these properties are not intrinsic of the graphite perfect ABABAB structure. It is due to mismatched internal interfaces, imperfections and carrier impurities of graphite. We have studied the resistance of a large number of samples of highly oriented pirolitic graphite with areas ranging from mm2 to a few micrometer squared and thickness from around 10nm to a few micrometers were the samples show to be more perfect and free of carrier impurities. The measured resistance increases when the temperature is lowered, not metallic, that is a semiconducting behaviour. This resistance can be explained by the parallel contribution of semiconducting graphite layers with low carrier concentration 109 cm-2 and the one from metalliclike internal interfaces and impurities. The results indicate that ideal graphite with the Bernal structure ABAB is narrow-gap semiconductor with an energy gap of around 40meV.

15h00
Tue
7

This work is done in collaboration with: P Esquinazi, J. Barzola-Quiquia and S. Dusari, University of Leipzig, Germany.

EVIDENCE FOR SUPERCONDUCTIVITY AT GRAPHITE INTERFACES

P. Esquinazi, A. Ballestar, T. Scheike, J. Barzola-Quiquia, W. Böhlmann, A. Setzer

Division of Superconductivity and Magnetism, Institute for Experimental Physics II, University of Leipzig, 04103 Leipzig, Germany

Theoretical studies in the last ten years predict that graphite as well as graphene are good candidates for high-temperature superconductivity. In fact, some reports of the past 38 years suggested its existence in these materials but did not attract the necessary attention or independent verifications were reported. We have studied the transport behavior of ~ 200 nm thick (in the graphene plane direction) lamellas of highly oriented pyrolytic graphite (HOPG). Our results provide evidence for the existence of Josephson-coupled quasi-two dimensional superconducting regions located at internal interfaces of the oriented graphite sample. Measurements of the temperature dependence of the voltage V, $I(V)$-characteristic curves and of the critical Josephson current indicate that superconductivity should exist above 150 K. Furthermore, we show reproducible evidence for granular superconductivity in powders of several tens of micrometers small graphite grains after treatment with pure water.

15h30
Tue
8

ANOMALOUS HALL EFFECT IN SUPERCONDUCTORS WITH SPIN-ORBIT INTERACTION

P. D. Sacramento

Departamento de Física and CFIF, Instituto Superior Técnico, TU Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

16h00
Tue
9

We calculate the anomalous Hall conductance of superconductors with spin-orbit interaction and with either uniform or local magnetization. In the first case we consider a uniform ferromagnetic ordering in a spin triplet superconductor, while in the second case we consider a conventional s-wave spin singlet superconductor with a magnetic impurity (or a diluted set of magnetic impurities). In the latter case we show that the anomalous Hall conductance can be used to track the quantum phase transition, that occurs when the spin coupling between the impurity and electronic spin density exceeds a certain critical value. In both cases we find that for large spin-orbit coupling the superconductivity is destroyed.

Wednesday, October 10

CATS, DECOHERENCE AND QUANTUM MEASUREMENT

A. O. Caldeira

Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas, 13083-859, Campinas, SP, Brazil

9h00 Wed 1

In this talk it is our intention to review the basic ideas of how entanglement relates to the so-called Schrödinger cat state and present a paradigmatic situation where states very similar to that one can be created. The example we have chosen is the SQUID ring which depending on the external bias allows us to implement a wealth of interesting physical situations to be treated. We shall argue that in these situations the question of dissipation is really relevant and the concept of decoherence naturally arises. Once we have accomplished that we discuss some possible implications of decoherence to the quantum theory of measurement . As a matter of fact, we shall employ an alternative measure of quantum correlation which goes beyond entanglement - the quantum discord - with the same purpose. We finally present very recent experimental results performed with twin photons which corroborate our predictions.

LONG RANGE ORDERING IN SU(3) AND SU(4) HEISENBERG MODELS

B. Bauer[1], P. Corboz[1], A. M. Läuchli[2], F. Mila[3], L. Messio[3],K. Penc[4], A. Tóth[5], M. Troyer[1]

1 Theoretische Physik, ETH Zürich, Zürich, Switzerland

2 Institut für Theoretische Physik, Universität Innsbruck, Innsbruck, Austria

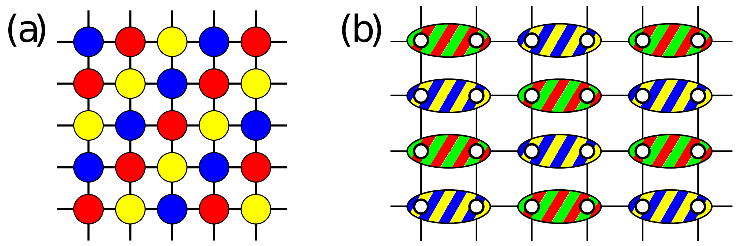
3 Institute of Theoretical Physics, EPFL, Lausanne, Switzerland

4 Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary

5 Department of Physics, University of Toronto, Toronto, Canada

9h30 Wed 2

We discuss the quantum fluctuation driven ordering in the SU(3) and SU(4) Heisenberg models on triangular and square lattices. In the case of the SU(3) symmetric model on the square lattice, a three sublattice stripe like long-range order develops from a classically degenerate manifold [1,3]. The SU(4) model undergoes a spontaneous dimerization on the square lattice, and since the ground state of a dimer is not a singlet for SU(4) but a 6-dimensional irrep, this leaves the door open for further symmetry breaking. We provide evidence that, unlike in SU(4) ladders, where dimers pair up to form singlet plaquettes, here the SU(4) symmetry is additionally broken, leading to a gapless spectrum in spite of the broken translational symmetry [2,3]. The results are achieved by a combination of analytical and numerical methods.



1. T. A. Tóth, A. M. Läuchli, F. Mila, and K. Penc, Phys. Rev. Lett **105**, 265301 (2010).
2. P. Corboz, A. M. Läuchli, K. Penc, M. Troyer, F. Mila, Phys. Rev. Lett. **107**, 215301 (2011).
3. B. Bauer, P. Corboz, A. M. Läuchli, L. Messio, K. Penc, M. Troyer, F. Mila, Phys. Rev. B **85**, 125116 (2012).

FERRONEMATIC ORDER IN UNDERDOPED CUPRATES

G. Seibold[1], C. Di Castro[2], M. Capati[2], M. Grilli[2] and J. Lorenzana[2].

1. Institut für Physik, BTU Cottbus, PBox 101344, 03013 Cottbus, Germany
2. ISC-CNR, CNISM and Dipartimento di Fisica, Università di Roma "La Sapienza", P.le Aldo Moro 5, I-00185 Roma, Italy

We study a model for underdoped cuprates where doped holes aggregate into oriented stripe segments which have a spin vortex and antivortex fixed to the extremes. Within the extended Hubbard model we find that the orientation of the segments is governed by the ratio between the nearest and the next-nearest hopping and the length is limited by the long-range Coulomb interaction. The interaction between segments stabilizes a state with macroscopic polarization, which we call a ferronematic. The resulting state can be characterized as a charge nematic that due to the net polarization breaks inversion symmetry and also exhibits an incommensurate spin modulation. Our calculations reproduce the doping dependent incommensurate response in the spin channel of lanthanum cuprates at low doping and allow rationalizing experiments in which the incommensurability has an order parameter like temperature dependence. The dipolar segments are also seeds which lead to smectic correlations (stripes) in some cuprates and, by branching, to more compact structures (droplets, checkerboard . . .).

