The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

IAEA International Atomic Energy Agency

Activity SMR: **2243**

Workshop on Frontiers in Ultracold Fermi Gases

6 June 2011 - 10 June 2011
Trieste - ITALY
INTELBIOMAT - European Science Foundation (ESF)

Posters Abstract

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Enrico ARRIGONI

Institute of Theoretical and Computational Physics
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POSTER 1
Title: Strongly-correlated lattice bosons in the superfluid phase: a selfenergy-functional cluster approach

Abstract:
We extend the variational cluster approach to deal with strongly-correlated lattice bosons in the superfluid phase.
To this end, we reformulate the method within a pseudoparticle formalism, whereby cluster excited states are described in terms of particle-like excitations. The approximation amounts to solving a multi-component noninteracting bosonic system by means of a multi-mode Bogoliubov approximation. A criterion for the stability of the solution is discussed. In order to provide a rigorous background for this approach we provide an extension of the selfenergy functional approach to include the bosonic superfluid phase, and show that the two approaches are equivalent.

We provide expressions for the single-particle normal and anomalous Green's functions, the condensate density, the grand-canonical potential, and other static quantities.

We apply the method to the two-dimensional Bose-Hubbard model and evaluate results in both Mott and superfluid phase. Our approach yields excellent agreement with Quantum Monte-Carlo calculations.
The extension to other problems of interest, such as correlated light-matter systems, Fermi-Bose mixtures, as well as systems out of equilibrium is discussed.

POSTER 2:
Title: Enhancement of d-wave superconducting correlations in the three-band Hubbard model coupled to apical oxygen phonons.

Abstract:
We study the hole binding energy and pairing correlations in the three-band Hubbard model coupled to an apical oxygen phonon by exact diagonalization and constrained-path Monte Carlo simulations. In the physically relevant charge-transfer regime, we find that the hole binding energy is strongly enhanced by the electron-phonon interaction, which is due to a novel potential-energy-driven pairing mechanism involving reduction of both electronic potential energy and phonon related energy. The enhancement of hole binding energy, in combination with a phonon-induced increase of quasiparticle weight, leads to a dramatic enhancement of the long-range part of d-wave pairing correlations. Our results indicate that the apical oxygen phonon plays a significant role in the superconductivity of high-T_c cuprates.

Grigory Evgenievich ASTRAKHARCHIK

Departament de Fisica i Enginyeria Nuclear
Universitat Politecnica de Catalunya
Spain

Other authors: S. Giorgini, J. Boronat

Title: Two-component Fermi gas of unequal masses at unitarity

Abstract:
Fixed-node diffusion Monte Carlomethod is used to study stability of a two-component Fermi gas at zerotemperature as a function of mass ratio of heavy M to light m components. It is found from a many-body calculation that the gas state becomes unstable with respect to formation of clusters at M/m = 13(1). This instability is observed in a normal state and is absent in simulations of a superfluid state.

and

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Spain

Other authors: A.E. Golomedov, Yu.E. Lozovik, J.Boronat

Title: Applicability of excitonic description in a two componentCoulomb gas.

Abstract:
Electron-hole attraction leads to formation of excitons atlow density in a two-component Coulomb gas. An important question is to whichextent excitons can be approximated by composite bosons. Keldysh and Kozlovpoint out that fermionic effects contribute already to the beyond mean-fieldterms of weakly interacting bosons. M. Combescot points out that pure bosondescription always misses important exchange terms. We use fixed node diffusionMonte Carlo method to study ground state properties of equalmass spin polarized two component electron hole plasma. We calculate energiesof four-body system under harmonic confinement and use them to extractexciton-exciton scattering length. Many-body homogeneous system is studied as afunction of density. We find that in the low-density regime the equation ofstate can be described by a mean-field boson theory with the same s-wavescattering length as obtained from four-body trapped system. At largerdensities we find that beyond-mean-field terms are well described by bosonicLee-Huang-Yang theory. Bose-Einstein condensation of excitons is investigatedthrough long-range asymptotics of the two-body density matrix. Condensatefraction of condensed excitons is reported along the crossover. [1] V. Keldysh and A. N. Kozlov, Sov. Phys.-JETP 27, 521(1968) [2] M. Combescot and O. Betbeder-Matibet, Phys. Rev. B 78,125206 (2008). [3] Z. Idziaszek and T. Calarco, Phys. Rev. A 71, 050701(R)(2005) [4] J. von Stecher, Chris H. Greene, and D. Blume, Phys.Rev. A 76, 053613 (2007) [5] J. Shumway and D. M. Ceperley, Phys. Rev. B 63, 165209(2001)

