Overscreened Kondo Effect in Ultracold Fermi Gas

Yshai Avishai*[1,2]

[1]Ben Gurion University (BGU) – Beer Sheva, Israel
[2]New York University at Shanghai – China

Abstract

The feasibility of realizing overscreened Kondo effect in ultra-cold Fermi gas of atoms with spin s $\geq 3/2$ in the presence of a localized magnetic impurity atom is proved realistic. Specifying (as a mere example), to a system of ultra cold 22Na Fermi gas and a trapped 197Au impurity, the mechanism of exchange interaction between the Na and Au atoms is elucidated and the exchange constant is found to be positive (antiferromagnetic). The corresponding exchange Hamiltonian is derived, and the Kondo temperature is estimated at the order of 1 μK. Within a weak-coupling renormalization group scheme, it is shown that the coupling renormalizes to the non-Fermi liquid fixed point. An observable displaying multi-channel features even in the weak coupling regime is the impurity magnetization: For T TK (the Kondo temperature) it is negative, and then it increases to become positive with decreasing temperature.

*Speaker

Study of multipolar excitations in superfluid and deformed nuclei with the finite amplitude method

Yann Beaujeault-Taudière*[1], Denis Lacroix[2], and Jean-Paul Ebran[3]

[1]DAM Île-de-France – Commissariat à l'énergie atomique et aux énergies alternatives : DAM/DIF, CEA, DAM, DIF, Arpajon, France – France

[2]IPN Orsay – CNRS : UMRR8608, Institut National de Physique Nucléaire et de Physique des Particules du CNRS – France

[3]CEA-DAM-DIF – CEA, CEA – France

Abstract

Studying how a nucleus responds to an external perturbation reveals many features about its structure or the underlying interactions between nucleons. Such information plays a prominent role when one aims at understanding how structure properties impact nuclear reactions, e.g. in various astrophysical scenarios such as the r process. The Quasiparticle Random Phase Approximation (QRPA), i.e. the generalization to superfluid systems of the linear response theory within the random phase approximation, provides one of the most direct approach to apprehend how a nucleus behaves under a gentle perturbation. A reformulation of QRPA recently lifted some intrinsic limitations that affected QRPA so far, namely the need to neglect some high-order contributions to the QRPA fields when tackling heavy nuclei or the application to systems displaying only a specific class of angular correlations in their ground state. The thesis thus aims at extending such a reformulation of QRPA in the case where the effective interaction between nucleons in the nuclear medium is considered of finite range, a primer in the community.

*Speaker

structural, electronic and elastic properties of alkaline earth oxides.

Yassine Chaouche*[1,2] and Mourad Souadkia[3]

[1]Larbi Tebessi University – Route de constantine, Algeria
[2]Yassine CHAOUCHE (Laboratoire de Physique Appliquée et Théorique) – route de constantine, Algeria
[3]Physics Laboratory-atGuelma,FacultyofMathematics,ComputingandMaterialSciences,University8Mai1945Guelma, P.O.Box401Guelma24000 – Algeria

Abstract

In this work, we have a complete analysis of structural, elastic and electronic properties of the three alkaline earth oxides, namely MgO, CaO and SrO by using the FP-LAPW method. In this approach, the local density approximation was used for exchange correlation potentials. Results are given for lattice constant, bulk modulus and its pressure derivative in both NaCl– (B1) and CsCl–(B2) structures. The computed equilibrium lattice constants are 4.165, 4.72, 5.073 (A for MgO, CaO and SrO, respectively. From these fits, we have also calculated the bulk moduli to be 1.74, 1.28, and 1.05 Mbar, and their pressure derivatives to be 4.29, 4.11, 5.00 for MgO, CaO and SrO, respectively. We also calculate the elastic constants (C11; C12 and C44) in both B1 and B2 phases for the three compounds. Band structure, density of states and band gap-pressure coefficients in NaCl–(B1) phase are also given. The results are compared with previous calculations and with experimental measurements.

*Speaker

Universality in ultradilute liquid Bose-Bose mixtures

Viktor Cikojević*[1], Leandra Vranješ Markić[1], Gregory Astrakharchik[2], and Jordi Boronat[2]

[1]Faculty of Science, University of Split, Ruera Boškovića 33, HR-21000 Split, Croatia – Croatia
[2]Departament de Física, Universitat Politècnica de Catalunya, Campus Nord B4-B5, E-08034 Barcelona, Spain – Spain

Abstract

We have studied quantum droplets in Bose-Bose mixtures using quantum Monte Carlo methods at T = 0. Using different interaction models, we determine range of validity of the universal equation of state of the symmetric liquid mixture as a function of two parameters: s-wave scattering length and the effective range. It is shown that the Lee-Huang-Yang correction is sufficient only for extremely dilute liquids with the additional restriction that the range of the potential is small enough. We developed a new density functional which goes beyond the Lee-Huang-Yang term and used it to determine density profiles of self-bound drops. Relation with experiments are discussed.

*Speaker

Multicomponent Superfluidity and Screening in Small Bandgap Electron-Hole Double Bilayer Graphene.