10h00
Wed
3

EXPLORING QUANTUM FLUCTUATIONS AND QUANTUM PHASE TRANSITIONS IN SPIN MODELS

Anders W. Sandvik

Department of Physics, Boston University, Boston, Massachusetts, USA

I will discuss quantum Monte Carlo simulations of spin models and show how results can be directly related to quantum field theories [1]. One example, which I will focus on here, is the quantum phase transition between a Néel antiferromagnet and a non-magnetic valence-bond-solid (VBS) state in two dimensions. Here simulations of a square-lattice J-Q model (the Heisenberg antiferromagnet with additional multi-spin interactions) with standard SU(2) S=1/2 spins can be generalized to SU(N) symmetry, which allows for direct comparisons with large-N expansion results for the non-compact CP(N-1) theory proposed to describe the "deconfined" quantum-critical point [2] separating the Neel and VBS states.

11h00
Wed
4

1. A recent review article on this topic is: R. K. Kaul, R. G. Melko, and A. W. Sandvik, arXiv:1204.5405 (to appear in Annual Review of Condensed Matter Physics).
2. T. Senthil, A. Vishwanath, L. Balents, S. Sachdev, and M. P. A. Fisher, Science **303**, 1490 (2004).

LATEST RESULTS ON HIGGS SEARCHES

P. Conde Muíño[1]

1 Laboratório de Instrumentacão e Física Experimental de Partículas Lisboa, Portugal

11h40 Wed 5

The Standard Model of Particle Physics (SM) is a very successful theory. It was able to predict several phenomena, like the existence of new particles, that were later on measured precisely. There are, however, missing pieces in the theory that could not yet be answered. One of those questions is the origin of the mass of the fundamental particles, explained through the spontaneous break up of the Electroweak Symmetry. This mechanism leads to the existence of a new particle, the so-called Higgs boson, proposed by the first time in 1964. Searches for the Higgs boson have been performed exhaustively at the Large Electron-Positron Collider (LEP) at CERN, at the Tevatron proton-antiproton collider in Fermilab and at the Large Hadron Collider (LHC), also at CERN. On the 4th of July this year CERN announced the discovery of a new boson in the searches for the Standard Model Higgs boson by the two LHC experiments, ATLAS and CMS.

In this presentation I will give an overview of the Higgs mechanims and the experimental results on the Higgs searches, focusing on the discovery of the new particle at CERN. I will discuss what is know about the nature of this particle and the future perspectives on the understanding of the Electroweak Symmetry breaking mechanism.

Thursday, October 11

ELECTRICAL CONTROL OF THE KONDO EFFECT IN A HELICAL EDGE LIQUID

Henrik Johannesson

Department of Physics, University of Gothenburg, Sweden

9h00 Thu 1

Magnetic impurities affect transport properties of the helical edge states of quantum spin Hall insulators by allowing single-electron backscattering. In this talk I will discuss recent work done in collaboration with E. Eriksson, A Ström, and G. Sharma where we have studied such a system in the presence of a Rashba spin-orbit interaction induced by an external electric field. As I will show, the Kondo temperature, as well as the impurity correction to the dc conductance, can be controlled by properly tuning the Rashba interaction via a gate.

1. E. Eriksson, A. Ström, G. Sharma, and H. Johannesson, arXiv:1207.3028.

DRIVING CONVENTIONAL SEMICONDUCTORS INTO TOPOLOGICAL INSULATING PHASE

Kai Chang

SKLSM, Institute of Semiconductors, Chinese Academy of Sciences,Beijing, China

9h30 Thu 2

All-electrical manipulation of electron spin in solids becomes a central issue of quantum information processing and quantum computing. The many previous proposals are based on spin-orbit interactions in semiconductors, unfortunately, the spin-orbit interactions in conventional semiconductors are quite weak. Topological insulator (TI), a strong spin-orbit coupling system, make it possible to control the spin transport electrically. Recent calculations proved that external electric fields can drive a HgTe quantum well from normal band insulator phase to topological insulator phase and controll the transport of the edge states. [1,2,3] The helical feature of the surface and/or edge states will lead to a twisted RKKY interaction which can be controlled by tuning the gate voltages[4]. The quantum states in TI quantum dots display very different features against the conventional semiconductor quantum dots[5].
Very recently, we propose a new method to drive conventional semiconductors into topological insulating phase. Utilizing strong electric field at the heterostructure interface, we find the GaN/InN/GaN quantum wells can be driven into the inverted band case, and the helical edge states can be found in a quantum spin Hall bar.[6]

1. W. Yang, Kai Chang, and S. C. Zhang, Phys. Rev. Lett. **100**, 056602 (2008); J. Li and Kai Chang, Appl. Phys. Lett. **95**, 222110 (2009).
2. L. B. Zhang, Kai Chang, X. C. Xie, H. Buhmann and L. W. Molenkamp, New J. Phys. **12**, 083058 (2010).
3. L. B. Zhang, F. Cheng, F. Zhai and Kai Chang, Phys. Rev. B **83** 081402(R) (2011); Z. H. Wu, F. Zhai, F. M. Peeters, H. Q. Xu and Kai Chang, Phys, Rev. Lett. **106**, 176802 (2011).
4. J. J. Zhu, D. X. Yao, S. C. Zhang, and Kai Chang, Phys. Rev. Lett. **106**, 097201 (2011).
5. Kai Chang, and Wen-Kai Lou, Phys. Rev. Lett. **106**, 206802 (2011).
6. M. S. Miao, Q. Yan, Van de Walle, L. Li, W. K. Lou and Kai Chang, ArXiv/condmat 1205.2912.

TOPOLOGICAL PHASES DRIVEN BY ELECTRON INTERACTIONS IN CERTAIN TWO-DIMENSIONAL LATTICES

Eduardo V. Castro

CFIF and Department of Physics, Instituto Superior Técnico, TU Lisbon, Portugal

The interplay between electron correlations and non-trivial band topology in fermionic systems will be discussed here from two complementary points of view. Taken the example of a spinless model in the honeycomb lattice, we will show how non-trivial topological phases can be stabilised through short range Coulomb repulsion between electrons [1]. Using a variational mean field approach and an enlarged unit cell we obtain a very rich phase diagram as doping and interaction strength are varied, where both topological insulating phases and topological Fermi liquids appear. In a complementary approach, we take several non-interacting models on the square lattice which have a non-zero topological Chern number that can be changed by varying the ratio of hopping parameters. A topologically non-trivial insulator is then realised if there is one fermion per site. We will show that, when interactions in the framework of the Hubbard model are introduced, the effective hopping parameters are renormalised and the system's topological number can change at a certain interaction strength smaller than that for the Mott transition [2].

10h00
Thu
3

1. Eduardo V. Castro, Adolfo G. Grushin, Belén Valenzuela, María A. H. Vozmediano, Alberto Cortijo, Fernando de Juan, Phys. Rev. Lett. **107**, 106402 (2011).
2. Miguel A. N. Araújo, Eduardo V. Castro, Pedro D. Sacramento, arXiv:1208.1289 [cond-mat.str-el] (2012).

PHASE TRANSITIONS IN FULL COUNTING STATISTICS

D. A. Ivanov[1,2]

1 Institute for Theoretical Physics, ETH Zürich, 8093 Zürich, Switzerland
2 Institute for Theoretical Physics, University of Zürich, 8057 Zürich, Switzerland

We propose to describe correlations in classical and quantum systems in terms of full counting statistics (FCS) of a suitably chosen discrete observable. Thermodynamic phases may be characterized by analytical properties of the extensive part of the FCS. We illustrate our construction with three examples: the classical Ising chain, the spin-1/2 XY chain, and free fermions in one dimension. In the last example, we conjecture an asymptotic expansion for the FCS, which generalizes the Fisher-Hartwig conjecture for Toeplitz determinants. This expansion also determines finite-size corrections to the entanglement entropy.