Luca BARBIERO

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Title: Homogeneous and Inhomogeneous magnetic phases of dipolar bosons

Abstract:
We study the emergence of several magnetic phases in dipolar bosonic gases subject to three-body loss mechanism employing numerical simulations based on the density matrix renormalization group(DMRG) algorithm. After mapping the original Hamiltonian in spin language, we find a strong parallelism between the bosonic theory and the spin-1 Heisenberg model with single ion anisotropy and long-range interactions. A rich phase diagram, including ferromagnetic, antiferromagnetic and non-local ordered phases, emerges in the one-dimensional case, and is preserved even in presence of a trapping potential.

Marcus BARTH

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Title: Tan relations in one dimension

Abstract:
We derive exact relations that connect the universal C/k4-decay of the momentum distribution at large k with both thermodynamic properties and correlation functions of two-component Fermi gases in one dimension with contact interactions. The relations are analogous to those obtained by Tan in the three-dimensional case and are derived from an operator product expansion of the one- and two-particle density matrix. In both one and three dimensions, a Stoner instability to a saturated ferromagnet for repulsive fermions with zero range interactions is ruled out at any finite coupling.

Stefan BAUR

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United Kingdom

Title: One dimensional polarized paired Fermi gases on a Feshbach resonance

Abstract:
We study the effects of spin polarization on the BEC-BCS crossover in one spatial dimension(1D). To this end we model the system using the Bose-Fermi resonance model in 1D and, by solving the three-body problem of a dimer and an excess fermion, we give arguments for a possible phase transition between the FFLO phase characterized by an oscillating superfluid correlation function and a Bose-Fermi mixture featuring nodeless superfluid correlations [Phys. Rev. A 81, 033628 (2010)]. In addition, we explain recent experiments of the Rice group [Nature 467, 567-569 (2010)] by solving thermodynamic Bethe ansatz equations for the Gaudin-Yang Hamiltonian. Work done in collaboration with Y.-A. Liao, A. S. C. Rittner, T. Paprotta, R. G. Hulet and J. Shumway.

Abdelaali BOUDJEMÂA and M. BENAROUS

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Title: On the anomalous density for Bose gases at finite temperature

Abstract:
We analyze the behavior of the anomalous density as function of the radial distance at different temperatures in a variational framework. We show that the temperature dependence of the anomalous density agrees with HFB-BdG calculations. Comparisons between the normal and the anomalous fractions at low temperature show that the latter remains higher and consequently the neglect of the anomalous density may destabilize the condensate. These results are compatible with those of Yukalov. Surprisingly, the study of the anomalous density in terms of the number of particles shows that the dip in the central density is destroyed for sufficiently small number of particles. We explain this effect.

Michele BURRELLO

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Title:
Ultracold atomic gases in non-Abelian gauge potentials and deformed quantum Hall states.

Abstract:
We study ultracold atoms in a realistic artificial U(2) non-Abelian gauge potential: the non-Abelian part of the vector potential makes the Landau levels non-degenerate, and, in the presence of strong intra-species interactions, deformed Laughlin ground states occur. However, at the degeneracy points of the Landau levels, fractional quantum Hall states appear and explicit analytical results can be obtained. These ground states are characterized by different filling factors and include non-Abelian wavefunctions such as deformed Moore-Read states, which present Ising anyons as excitations. The cases of free fermions and interacting bosons are addressed.