10h20
Thu
4

1. D. A. Ivanov and A. G. Abanov, arXiv:1203.6325 (2012).
2. D. A. Ivanov, A. G. Abanov, and V. V. Cheianov, arXiv:1112.2530 (2011).
3. R. Süsstrunk and D. A. Ivanov, in preparation (2012).

EXOTIC MAGNETIC ORDERS FOR HIGH SPIN ULTRACOLD FERMIONS

E. Szirmai[1], M. Lewenstein[2,3]

1 Department of Theoretical Physics, "BME-MTA Exotic Quantum Phases - Lendulet Research Group" Institute of Physics, BUTE, Budafoki ut 8, H-1111, Budapest, Hungary "

2 ICFO-Institut de Ciències Fotòniques, Mediterranean Technology Park, E-08860 Castelldefels (Barcelona), Spain

3 ICREA-Institució Catalana de Recerca i Estudis Avançats, Lluis Companys 23, E-08010 Barcelona, Spain

11h10
Thu
5

We study Hubbard models for ultracold bosonic or fermionic atoms loaded into an optical lattice. The atoms carry a high spin $F > 1/2$, and interact on site via strong repulsive Van der Waals forces. Making convenient rearrangements of the interaction terms, and exploiting their symmetry properties, we derive low energy effective models with nearest-neighbor interactions, and their properties. We apply our method to $F = 3/2$, and $5/2$ fermions on two-dimensional square lattice at quarter, and $1/6$ fillings, respectively, and investigate mean-field equations for repulsive couplings. We find for $F = 3/2$ fermions that the plaquette state appearing in the highly symmetric SU(4) case does not require fine tuning, and is stable in an extended region of the phase diagram. This phase competes with an SU(2) flux state, that is always suppressed for repulsive interactions in absence of external magnetic field. The SU(2) flux state has, however, lower energy than the plaquette phase, and stabilizes in the presence of weak applied magnetic field. For $F = 5/2$ fermions a similar SU(2) plaquette phase is found to be the ground state without external magnetic field.

1. E. Szirmai and M. Lewenstein, Europhysics Letters **93**, 66005 (2011).

PROBING THE QUANTUM BEHAVIOR OF A NANOMECHANICAL RESONATOR COUPLED TO A DOUBLE QUANTUM DOT

Jian-Qiang You

Department of Physics, Fudan University, Shanghai 200433, China
and Beijing Computational Science Research Center, Beijing 100084, China

11h30
Thu
6

We propose a current correlation spectrum approach [1] to probe the quantum behavior of a nanomechanical resonator (NAMR). The NAMR is coupled to a double quantum dot (DQD), which acts as a quantum transducer and is further coupled to a quantum-point contact (QPC). By measuring the current correlation spectrum of the QPC, shifts in the DQD energy levels, which depend on the phonon occupation in the NAMR, are determined. Thus quantum behaviors of the NAMR could be observed. In particular, the cooling of the NAMR into the quantum regime could be examined. In addition, the effects of the coupling strength between the DQD and the NAMR on these energy shifts are studied. We also investigate the impacts on the current correlation spectrum of the QPC due to the backaction from the charge detector on the DQD.

1. Z. Z. Li, S. H. Ouyang, C. H. Lam and J. Q. You, Phys. Rev. B **85**, 235420 (2012).

VISIBILITY OF THE AMPLITUDE (HIGGS) MODE IN CONDENSED MATTER

Daniel Arovas

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

The amplitude mode is a ubiquitous collective excitation in condensed-matter systems with broken continuous symmetry. It is expected in antiferromagnets, short coherence length superconductors, charge density waves, and lattice Bose condensates. Its detection is a valuable test of the corresponding field theory, and its mass gap measures the proximity to a quantum critical point. However, since the amplitude mode can decay into low-energy Goldstone modes, its experimental visibility has been questioned. Here we show that the visibility depends on the symmetry of the measured susceptibility. The longitudinal susceptibility diverges at low frequency as Im $\chi_{\sigma\sigma} \sim \omega^{-1}$ (d = 2) or $\log(1/|\omega|)$ (d = 3), which can completely obscure the amplitude peak. In contrast, the scalar susceptibility is suppressed by four extra powers of frequency, exposing the amplitude peak throughout the ordered phase. We discuss experimental setups for measuring the scalar susceptibility. The conductivity of the $O(2)$ theory (relativistic superfluid) is a scalar response and therefore exhibits suppressed absorption below the Higgs mass threshold, $\sigma \sim \omega^{2d+1}$. In layered, short coherence length superconductors, (relevant, e. g., to cuprates) this threshold is raised by the interlayer plasma frequency.

12h00 Thu 7

DETERMINATION OF THE SPIN DIFFUSION LENGTH IN SILICON AT LOW TEMPERATURES

Andre Avelino Pasa

1 Departamento de Física Universidade Federal de Santa Catarina Florianopolis, Brazil.

A brief review on measuring the spin diffusion length on semiconductors will be addressed. However, the presentation will be focused on results obtained in n-type silicon substrates and spin polarized currents injected from ferromagnetic contacts through a tunnel barrier. The magnetoresistance of nanofabricated Ni/alumina/Si contacts was used to determine the spin diffusion length, when measured as a function of temperature and gap between contacts. The results are shown between 11 and 30 K. For temperatures above this upper limit no magnetoresistance effect was observed for the range of contact distances used (100 to 1500 nm). By fitting the data with an exponential, the diffusion condition, as a function of the gap, where the magnetoresistance takes place, we deduced the values of spin diffusion length and spin lifetime. The reduction of magnetoresistance at 30 K is consistent with the theory for spin injection from a metal to a semiconductor. This is more evident when measuring the resistances at different currents and voltages. The magnetoresistance increases when the currents or fields are increased.

15h00 Thu 8

A QUANTUM ENTANGLEMENT INDUCED EFFECT: MAGNETO-MOBILITY IN ORGANIC SEMICONDUCTORS

Wei Si, Yao Yao, Xiao-Yuan Hou, Chang-Qin Wu

Department of Physics, Fudan University, Shanghai 200433, China

15h30 Thu 9

Different from their inorganic counterparts, a basic characteristic of carriers' transport in organic semiconductors is the incoherent hopping of charge carriers between molecules. In the meantime, the motion of their spins is coherent. Based on the peculiar transport property, we proved the carriers hopping rate is modulated by the entanglement of carriers' spin with hydrogen nuclei in organic molecules. The entanglement is altered by applied magnetic field, which leads to the magneto-mobility in organic semiconductors.

Independent of model parameters, the calculated magneto-mobility $\Delta\mu/\mu$ shows a Lorenzian-shape saturation at large magnetic field together with a sign change at ultra-small field, that should be viewed as the criterion set by experiments[1]. The magnitude of $\Delta\mu/\mu$ as well as the values of $B_{1/2}$ (the half width at the half-maximum) and B_m (the magnetic field at which the magneto-mobility reaches its minimum) depend on the mobility μ. Of course, they are also changed if more hydrogen nuclei are included, while its basic feature is unchanged. The obtained isotopic effect by replacing the protons of spin 1/2 with the deuterons of spin 1 is surprisingly consistent with the experiment[1]. An anomalous response of current to minority carrier's mobility in the space charge limited current regime is believed to cause the observed positive magnetoresistance[2]. With the magneto-mobility, we have reached a comprehensive understanding of the magnetic field effects in various organic devices[3].