Roberta CITRO

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Title: Quantum pumping and quantum stirring of interacting bosons in optical lattices

Abstract:
Quantum pumping and quantum stirring in an interacting onedimensional Bose-Einstein condensate are analyzed. It is shown that a spatially periodic potential, oscillating adiabatically in time with frequency w0 acts as a quantum pump inducing an atom current from broken spatiotemporal symmetries of the driven potential. The current generated by the pump is strongly affected by the interactions. It has a power law dependence on the frequency with the exponent determined by the interaction, while the coupling to the pump affects the amplitudes[1]. It depends on the phase difference between two umklapp terms of the drive, providing evidence for the full quantum character of the boson transport. As other example of non-equilibrium effect, quantum stirring with a laser beam of a one-dimensional Bose gas confined to a ring is considered. Within the Luttinger liquid theory framework, we calculate the fraction of stirred particles per period as a function of the stirring velocity, the interaction strength, and the coupling between the stirring beam and the bosons[2]. We show that the stirred fraction is never zero due to the presence of strong quantum fluctuations in one dimension, implying imperfect superfluid behavior under transport in one-dimension. The results suggest the realization of a quantum pump and quantum stirring with laser-cooled atoms in reduced dimensionality.

[1] R. Citro and N. Andrei, Phys. Rev. A 83, 015601 (2011) .
[2] R. Citro, A. Minguzzi, F. W. Hekking, Phys. Rev. A 79, 172505 (2009).

Silvia CHIACCHIERA

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Other authors: D. Davesne, T. Lepers, M. Urban

Title: Collective modes in cold trapped Fermi gases

Abstract: We study the collective modes of cold trapped Fermi gases in the normal-fluid phase via the Boltzmann equation. Previous works showed that data are not described satisfactorily in this framework, not even including in-medium effects. We argue that the method used to solve Boltzmann equation was inappropriate. Thanks to a comparison of numerical and analytical approaches, we show that the commonly used 2nd-order moments method is insufficient. Extending the method to 4th order, we improve considerably the description of the frequency and damping of the modes.

Stability of Superfluid Phases in the 2D Spin-Polarized Attractive Hubbard Model

A. Kujawa-Cichy[a] and R. Micnas[a]
[a]Solid State Theory Division, Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland

We study the evolution from the weak coupling (BCS-like limit) to the strong coupling limit of tightly bound local pairs (LP's) with increasing attraction, in the presence of the Zeeman magnetic field (h) for $d = 2$, within the spin-polarized attractive Hubbard model. The broken symmetry Hartree approximation and strong coupling expansion are used. We also apply the Kosterlitz-Thouless (KT) scenario to determine the phase coherence temperatures. For spin independent hopping integrals ($t^{\uparrow} = t^{\downarrow}$), we find no stable homogeneous polarized superfluid (SC_M) state in the ground state for the strong attraction and obtain that for a two-component Fermi system on a 2D lattice with population imbalance, phase separation is favored for a fixed particle concentration, even on the LP (BEC) side. We also examine the influence of spin dependent hopping integrals (mass imbalance) on the stability of the SC_M phase. We find a topological quantum phase transition (Lifshitz type) from the unpolarized superfluid phase (SC_0) to SC_M and tricritical points in the $(h - |U|)$ and $(t^{\uparrow}/t^{\downarrow} - |U|)$ ground state phase diagrams. We also construct the finite temperature phase diagrams for both $t^{\uparrow} = t^{\downarrow}$ and $t^{\uparrow} \neq t^{\downarrow}$ and analyze the possibility of occurrence of a spin polarized KT superfluid.

Marcello DALMONTE

Alma Mater Studiorum
Universita di Bologna
Department of Physics
Italy

Title: Pairing and Mott instabilities of 1D and quasi-1D dipolar gases

Abstract:
Recent developments in cooling and controlling ultracold gases of magnetic atoms and polar molecules open a new perspective on many-body physics of ultracold gases, which was previously strongly related to contact interactions. We will present a theoretical analysis of bosonic and fermionic gases confined in 1D and quasi-1D geometries, combining analytical approaches based on the Tomonaga-Luttinger liquid formalism with numerical DMRG calculations. Several phenomena are investigated, from the formation of a staircase of insulating phases to the emergence of exotic pairing instabilities which are stable even in standard experimental setups.

Raka DASGUPTA

S. N. Bose National Centre for Basic Sciences
India

Title: Effects of Three-body Scattering Processes on the BCS-BEC Crossover

Abstract:
We investigate the BCS-BEC crossover taking into account an additional three-body interaction, which is essentially the scattering between the Cooper pairs and the newly formed bosons. We show that if the two-body interaction is attractive, the presence of this additional three-body term makes the crossover process a nonreversible one. Starting from a stable Bose-Einstein condensate (BEC) state, crossover to BCS can be achieved; but if the BCS state is the starting point, instead of a stable BEC region, what the system crosses over to is a metastable condensed state.

Sumita DATTA

Department of Theoretical Physics
Indian Association For the Cultivation of Science
India

Title: Visualizing Anderson Localization in 3d using Monte Carlo method

Abstract:
We study the effect of Anderson localization on a Bose-Einstein condensate in 3d in a disordered potential by Feynman-Kac path integral technique. Simulations are performed in continuous space using canonical ensemble. Owing to the high degree of control over the system parameters we also study the interplay of disorder and interaction in the system. We numerically compute the localization length, mobility edge and density profile of the condensate. We observe that as the interaction strength increases, the wave functions become more and more localized.

Arya DHAR

Indian Institute of Astrophysics
India

Title : Quantum Phases of Ultracold Bosonic Atoms in a One Dimensional Optical Superlattice.

Abstract :
We analyze various quantum phases of ultracold bosonic atoms in a periodic one dimensional optical superlattice. Our studies have been performed using the finite size density matrix renormalization group (FS-DMRG) method in the framework of the Bose-Hubbard model.
Calculations have been carried out for a wide range of densities and the energy shifts due to the superlattice potential.
At commensurate fillings, we find the Mott insulator and the superfluid phases as well as Mott insulators induced by the superlattice. At a particular incommensurate density, the system is found to be in the superfluid phase coexisting with density oscillations for a certain range of parameters of the system.

Tara DRAKE

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U.S.A.

Title: Investigating the Pseudogap Phase using Photoemission Spectroscopy

Abstract:
We present work investigating the single particle energies of atoms in the BCS-BEC crossover using atom photoemission spectroscopy. We demonstrate a general method to probe the momentum distribution of ultracold atoms near the center of a trap. Two intersecting Laguerre-Gaussian beams selectively remove atoms at the edge of the cloud from our imaging state before releasing the trapped gas for time of flight expansion. This allows us to observe a sharp Fermi surface of a degenerate K-40 atom cloud. We then apply the technique to atom photoemission spectroscopy to probe the effect of density inhomogeneity on this measurement technique.

Omjyoti DUTTA

ICFO - The Institute of Photonic Sciences
Group of Prof- Maciej Lewenstein
Spain

Title: Self-induced orbital order in fermionic systems in optical lattices.

Abstract:
In this presentation we investigate self-induced orbital order in Fermionic systems in the presence of optical lattices. We specifically look into three different systems, i) Dipolar fermions ii) Bose-Fermi mixtures and iii) Fermi-Fermi mixtures. We find different crystalline states with self-induced p-orbital orders for certain filling factors. Also due this self-induced effect results in creation of fermions in p-orbitals. We briefly discuss there properties in the non-crystalline state.

Riccardo FANTONI

National Institute for Theoretical Physics
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South Africa

Title: Diffusion Monte Carlo of a Fermion fluid between the ideal gas and the Jellium model

Abstract:
We study, through the diffusion Monte Carlo method, a quantum fermion fluid, in the three dimensional Euclidean space, at zero temperature, where the point particles have spin one-half and interact with a pair potential which can be continuously changed from zero to the Coulomb potential depending on a parameter μ. The fluid is immersed in a uniform background of continuously distributed point particles which interact with the particles of the fluid with the same pair potential but of opposite sign. We determine the radial distribution functions of the fluid for various values of density, μ, and polarization.