1. T. D. Nguyen, *et al.*, Nature Materials **9**, 345 (2010); Phys. Rev. Lett. **105**, 166804 (2010).
2. J. D. Bergeson, *et al.*, Phys. Rev. Lett. **100**, 067201 (2008); F. L. Bloom, *et al.*, Phys. Rev. Lett. **103**, 066601 (2009)
3. Wei Si, *et. al.*, to be published.

RECENT ADVANCES IN THE NUMERICAL SIMULATION OF THE HUBBARD MODEL

S. Sorella[1,2,3], S. Yunoki[3,4,5], Y. Otsuka[3]

1 SISSA – International School for Advanced Studies, Via Bonomea 265, 34136 Trieste, Italy,
2 Democritos Simulation Center, CNR – IOM Instituto Officina dei Materiali, 34151 Trieste, Italy,
3 Computational Materials Science Research Team, RIKEN AICS, Kobe, Hyogo 650-0047, Japan,
4 Computational Condensed Matter Physics Laboratory, RIKEN ASI, Saitama 351-0198, Japan, and
5 CREST, Japan Science and Technology (JST), Kawaguchi, Saitama 332-0012, Japan

16h20 Thu 10

In the last few years an enormous progress in computer performances and a significative advance in computational techniques, especially based on quantum Monte Carlo[1], are opening a new frontier for the solution of fundamental problems in the physics of strongly correlated systems, that has been lacking for too many decades. We report recent calculations for the Hubbard model on the honeycomb lattice at half filling, for cluster sizes containing up to 2500 sites, much larger than previous simulations[2], ruling out possible spin liquid phases. Moreover, with an efficient algorithm able to accelerate the convergence to ground state properties before the sign problem becomes prohibitive, we are able to draw a reliable diagram of the possible homogeneous phases of the square lattice Hubbard model in the moderate correlation regime.

1. S. Sorella, Phys. Rev. B **84**, 241110(R) (2011).
2. S. Sorella, Y. Otsuka and S. Yunoki in preparation.

CLUSTER APPROACHES TO QUANTUM PHASE TRANSITION AND NON-EQUILIBRIUM PROPERTIES OF STRONGLY CORRELATED QUANTUM-MANY-BODY SYSTEMS

W. von der Linden[1], E. Arrigoni[1], M. Knap[1,2], M. Nuss[1]

1 Institute of Theoretical and Computational Physics, Graz University of Technology, Austria
2 Department of Physics, Harvard University, USA

16h50 Thu 11

We show, how cluster perturbation theory and its extension, the Variational Cluster Approach, can be generalized to symmetry broken states and to non-equilibrium properties. Applications will be presented for the quantum phase transition in the Bose-Hubbard and the Jaynes-Cummings model [1,2]. As far as non-equilibrium properties are concerned, results will be discussed for transport properties of the single-site Anderson impurity model imbedded into conducting leads [3-5] as well as transport trough a benzene ring. In the latter case we also study the impact of phonons and external magnetic fields.

1. M. Knap, E. Arrigoni, and W. von der Linden, Phys. Rev. **B 83**, 134507 (2011)
2. S. Ejima, H. Fehske, F. Gebhard, K. zu Münster, M. Knap, E. Arrigoni, and W. von der Linden, Phys. Rev. **A 85**, 053644 (2012)
3. M. Knap, W. von der Linden, and E. Arrigoni, Phys. Rev. **B 84**, 115145 (2011)
4. M. Nuss, E. Arrigoni, M. Aichhorn, and W. von der Linden, Phys. Rev. **B 85**, 235107 (2012)
5. M. Nuss, C. Heil, M. Ganahl, M. Knap, H.G. Evertz, E. Arrigoni, and W. von der Linden, arXiv:1207.5641 (2012)

Friday, October 12

NOVEL MACROSCOPIC QUANTUM STATES IN DIPOLAR SYSTEMS

Gora Shlyapnikov

Van der Waals-Zeeman Institute, University of Amsterdam, Valckenierstraat 65/67, NL-1018 XE Amsterdam, The Netherlands

I will discuss novel superfluid phases in two-dimensional systems of fermionic dipoles, which can be field-alligned polar molecules or atoms with a large magnetic moment. It will be shown that the description of the topological $p_x + ip_y$ phase that emerges for microwave-dressed polar molecules, requires to go beyond the standard approach of a weakly interacting gas. This is related to the long-range character of the dipole-dipole interaction and strongly enhances the superfluid transition temperature. The same happens in the case of interlayer superfluids in bilayer systems of dipoles. I then discuss prospects for realization of other interesting states in dipolar systems.

9h00
Fri
1

FIDELITY SPECTRUM AND CHARACTERIZATION OF DIFFERENT PHASES OF QUANTUM SYSTEMS

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We present a brief overview of the use of quantum fidelity in the study of phase transitions [1], with a special emphysis to the fidelity-induced metric, and its connection to geometric Berry and Uhlmann phases [2]. We also establish the relation between the fidelity susceptibility and thermodynamical susceptibility associated to a given phase transition [2]. We study in more detail the logarithmic spectrum of the operator whose trace defines the quantum fidelity between two density operators [3]. We denote it by the fidelity spectrum, and study in the cases of the XX spin chain in a magnetic field, a magnetic impurity inserted in a conventional superconductor and a bulk superconductor at finite temperature. When the density operators are equal, the fidelity spectrum reduces to the entanglement spectrum, establishing a connection between the two information-theoretic approaches to quantum phase transitions: the fidelity and the entanglement spectrum approaches. We find that the fidelity spectrum can be a useful tool in giving a detailed characterization of different phases of many-body quantum systems.

9h40
Fri
2

1. P. Zanardi and N. Paunković, Phys. Rev. E **74**, 031123 (2006).
2. N. Paunković and V.R. Vieira, Phys. Rev. E **77**, 011129 (2008).
3. P.D. Sacramento, N. Paunković and V.R. Vieira, Phys. Rev. A **84**, 062318 (2011).

SHORTCUTS TO ADIABATICITY: THEORY AND APPLICATION

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10h10 Fri 3

By definition, quantum adiabatic process means a slow process which allows the state to follow the instantaneous eigenstates of time-dependent Hamiltonian. For some reasons, for example, to avoid the decoherence effects, or to implement large-scale quantum information processing, one may want to speed up the adiabatic process, that is, to achieve the adiabatic-like control but in very short time. In this talk, we first introduce the recently proposed techniques of shortcuts to adiabaticity, including quantum transitionless driving and invarian-based inverse engineering. Moreover, we present new methods to speed-up manipulations of cold atoms in a harmonic trap: fast expansion and transport. In both cases, the final atomic state is the same as in the adiabatic process, but the state is achieved with fidelity one in arbitrarily short time, keeping the same populations of vibrational levels in the initial and final trap. Besides, we present shortcuts to adiabatic passage for population transfer in two-level and three-level quantum systems. The talk ends up with a discussion of other results and applications.

1. X. Chen, A. Ruschhaupt, S. Schmidt, A. del Campo, D. Guéry-Odelin, and J. G. Muga, Phys. Rev. Lett. **104**, 063002 (2010).
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3. S. Ibáñez, X. Chen, E. Torrontegui, A. Ruschhaupt, and J. G. Muga, Phys. Rev. Lett. **109**, 100403 (2012).