Vivian V. FRANÇA and **Andreas BUCHLEITNER**

Freiburg University
Germany

Title: Microscale phase separation in fermionic systems with exotic superfluidity

Abstract:
Here we show that the ground-state of one-dimensional superfluids with spin-imbalanced populations is indeed microscale phase separated, as predicted almost fifty years ago by Fulde-Ferrell and Larkin-Ovchinnikov (FFLO). For strongly interacting systems, we find that the microscale structure can be observed directly in the density profiles. We also deduce an analytical upper bound for the critical polarization below which the FFLO-state takes place. The phase diagram depicted here indicates the parameters for which exotic superfluidity can be theoretically and experimentally explored.

Elisa FRATINI and **Pierbiagio PIERI**

Physics Section
School of Science and Technology
University of Camerino and CNISM
Italy

Title: Quantum phase transition in a resonant Bose-Fermi mixture

Abstract:
We consider a homogeneous Bose-Fermi mixture, with a boson-fermion attractive interaction tuned by a Fano-Feshbach resonance. We analyse by diagrammatic means the quantum phase transition from the normal to the condensed phase, studying the properties of the system in the zero temperature limit and close to criticality.
We describe the behaviour of the critical coupling as a function of the density and mass imbalances and obtain the corresponding curves for the boson and fermion chemical potentials. We study the boson and fermion momentum distribution functions, comparing them with the molecular one, to describe the system in terms of composite fermions and unpaired bosons and fermions.
We find a very weak dependence of the quantum critical point on the population imbalance and a pronounced dependence on the mass ratio. For vanishing boson densities we verify that the critical coupling coincides with that found for the polaron-molecule transition in a strongly imbalanced Fermi gas.

Domenico GIULIANO

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Italy

Title: Simulating Quantum Magnets with a Bose Hubbard model

Abstract:
We study the correlation functions in the one-dimensional Bose-Hubbard model at half-integer filling. If J is the Josephson energy between neighbouring wells and U the on-site interaction energy, we show that, even at relatively large values of the ratio J/U (0.3), the Bose-Hubbard correlation functions yield a very accurate estimate of the correlation functions of an effective spin-1/2 XXZ Hamiltonian. The parameters characterizing the spin chain are determined by applying the Glazek-Wilson [PRB 48, 5863 (1993)] renormalization scheme to the Bose-Hubbard Hamiltonian. We compare the analytical results available for the XXZ correlation function in a finite chain of length L to the numerical results obtained for the Bose-Hubbard model. Our analysis strongly suggests that interacting bosons on a lattice may be used to simulate the correlation functions of a spin-1/2 XXZ Hamiltonian with tuneable anisotropy.

Vandna GOKHROO

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India

Title: Sub-Doppler deep-cooled bosonic and fermionic isotopes of potassium in a compact 2D+–3D MOT set-up

Abstract:
In my poster, I will describe sub-Doppler deep cooling of cold fermionic 40K and bosonic 39K isotopes of potassium produced in a three dimensional magneto optical trap (3D MOT) loaded by a very compact 2D+ MOT. The loading rate and atom numbers achieved in the compact simple set up are comparable to that in previous set ups with more elaborate vacuum design. We attained relatively low temperatures of 34μK and 30μK for 39K and 40K after sub Doppler cooling process. With an added optical dipole trap the set up is meant to study quantum dynamics of a few fermionic and bosonic atoms near or well within quantum degeneracy.

Marco GUGLIELMINO

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Italy

Title: Ising antiferromagnet with ultracold bosonic mixtures confined in a harmonic trap

Abstract:
We present accurate results based on Quantum Monte Carlo simulations of two-component bosonic systems on a square lattice and in the presence of an external harmonic confinement. Starting from hopping parameters and interaction strengths which stabilize the Ising antiferromagnetic phase in the homogeneous case and at half integer filling factor, we study how the presence of the harmonic confinement challenge the realization of such phase. We consider realistic trapping frequencies and number of particles, and establish under which conditions, i.e. total number of particles and population imbalance, the antiferromagnetic phase can be observed in the trap.

Johannes HOFMANN

Department of Applied Mathematics and Theoretical Physics
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Title: Current response, structure factor and hydrodynamic quantities of a two- and three-dimensional Fermi gas from the operator product expansion

Abstract:
We apply the operator product expansion to determine the asymptotic form of the current response of a Fermi gas in two and three dimensions. The leading order term away from the one-particle peak is proportional to a two-particle operator known as the contact whose coefficient is determined exactly. We also calculate the dynamic structure factor and the high-frequency tails of the spectral viscosities as a function of the scattering length. Our results are used to derive certain sum rules for the viscosities.