FACTORIZATION, FRUSTRATION, AND ENTANGLEMENT ORDER PARAMETERS IN COMPLEX QUANTUM SYSTEMS

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10h30 Fri 4

We will report on current progress in the application of tools of entanglement theory to quantum many-body systems. We will first review the general theory of ground-state factorization points [1]. Next, we will consider the interplay between classical and quantum frustration, and we will introduce universal lower bounds relating frustration to ground-state entanglement [2] and factorization [3]. Finally, we will discuss the relevant role played by frustration and factorization concerning the behaviour of the Rényi entanglement entropies S_n in quantum many-body systems. In particular, we will show that violation of monotonic scaling for $n > 2$ implies the existence of entanglement-driven phase transitions that are independent of symmetry breaking and cannot be detected by local order parameters [4]. A hierarchy of nonlocal entanglement order parameters will be identified, and their possible application to systems with spin-liquid ground states and hidden topological order will be briefly outlined.

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2. S. M. Giampaolo, G. Gualdi, A. Monras, and F. Illuminati, Phys. Rev. Lett. **107**, 260602 (2011).
3. S. M. Giampaolo, G. Adesso, and F. Illuminati, Phys. Rev. Lett. **104**, 207202 (2010).
4. S. M. Giampaolo, S. Montangero, F. Dell'Anno, S. De Siena, and F. Illuminati, arXiv:1208.0735 (2012).

ARTIFICIAL ACOUSTIC ATOM AND CRYSTAL

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Quantum interference in atomic systems has led to several fascinating and extraordinary effects because of its destructive and constructive effects between different excitation pathways of the excited states. In this talk, we propose a coupled-Helmholtz-resonator structure to design an acoustic three-level V-type "atom" and mimic quantum interference behaviors in atomic systems, and using these atoms as basic units we design new types of acoustic metamaterial which exhibit negative effective density or negative effective modulus in a wide frequency range. We analytically explore the analogy between a single Helmholtz resonator and a two-level atom. An acoustic three-level atom is constructed by using two coupled Helmholtz resonators, which presents the specific transmission spectra resulting from interference effects between different resonance pathways, experiments in the audible regime is in good agreement with our theoretical predictions[1]. Along this idea, we fabricated an acoustic composite structure consisting of a periodic array of interspaced membranes and side holes which exhibit both negative effective density and negative effective modulus in a wide frequency range[2]. Experimental data on the transmission, effective density, and phase velocity are presented. The system exhibits two critical frequencies, ω_{SH} and ω_c. Our metamaterial is double negative and transparent for frequencies lower than ω_{SH}. For the frequencies $\omega_{SH} \leq \omega \leq \omega_c$, the medium is opaque and only the density is negative. For the frequencies above ω_c, the system is double positive and transparent. The present medium exhibits a very wide double negative spectral range that opens the possibility of the application of metamaterials for "white lights".

11h20 Fri 5

1. W. Tan, C. Z. Yang, H. S. Liu, Z. G. Wang, H. Q. Lin and H. Chen, EPL,**97**, 24003 (2012).
2. S. Lee, C. M. Park, Y. M. Seo, Z. G. Wang, C. K. Kim, Phys. Rev. Lett. **104**, 054301 (2010) .

QUANTUM ENTANGLEMENT FOR TYPICAL AND LESS TYPICAL STATES

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1 Department of Physics and Astronomy, University of Southern California, Los Angeles USA

Most states in the Hilbert space are maximally entangled. This fact has proven useful to investigate - among other things - the foundations of statistical mechanics. Unfortunately, most states in the Hilbert space of a quantum many body system are not physically accessible. I will discuss how one can build ensembles of physically accessible states and study their typical properties by quantum information theoretic ideas and tools. Emphasis will be given to area laws and their violations.

11h50 Fri 6

ABSTRACTS OF THE POSTER PRESENTATIONS

Poster sessions

EXACT SOLUTION FOR A BOSON-FERMION MODEL AND APPLICATION TO ULTRA-COLD ATOMS

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PS 1

The progress on ultra-cold atoms experiments allowing to tune fermionic systems through a Freshbach resonance where itinerant fermionic atoms may form tightly bound pairs ("bosonic" molecules) [1,2]; has lead to a renewed theoretical interest in boson-fermion models. We study a 1D boson fermion resonance model describing itinerant spin-1/2 fermions and itinerant scalar bosons coupled through a local interaction which describes the binding of a pair of opposite spin fermions to form a scalar boson, and the reverse process. The model also includes a detuning term characterized by a detuning parameter ν. It is found that the model has an exact solution by Bethe Ansatz. We find that the model supports fermion bound pairs. For sufficiently large values of ν the ground state consists of purely unbound fermions forming a Fermi liquid. As one decreases the detuning parameter the system goes through a Feshbach resonance and the ground state becomes unstable with respect to the formation of bound fermion pairs. In this case unbound fermions and bound fermions pairs coexist. The BCS-BEC scenario will also be discussed.

1. M. W. Zwierlein, C. A. Stan, C. H. Schunck, S. M. F. Raupach, S. Gupta, Z. Hadzibabic, and W. Ketterle, Phys. Rev. Lett. **91**, 250401 (2003)
2. C. A. Regal, M. Greiner, and D. S. Jin, Phys. Rev. Lett. **92**, 040403 (2004) .

DYNAMICS OF THE ROTATED DICKE MODEL

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1 Physics Department, University of Fribourg, Chemin du Musée 3, 1700 Fribourg, Switzerland

PS 2

We study the quantum dynamics of a rotationally driven Dicke model where the collective spin is rotated around the z axis. In the absence of the rotating wave approximation we observe that depending on the choice of the initial quantum state the position of the quantum critical point is shifted by the amount given by the applied rotation velocity. This allows us to probe the quantum criticality of the Dicke model "from a distance", without actual crossing of the surface of quantum criticality but instead by encircling it in a parameter space. Moreover, for the coherent initial state we observe interesting reentrant behavior of quantum critical behavior and construct a non-equilibrium phase diagram of the rotated model.

CURRENT RESPONSE AS A GEOMETRIC PHASE: INTERPRETATION OF CONDUCTIVITY IN PROJECTED VARIATIONAL WAVE-FUNCTIONS

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Using the total position shift operator the current response of a system with periodic boundary conditions is expressed in terms of a geometric phase. The resulting expression is similar to the result of the modern theory of polarization, except that while the latter is written as a Berry phase depending on the crystal momentum, the current response is a phase parametrized by the total position of the charge carriers. The resulting expressions are then used to interpret conductivity in the case of projected wavefunctions: in particular it is demonstrated that the conductivity properties of the Gutzwiller and Baeriswyl projected wave functions, as well as combinations thereof are determined by the Fermi sea for the former, and the large U limit (unprojected wave functions) for the latter. The difference between the superfluid and Drude weights will also be addressed, and it will be argued that the Gutzwiller wave function exhibits a finite superfluid weight proportional to the kinetic energy.

PS 3

1. J. Phys. A: Math. and Theor. **42**, 412003 (2009).
2. J. Phys. Soc. Japan **81** 023701(2012).
3. arXiv.org:1208.0671.

FAST AND ROBUST SPIN MANIPULATION IN A QUANTUM DOT

Yue Ban[1], Xi Chen[1,2], E. Ya Sherman[1,3] and J. G. Muga[1,2]

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Coherent spin manipulation in quantum dots is the key element in the state-of-the-art technology of spintronics. We apply an invariant-based inverse engineering method [1] to control the electron spin by time-dependent electric fields in a quantum dot with spin-orbit coupling and a weak magnetic field. The designed electric fields provide a shortcut to adiabaticity [1-3] that rapidly flips the spin, in the time duration that can be much shorter than the decoherence time. This approach, being robust with respect to the environmental noise and the device-dependent noise, can open new possibilities for the spin-based quantum information processing.

PS 4

1. X. Chen, E. Torrontegui, and J. G. Muga, Phys. Rev. A **83**, 062116 (2011).
2. M. Demirplak and S. A. Rice, J. Phys. Chem. A **107**, 9937 (2003); J. Phys. Chem. B **109**, 6838 (2005); J. Chem. Phys. **129**, 154111 (2008).
3. M. V. Berry, J. Phys. A **42**, 365303 (2009).

DMRG STUDY OF TRANSPORT IN QUANTUM DOTS OUT OF EQUILIBRIUM

E. Canovi

University of Stuttgart

PS 5

We study electrical transport in quantum dots (QD) out of equilibrium by means of the Density Matrix Renormalization Group (DMRG). This method allows to go beyond linear response theory, i.e. to deal with a finite bias, and to handle large interactions. We concentrate on charge fluctuations in QDs and study the interacting resonant level model (IRLM) which describes spinless fermions. We first study the one-impurity case. We benchmark the correctness of our code against known results and then switch to the case of two impurities, for which we show some our results.

FIELD EFFECT SUPERCONDUCTIVITY IN MULTIGRAPHENE

A. Ballestar[1], S. Dusari[1], J. Barzola-Quiquia[1], P. Esquinazi[1], R. da Silva[2] and Y. Kopelevich[2]

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PS 6

We have studied the temperature and magnetic field dependence of the electrical resistivity of mesoscopic tens of nanometers thick multigraphene samples as a function of bias voltage applied perpendicular to the graphene planes. We found that the resistivity changes asymmetrically with the bias voltage. For large and negative bias voltages the resistivity shows non-percolative superconducting-like transitions at ~ 15 to 20K while for positive bias voltage no remarkable effect is observed. The transition can be suppressed at high enough magnetic fields applied normal or parallel to the main plain of the samples. We discuss the obtained results in terms of electric field induced superconductivity at localized near surface regions of the graphite sample.

FIDELITY SUSCEPTIBILITY OF THE REDUCED BCS HAMILTONIAN

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The fidelity susceptibility has been widely used for quantum phase transitions, and more recently it has also been proposed in the context of crossover phenomena. The BCS-BEC crossover has been characterized by this quantity using mean-field theory[1], whereas both BCS-BEC and
nite size crossovers have been treated in this way using the exact solution of the reduced BCS Hamiltonian[2]. We have calculated the fidelity susceptibility for the Richardson model (with non-degenerate and equally spaced energy levels) to address the question to what extent the BCS solution for the grand canonical ensemble matches the exact solution for a fixed number of particles. A technique introduced recently[3,4] allows us to study the ground state of relatively large systems (up to 2000 to 3000 energy levels). We find that the fidelity susceptibility increase with the number of levels N is extremely slow for N > 1000, where finite size corrections appear to be very small. The comparison with the thermodynamic limit of the BCS solution shows a rather large discrepancy, especially for large couplings (i.e., in the BEC regime). We are currently using analytical techniques for interpreting our numerical results. We hope to gain new insight into the old problem of determining the exact ground state of the reduced BCS Hamiltonian in the thermodynamic limit. PS 7

1. A. Khan and P. Pieri, Phys. Rev. A **80**, 012303 (2009).
2. B. Gut, Ph. D. thesis, Fribourg 2009, unpublished.
3. A. Faribault, O. El Araby, C. Strater and V. Gritsev, Phys. Rev. B **83**, 235124 (2011).
4. O. El Araby, V. Gritsev, A. Faribault, Phys. Rev. B **85**, 115130 (2012).

UNCONVENTIONAL VORTEX STATES IN NANOSCALE SUPERCONDUCTORS DUE TO SHAPE-RESONATED INHOMOGENEITY OF THE COOPER-PAIR CONDENSATE

L.-F. Zhang[1], L. Covaci[1], M. V. Milošević[1], G .R. Berdiyorov[1], F. M. Peeters[1]

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Vortex matter in mesoscopic superconductors is known to be strongly affected by the geometry of the sample. However, in nanoscale superconductors with coherence length comparable to the Fermi wavelength the shape resonances of the order parameter results in an additional contribution to the quantum topological confinement - leading to unconventional vortex configurations[1]. Our Bogoliubov-de Gennes calculations in a square geometry reveal a plethora of asymmetric, giant multi-vortex, and vortex-antivortex structures, which are very different from those predicted by the Ginzburg-Landau theory. These unconventional states are relevant for high-T_c nanograins, confined Bose-Einstein condensates, and graphene flakes with proximity-induced superconductivity. PS 8

1. L.-F. Zhang, L. Covaci, M. V. Milošević, G. R. Berdiyorov, and F. M. Peeters, Phys. Rev. Lett. **109**, 107001 (2012).

PROPERTIES OF THE HOLOGRAPHIC SUPERCONDUCTOR

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PS 9

The AdS/CFT correspondence has been used to study superconductors, the called holographic superconductor. There is a critical temperature, below which a charged condensate forms via a second order phase transition and the (DC) conductivity becomes infinite. The frequency dependent conductivity develops a gap determined by the condensate. [1]It also have some properties that agree with G-L theory,like the mean-field critical exponents at T_c, vortex solution under magnetic field and so on.[2]

1. S. A. Hartnoll, C. P. Herzog and G. T. Horowitz, "Building a Holographic Superconductor," Phys. Rev. Lett. **101**, 031601 (2008) [arXiv:0803.3295 [hep-th]]..

2. H. Zeng, Z. Fan, H. S. Zong, " d-wave Holographic Superconductor Vortex Lattice and Non-Abelian Holographic Superconductor Droplet," [arXiv:1007.4151 [hep-th]].

ON THE HOLOGRAPHIC JOSEPHSON JUNCTION

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PS 10

I will talk about the recent applications of Anti-de Sitter(AdS)/Conformal Field Theory(CFT) correspondence in the condensed matter physics, in particular for the holographic Josephson junctions. By tuning the chemical potential properly, one can actually realize this kind of holographic Josephson junctions. I will show that we can indeed get the famous sine relations for the current and the phase difference across the junction.

1. G. T. Horowitz, J. E. Santos and B. Way, Phys. Rev. Lett. **106**, 221601 (2011) [arXiv:1101.3326 [hep-th]].
2. Y. -Q. Wang, Y. -X. Liu, R. -G. Cai, S. Takeuchi and H. -Q. Zhang, JHEP **1209**, 058 (2012) [arXiv:1205.4406 [hep-th]].