Yun LI

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Title: Universal contact and collective excitations of a strongly interacting Fermi gas

Abstract: We study the relationship between the Tan's contact parameter and the macroscopic dynamic properties of an ultracold trapped gas, such as the frequencies of the collective oscillations and the propagation of sound in 1D configurations. We find that the values of the contact, extracted from the most recent low temperature measurements of the equation of state, reproduce with high accuracy the experimental values of the collective frequencies of the radial breathing mode measured near unitarity, at the lowest temperatures. We show that the temperature dependence of the contact parameter show up in a visible way in the frequency of the collective excitations of the unitary Fermi gas.

Natalia MATVEEVA

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Italy

Title: "Dipolar Drag in Bilayer Harmonically Trapped Gases

Abstract:
We consider two separated pancake-shaped trapped gases interacting with a dipolar (either magnetic or electric) force. We study how the center of mass motion propagates from one cloud to the other as a consequence of the long-range nature of the interaction. The corresponding dynamics is fixed by the frequency difference between the in-phase and the out-of-phase center of mass modes of the two clouds, whose dependence on the dipolar interaction strength and the cloud separation is explicitly investigated.
We discuss Fermi gases in the degenerate as well as in the classical limit.

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Title: Binary mixtures of condensates in generic confining potentials

Abstract:
We study a binary mixture of Bose-Einstein condensates, confined in a generic potential, in the Thomas-Fermi approximation [1]. We search for the zero-temperature ground state of the system, both in the case of fixed numbers of particles and fixed chemical potentials. If the inter-species repulsive interaction is sufficiently intense, the energetically favored configurations are characterized by domain walls separating the two species. The stability of configurations is analyzed. The most stable configurations are the ones in which the number of domain walls is the greatest possible [2].

[1] Pitaevskij L and Stringari S, Bose-Einstein Condensation (Clarendon Press, Oxford, 2003)

[2] P. Facchi, G. Florio, S. Pascazio, and F. V. Pepe, arXiv:1105.2482

Alexander PIKOVSKI

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Title: State-changing collisions in ultra-cold polar molecules in a bilayer.

Abstract:

Ultra-cold polar molecules in a bilayer geometry may be affected by inter-layer dipolar interactions, even in the absence of inter-layer hopping. We show that these interactions may lead to interesting effects even if the molecules are not polarized. In particular we consider the case in which the molecules in each layer are initially prepared in a different rotational state. We show that in that case the inter-layer dipole-dipole interaction induces a swap of the rotational state of molecules in different layers in two-body collisions, resembling spin-changing collisions in spinor gases. Due to the peculiar character of the inter-layer dipole-dipole interaction, the rate of these state-changing collisions shows a non-trivial behavior as a function of density, temperature and inter-layer spacing. Interestingly, for optically trapped highly reactive molecules like KRb, such state swaps lead to immediate losses, and hence the state-changing collisions can be easily observed by monitoring the molecule number.

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Title: Temperature and coupling dependence of the universal contact intensity for ultra-cold Fermi gases

Abstract:
Several physical properties of ultra-cold Fermi gases are characterized by the contact intensity C, which enters the pair-correlation function at short distances and describes how the two-body physics merges into its surrounding. We show that the local order established by pairing fluctuations about the critical temperature Tc of the superfluid transition enhances the contact C in a temperature range where pseudo-gap phenomena are maximal. We also show that our ab initio results for C in a trap compare well with recently available experimental data over a wide coupling and temperature range.

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Title:
Ultracold atoms in optical lattices: beyond the Hubbard model

Abstract:
We investigate the properties of strongly interacting gases in optical lattices. We address the regime of weak and intermediate optical lattice potentials, where the conventional description in terms of the single (or few) band Hubbard model is not valid. In this interesting regime intriguing quantum phenomena appear due to the interplay between strong inter-atomic interactions and the external periodic potential.
In the case of bosonic atoms, we introduce a novel path-integral Monte Carlo technique which allows to simulate the superfluid to insulator transition in continuous space at arbitrary optical lattice intensities V_0. We determine the zero-temperature phase-diagram as a function of the s-wave scattering length and V_0.
For Fermions, we apply Kohn-Sham Density Functional Theory (DFT) using a new energy-density functional for repulsive Fermi gases. The first results based on a local spin-density approximation show evidence of a ferromagnetic phase at strong interactions and of an antiferromagnetic phase in the intermediate coupling regime.
As an outlook, we will discuss how the development of DFT for ultracold atomic gases can form a strong link between materials science and atomic physics.

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Title: Adiabatic Trap Deformation For Preparing Quantum Hall States

Abstract:
One of the biggest challenges in physics of trapped ultracold atoms is the observation of the fractional quantum Hall effect (FQHE), when a gas of bosonic atoms is put in rapid rotation. A considerable experimental effort have been spent in this direction, but some fundamental obstacles seem to prevent the gas from going beyond the vortex-lattice phase when rotation is generated by stirring the gas inside a harmonic trap. One of the main obstacles consists in the difficulty of imparting to the system a sufficient amount of angular momentum. Here, we discuss and propose feasible schemes for preparing adiabatically quantum-Hall states starting from a gas initially confined in a ring by using a "Mexican-hat" potential with a strong bump at the center. Setting a given rotation speed of the ring, it is possible to inject into the atomic gas an appropriate quantity of angular momentum, stored in the form of a giant vortex state. Afterwards, the potential is adiabatically deformed into a harmonic trap. We provide clear numerical evidence that the interacting bosonic gas in the ring for some precise values of angular frequency is indeed adiabatically connected with known quantum-Hall states, like the $\nu=1/2$ Laughlin or the $\nu=1$ Pfaffian.

Richard SCHMIDT

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Germany

Other authors: Tilman Enss and Wilhelm Zwerger

Title: The polaron-to-molecule transition: Dynamics and rf response from functional renormalization group

Abstract:
A light impurity in a Fermi sea undergoes a transition from polaron to molecule for increasing interaction. We develop a new computational functional RG method to compute the spectral functions of the polaron and molecule in a unified framework with full self-energy feedback. We discuss the energy spectra, decay widths, and the quasi-particle weight of the attractive and repulsive polaron as well as the molecule across the transition. We finally propose an experimental procedure to measure the repulsive branch using rf spectroscopy and calculate the corresponding spectra.

Robin SCOTT

INO CNR BEC
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Italy

Title: Dynamics of dark solitons in a trapped superfluid Fermi gas

Abdtract:
We study soliton dynamics in a trapped superfluid Fermi gas across the Bose-Einstein condensate to Bardeen-Cooper-Schrieffer (BEC-BCS) crossover by solving the time-dependent Bogoliubov-de Gennes equations. We find that solitons can perform stable oscillations across the crossover, given that their speed does not approach the Landau critical speed for pair-breaking. Furthermore, the oscillation period dramatically increases as the soliton becomes shallower on the BCS side of the resonance. We propose an experimental protocol to test these predictions. Finally, we show that soliton collisions are only elastic in the BEC limit, and may destroy the solitons in the BCS regime.

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Title: Collective modes and quantum phases of a quasi-two-dimensional dipolar Fermi gas

Abstract:
We study collective modes (zero sound) and quantum phases of a dipolar Fermi gas that is tightly confined in one spatial direction. Dipoles are polarized by an external field. We obtain the zero temperature phase diagram as a function of the strength of the dipole-dipole interaction and the tilting angle of the dipoles with respect to the plane of confinement.