ITINERANT INTERACTING SPINLESS FERMIONS IN THE AB2 CHAIN

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We study spinless fermions in a flux threaded AB_2 chain taking into account nearest-neighbor Coulomb interactions. The exact diagonalization of the spinless AB_2 chain is presented in the limiting cases of infinite or zero nearest-neighbor Coulomb repulsion for any filling. Without interactions, the AB_2 chain has a flat band even in the presence of magnetic flux. We show that the respective localized states can be written in the most compact form as standing waves in one or two consecutive plaquettes. We show that this result is easily generalized to other frustrated lattices such as the Lieb lattice. A restricted Hartree-Fock study of the V/t versus filling phase diagram of the AB_2 chain has also been carried out. The validity of the mean-field approach is discussed taking into account the exact results in the case of infinite repulsion. The ground-state energy as a function of filling and interaction V is determined using the mean-field approach and exactly for infinite or zero V. In the strong-coupling limit, two kinds of localized states occur: one-particle localized states due to geometry and two-particle localized states due to interaction and geometry. These localized fermions create open boundary regions for itinerant carriers. At filling $\rho = 2/9$ and in order to avoid the existence of itinerant fermions with positive kinetic energy, phase separation occurs between a high-density phase ($\rho = 2/3$) and a low-density phase ($\rho = 2/9$) leading to a metal-insulator transition. The ground-state energy reflects such phase separation by becoming linear on filling above 2/9. We argue that for filling near or larger than 2/9, the spectrum of the t-V AB_2 chain can be viewed as a mix of the spectra of Luttinger liquids (LL) with different fillings, boundary conditions, and LL velocities. PS 11

1. A. A. Lopes, R. G. Dias, Phys. Rev. B **84**, 085124 (2011).

CHARGE AND SPIN FRACTIONALIZATION BEYOND THE LUTTINGER LIQUID PARADIGM

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We find different kind of charge and spin fractional excitations in the Luttinger Liquid (LL) phase of the one-dimensional t-J model [1,2] that go beyond of the already known spin-charge separation and of the chiral-charge fractionalization predicted at low energies by the LL theory [3]. Depending on the interaction constant J and on the electronic density n two main regimes are identified: one regime where $v_s > v_c$ and another where $v_s < v_c$, where $v_{c(s)}$ is the charge(spin) velocity. At low energies, i.e
PS 12
for $k \sim k_F$, complete spin-charge separation is present in both regimes as it is expected from the LL theory [4]. For $v_s > v_c$ and $k > k_F$ the spinon starts to carry a fraction of charge that increases with k while the holon still continues carrying only charge. For $v_s < v_c$ and $k > k_F$ the role of the spin a charge degrees of freedom is reversed and now the holon carries a fraction of spin that increases with k while the spinon still continues carrying almost no charge. These results are an evidence that the usual low energy picture of pure-spin and pure-charge separation cannot be held anymore at high energies.

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MAGNETIC EXCITATIONS IN THE SPIN-1 ANISOTROPIC ANTIFERROMAGNET NICL$_2$-4SC(NH$_2$)$_2$ [1]

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PS 13

The spin-1 anisotropic antiferromagnet $NiCl_2$-4SC$(NH_2)_2$ exhibits a field-induced quantum phase transition that is formally analogous to Bose-Einstein condensation. Here we present results of systematic high-field electron spin resonance (ESR) experimental and theoretical studies of this compound with a special emphasis on single-ion two-magnon bound states. In order to clarify some remaining discrepancies between theory and experiment, the frequency-field dependence of magnetic excitations in this material is reanalyzed. In particular, a more comprehensive interpretation of the experimental signature of single-ion two-magnon bound states is shown to be fully consistent with theoretical results. We also clarify the structure of the ESR spectrum in the so-called intermediate phase.

1. C. Psaroudaki et al. Phys Rev B 85 , 014412 (2012).

SPIN-LIQUID VERSUS SPIRAL-ORDER PHASES IN THE ANISOTROPIC TRIANGULAR LATTICE

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We study the competition between magnetic and spin-liquid phases in the Hubbard model on the anisotropic triangular lattice, which is described by two hopping parameters t and t' in different spatial directions and is relevant for layered organic charge-transfer salts [1]. By using a variational approach that includes spiral magnetic order, we provide solid evidence that a spin-liquid phase is stabilized in the strongly-correlated regime and close to the isotropic limit $t'/t = 1$. Otherwise, a magnetically ordered spiral state is found, connecting the (collinear) N and the (coplanar) 120^o phases. The pitch vector of the spiral phase obtained from the unrestricted Hartree-Fock approximation is substantially renormalized in presence of electronic correlations, and the N phase is stabilized in a wide regime of the phase diagram, i.e., for $t'/t < 0.75$. We discuss these results in the context of organic charge-transfer salts.

PS 14

1. B.J. Powell and R.H. McKenzie, Rep. Prog. Phys. **74**, 056501 (2011).

CONCEPT OF TUNABLE QUBIT BASED ON A MOLECULE OF TWO FRACTIONAL JOSEPHSON VORTICES

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We propose a concept of a qubit based on two coupled fractional vortices pinned at two artificially created κ discontinuities of the Josephson phase in a long Josephson junction. Each discontinuity can be created by a pair of tiny current injectors with the current $I_{\text{inj}} \propto \kappa$ applied. Similar to the previous proposal based on a 0-π-0 junction [1] we map the dynamics of the system to the dynamics of a single particle in a double-well potential and calculate the effective parameters of this potential. By tuning the discontinuities $\kappa \propto I_{\text{inj}}$ during experiment one is able to control the parameters of the effective double-well potential. The system can be used to study macroscopic quantum phenomena involving tailored vortex matter.

PS 15

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ESTIMATING QUASI-LONG-RANGE ORDER VIA RÉNYI ENTROPIES

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PS 16

We show how entanglement entropies allow for the estimation of quasi-long-range order in one dimensional systems whose low-energy physics is well captured by the Tomonaga-Luttinger liquid universality class. First, we check our procedure in the exactly solvable XXZ spin-1/2 chain in its entire critical region, finding very good agreement with Bethe ansatz results. Then, we show how phase transitions between different dominant orders may be efficiently estimated by considering the superfluid-charge density wave transition in a system of dipolar bosons; moreover, we discuss the application of this method to multispecies systems such as the one dimensional Hubbard model. Finally, we study the case of the critical non-integrable XXZ spin-3/2 chain.

1. M. Dalmonte, E. Ercolessi, L. Taddia, Phys. Rev. B **8**4, 085110 (2011); *ibid.* **8**5, 165112 (2012).

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Évora and how to reach it

Évora is located in the south of Portugal, about 130 km east of Lisbon. The monumental feature of Évora - together with its picturesque aspect - made UNESCO include its historic centre in its list of cultural heritage of mankind. Follow this link (City of Évora) to find more: http://home.dbio.uevora.pt/ femi/porttow/evora.html

Airport bus services:

The organizing commitee arranged special buses with departure from Lisbon airport around 8:00 pm on Sunday 7 October 2012, and from Évora with departure around 6:30 pm on Friday 12 October 2012, with arrival to Lisbon airport at around 8:00 pm. The use of these buses requires prior registration at the event secretary.

Bus Timetables

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

By bus:

From the Lisbon International Airport you should take the metro red line, which is the only line available, to the end of the line (São Sebastião station). There you should change to the blue line, Amadora Este direction, and leave at Sete Rios Station (two metro stations). At the bus station in Sete Rios you can take a direct bus to Évora. The journey will last approximately 1h40. 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

Below you will find departure and arrival timetables to and from Évora.

Bus Timetables

LISBOA → EVORA (131 Kms)

Departure	Arrival	Price	Frequency
07:00	08:45	12.50	Except Saturdays and Sundays
08:00	09:30	12.50	Daily
08:30	10:15	12.50	Daily
09:30	11:00	12.50	Daily
10:30	12:15	12.50	Daily
11:45	13:35	12.50	Daily
12:00	13:30	12.50	Daily
13:00	14:45	12.50	Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
13:45	15:15	12.50	Daily
14:15	16:50	12.50	Daily
15:00	16:40	12.50	Daily
16:00	17:45	12.50	Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
17:00	18:30	12.50	Daily
17:00	18:45	12.50	Daily
17:15	19:00	12.50	Daily
17:45	19:15	12.50	Daily
18:00	19:30	12.50	Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
19:00	20:40	12.50	Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
19:30	21:00	12.50	Daily
20:00	21:30	12.50	Sundays
20:30	22:15	12.50	Daily
21:30	23:15	12.50	Fridays
22:00	23:45	12.50	Daily
22:30	00:00	12.50	Sundays

Bus Timetables

EVORA → LISBOA (131 Kms)

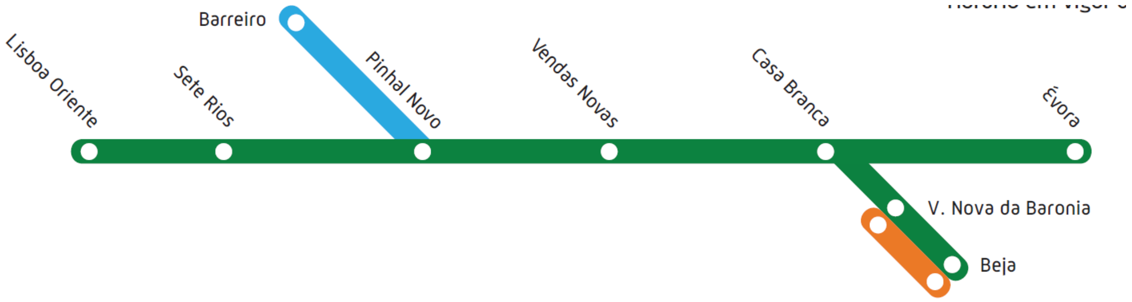
Departure	Arrival	Price	Frequency
06:00	07:45	12.50	Daily
07:00	08:30	12.50	Daily
07:30	09:00	12.50	Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
08:00	09:45	12.50	Except Sundays
08:30	10:00	12.50	Daily
09:45	11:30	12.50	Daily
10:15	11:45	12.50	Daily
12:30	14:15	12.50	Except Saturdays and Sundays
13:00	14:30	12.50	Daily
14:00	15:30	12.50	Daily
14:45	16:15	12.50	Daily
15:00	16:45	12.50	Mondays, Tuesdays, Wednesdays, Thursdays and Fridays
16:00	17:45	12.50	Daily
17:30	19:15	12.50	Daily
18:15	19:45	12.50	Daily
19:00	20:45	12.50	Daily
19:30	21:15	12.50	Daily
20:00	21:45	12.50	Daily
21:00	22:45	12.50	Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Sundays
21:30	23:00	12.50	Sundays

By train:

From the Lisbon International Airport you should take the metro red line, which is the only line available, to the Oriente metro station (three metro stations). At the Oriente Railway Station you can take an intercity train to Évora. The journey will last approximately 1h.30.

Below you will find departure and arrival timetables to and from Évora.

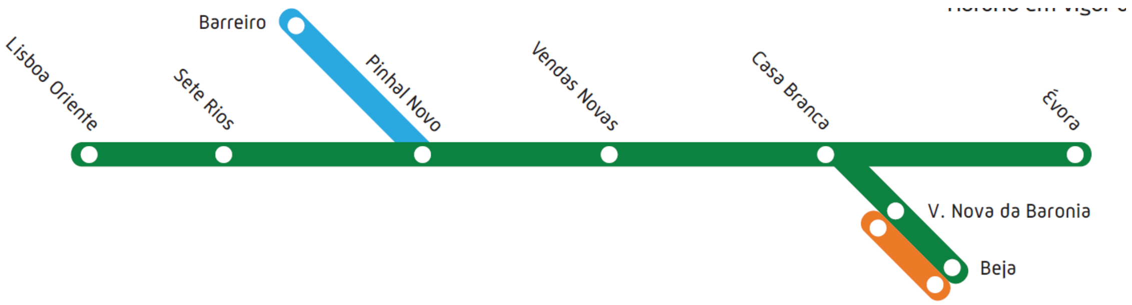
Train Timetables



Monday to Friday (Except Public Holidays)

Categoria Category	R (Regional)	Urbano	IC	IC	Urbano	IC	IC	R (Regional)	Urbano	IC	IC	Urbano	IC	IC
Número Number	4801	17205	590	581	17213	592	583	4805	17245	596	587	17253	598	589
Característica Characteristic	1							1						
Observações Remarks			R	R		R	R			R	R		R	R
Lisboa Oriente P			6:50			8:50				16:50			18:50	
Entrecampos			6:59			8:59				16:59			18:59	
Sete Rios			7:04			9:04				17:04			19:04	
Pragal			7:15			9:15				17:15			19:15	
Barreiro		6:55	|		8:55	|			16:55	|		18:55	|	
Pinhal Novo		7:13	|		9:13	|			17:13	|		19:13	|	
Pinhal Novo			7:38			9:38				17:38			19:38	
Poceirão			7:47			|				|			|	
Fernando Pó			7:52			|				|			|	
Pegões			7:57			|				|			|	
São João das Craveiras			8:01			|				|			|	
Vendas Novas			8:09			10:01				18:01			20:01	
Casa Branca C			8:22			10:14				18:14			20:14	
Casa Branca P			8:23			10:15				18:15			20:15	
Évora C			8:33			10:25				18:25			20:25	
Casa Branca P				8:28			10:19				18:21			20:19
Alcáçovas				8:36			10:27				18:29			20:27
Vila Nova da Baronia	7:08			8:48			10:38	13:29			18:43			20:38
Alvito	7:15			8:54			10:45	13:36			18:50			20:45
Cuba	7:25			9:05			10:55	13:46			19:00			20:55
Beja C	7:40			9:19			11:10	14:01			19:15			21:10

Train Timetables



Saturdays, Sundays and Public Holidays

Categoria Category		URBANO	IC	IC	URBANO	IC	IC	URBANO	IC	IC
Número Number		17215	594	585	17243	596	587	17251	598	589
Característica Characteristic										
Observações Remarks			R	R		R	R		R	R
Lisboa Oriente	P		9:50			16:50			18:50	
Entrecampos			9:59			16:59			18:59	
Sete Rios			10:04			17:04			19:04	
Pragal			10:15			17:15			19:15	
Barreiro		9:25	|		16:25	|		18:25	|	
Pinhal Novo		9:43	|		16:43	|		18:43	|	
Pinhal Novo			10:38			17:38			19:38	
Poceirão			|			|			|	
Fernando Pó			|			|			|	
Pegões			|			|			|	
São João das Craveiras			|			|			|	
Vendas Novas			11:01			18:01			20:01	
Casa Branca	C		11:14			18:14			20:14	
Casa Branca	P		11:15			18:15			20:15	
Évora	C		11:25			18:25			20:25	
Casa Branca	P			11:19			18:21			20:19
Alcáçovas				11:27			18:29			20:27
Vila Nova da Baronia				11:38			18:43			20:38
Alvito				11:45			18:50			20:45
Cuba				11:55			19:00			20:55
Beja	C			12:10			19:15			21:10

HOW TO CONNECT TO WIRELESS NETWORK:

1st STEP:

1- Activate **Wireless connection**

2- Manually add "**Wireless network**"

3- Configurations:

network's name: **FWUE**
security: **NONE** or **WITHOUT AUTHENTICATION (OPEN)**
select: **CONNECT AUTOMATICALLY**
select: **CONNECT EVEN IF NETWORK IS OFF**

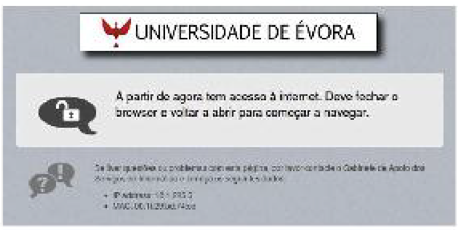
2nd STEP:

Turn on your web browser. You will see the following page:

enter:

USERNAME: ccqs
PASSWORD: ccqs

You will see the following web page:



You should now turn off and then reinitiate your web browser.

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