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Title: Degenerate mixtures of ultracold 40K-6Li Fermions in low dimensions

Abstract:
We present the design of our new apparatus for creating cold mixtures of 6Li and 40K Fermions with which we intend to study condensed matter physics phenomena. Our experimental setup will allow us to simulate several Hamiltonians describing interacting many-body Fermionic systems in one, two and three dimensions. We report on the initial performances of our subsystems including a 2D MOT source of Potassium atoms, a Zeeman slowed Lithium beam, and a dual species magneto-optical trap.
We are now working on the magnetic transport towards the science chamber where we intend to evaporate the mixture to quantum degeneracy in an optically plugged quadrupole trap. In this chamber with large optical access periodic potentials will be realized using optical lattices and a high resolution imaging system will be installed.
We furthermore report on the first photoassociative creation of 6Li-40K molecules in a magneto-optical trap.

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Title: Ground state of alkine-earth fermionic atoms in one-dimensional optical lattices

Abstract:
We study the ground state of alkine-earth-metal atoms confined in one-dimensional optical lattices modeled by the Kondo lattice model plus a quadratic confining potential. We consider the half-filling case and both ferromagnetic and antiferromagnetic interaction between the localized and delocalized atoms. We found Kondo insulator domains that always coexist with metallic and/or band insulator regions. We observe that the on-site delocalized-localized spin correlation remains constant in the insulating regions and use it to determine the phase diagram. Metallic regions were found for both ferromagnetic and antiferromagnetic couplings.

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Title: Exotic magnetic orders for high spin ultracold fermions

Abstract:
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.

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Title: Gauge fields emerging from time reversal symmetry breaking for spin-5/2 fermions in a honeycomb lattice

Abstract:
We propose an experimentally feasible setup with ultracold alkaline earth atoms to simulate the dynamics of U(1) lattice gauge theories in 2+1 dimensions with a Chern-Simons term. To this end we consider the ground state properties of spin-5/2 alkaline earth fermions in a honeycomb lattice. We use the Gutzwiller projected variational approach in the strongly repulsive regime in the case of filling 1/6. The ground state of the system is a chiral spin liquid state with $2\pi/3$ flux per plaquette, which spontaneously violates time reversal invariance. We demonstrate that due to the breaking of time reversal symmetry the system exhibits quantum Hall effect and chiral edge states. We relate the experimentally accessible spin fluctuations to the emerging gauge field dynamics. We discuss also properties of the lowest energy competing orders.

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Title: Adiabatic Demagnatization Cooling of 2 component Feri Gaz

Abstract:
A cooling scheme for two-component fermions in optical lattices will be presented that employs the internal structure of high-spin Fermi gases. Adiabatically changing the quadratic Zeeman coupling from a uniform distribution to a space dependent one allows for the creation of an inner spin-1/2 core surrounded by spin-S wings. Due to frustration, spin-S regions act via spin-changing collisions as an effective entropy absorbers for the spin-1/2 core with increasing efficiency at lower temperatures and higher dimensions. Explicit results are obtained using thermodynamic Bethe ansatz approach in 1D spin-3/2 fermions, showing that the entropy of the spin-1/2 Mott region can be significantly reduced. The findings suggest that the proposed method can be highly efficient, opening a feasible path for accessing antiferromagnetic order in two-component unltracold fermions in optical lattices.

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Title: Dynamic structure factor of the normal Fermi gas from the collisionless to the hydrodynamic regime

Abstract:
We theoretically investigate the dynamic structure factor of a normal Fermi gas at finite temperatures [1]. Using the moment method for the Boltzmann equation, we show that the Brillouin peak in the dynamic structure factor exhibits a smooth crossover from zero to first sound as functions of temperature and interaction strength. When the system is in the hydrodynamic regime, we show that the dynamic structure factor obtained using this method also exhibits a definite Rayleigh peak. The crossover between zero and first sound modes has been extensively studied for a long time, and the dynamic structure factor of normal Fermi gases in both the collisionless and hydrodynamic regimes has been discussed in detail [2]; however, there has been no comprehensive study of the dynamic structure factor over the full crossover range from the collisionless regime to the collisional regime. In this sense, it is quite important to determine the spectral function over the full range of crossover from the collisionless regime to the hydrodynamic regime in this unified manner. [1] S. Watabe, and T. Nikuni, Phys. Rev. A 82, 033622 (2010). [2] For example, D. Pines and P. Nozieres, The Theory of Quantum Liquids, Volume I: Normal Fermi Liquids, (Westview Press, 1994).