Sara Conti*[1,2], David Neilson[3], Andrea Perali[4], and Francois Peeters[2]

[1]University of Camerino, Physics Division, Camerino. (Italy) – Italy
[2]University of Antwerp, Department of Physics, Antwerpen. (Belgium) – Belgium
[3]University of Antwerp, Department of Physics, Antwerpen. (Belgium) – Belgium
[4]Università di Camerino, Supernano Laboratory, Camerino. (Italy) – Italy

Abstract

Electron-hole superfluidity has recently been observed in double bilayer graphene[1], as had been theoretically predicted in Ref. [2]. The electrons and holes are confined in the two different bilayers which are atomically close together. The multiband nature of the bilayer graphene is expected to be very important because the small band gaps between conduction and valence bands make the valence band contributions non-negligible for the physical processes[3]. Here we report on a complete mean-field study that takes into account the effects of multichannel electron-hole pairing[4]. These include Josephson-like pair transfer between bands; screening from both intraband and interband excitations; and effects of the non-parabolic band dispersion that accompanies the non-zero, variable band gaps in bilayer graphene. The full self-consistent calculation predicts the same density range for the superfluidity as the density range observed in the recent experiment.For all non-zero band gaps, we find that the boost in the density of states from the flattening of the bands significantly strengthens the superfluidity.We find that the presence of electron-hole pairs modified in a fundamentally different way the intraband screening, that is suppressed by superfluidity at low density, and interband screening, that remains unaffected also in the strongly interacting regime. Unexpectedly, the net effect of the screening is to restrict the superfluid pairing entirely to the conduction band - even for very small band gaps.

G. W. Burg, N. Prasad, K. Kim, T. Taniguchi, K. Watanabe, A. H. MacDonald, L. F. Register, and E. Tutuc, *Strongly enhanced tunneling at total charge neutrality in double bilayer graphene-WSe2 heterostructures.* Phys. Rev. Lett. 120, 177702 (2018).

A. Perali, D. Neilson, and A. R. Hamilton, *High-temperature superfluidity in double-bilayer graphene.* Phys. Rev. Lett. 110, 146803 (2013).

S. Conti, A. Perali, F. M. Peeters, and D. Neilson, *Multicomponent electron-hole superfluidity and the BCS-BEC crossover in double bilayer graphene.* Phys. Rev. Lett. 119, 257002 (2017).

S. Conti, A. Perali, F. M. Peeters, and D. Neilson, *Multicomponent screening and superfluidity in gapped electron-hole double bilayer graphene with realistic bands.* Phys. Rev. B. 99,

*Speaker

144517 (2019).

Low-energy K- interaction studies with light nuclei by AMADEUS

Raffaele Del Grande*[1]

[1]Laboratori Nazionali di Frascati – Italy

Abstract

The AMADEUS collaboration aims to provide information on the Kbar-nucleon/nuclei interaction in the low-energy regime. The investigation of the antikaon dynamics in nuclear medium is fundamental for the understanding of the non-perturbative QCD in the strangeness sector, with implications going from nuclear physics to astrophysics. Hyperon-nucleon/nuclei and hyperon-pion correlated production in K- nuclear absorption on H, 4He, 9Be and 12C nuclei are analysed with the aim to explore the possible existence of kaonic bound states in nuclei and the properties of hyperon resonances in nuclear environment. AMADEUS takes advantage of the DAFNE collider, which provides a unique source of monochromatic low-momentum kaons (p _˜ 127 MeV/c), and exploits the KLOE detector as active target, providing large acceptance and resolution for the data.

*Speaker

Application of renormalized RPA to polarized Fermi gases

David Durel*[1]

[1]Institut de Physique Nucléaire dÓrsay – Université Paris-Sud - Paris 11, Institut National de Physique Nucléaire et de Physique des Particules du CNRS, Centre National de la Recherche Scientifique : UMR8608 – France

Abstract

Cold atoms allow the study of a fundamental property of a system of fermions which is to be superfluid below a certain critical temperature. The advantage of these systems is the experimental control of the intensity of the interaction thanks to the Feshbach resonance. This makes it possible to realize the BCS-BEC crossover from weak attractive interaction (BCS limit) througth the resonance (unitary limit) to weakly repulsive interaction (BEC limit). In the crossover regime, the ultra-cold fermion gases represent a strongly correlated system whose theoretical description is a challenge, as conventional approaches (like BCS) fail to reproduce such systems. In this work we consider zero-temperature gases whose spin-up and spin-down populations are different. These polarized gases open the way to a new superfluid phase called FFLO phase predicted theoretically but never observed experimentally. At zero temperature, it is the polarization of the gas that determines if we are in the normal or superfluid phase. The critical polarization for a gas at zero temperature plays a similar role as the critical temperature for the unpolarized gas at finite temperature.
In-medium correlations can be described with the particle-particle RPA (pp-RPA). This approach is based on the formalism of the T matrix at zero-temperature and gives access to the occupation numbers of the spin up and down populations. These occupation numbers are calculated in two different ways, with the Dyson equation truncated at first order and with the complete Dyson equation. These two methods give different results for strong interaction strength. However, in the case of polarized fermion gases, standard pp-RPA overestimates the correlations and therefore the critical polarization. The idea presented here is to use instead a self-consistent approach, called renormalized RPA (r-RPA). The occupation numbers are reinjected into the T matrix until convergence is reached. The main result obtained with r-RPA is the reduction of the critical polarization compared to the standard RPA. We discuss also the asymptotic behavior of the occupation numbers and the value of the contact and some fundamental problems of the theory like the violation of Luttinger's theorem.

*Speaker

Berezinskii–Kosterlitz–Thouless transition in a two dimensional system of dipoles including anisotropy

Raúl Bombín Escudero*[1], Jordi Boronat[2], and Ferran Mazzanti[3]

[1]Department of Physics - UPC [Barcelona] – Spain
[2]Universitat Politècnica de Catalunya [Barcelona] (UPC) – Universitat Politècnica de Catalunya C. Jordi Girona, 31. 08034 Barcelona, Spain
[3]Departament de Fisica i Enginyeria Nuclear, Universitat Politècnica de Catalunya (DFEN, UPC) – Campus Nord B4-B5, E-08034 Barcelona., Spain

Abstract

We study a system of bosonic dipoles that are polarized with all their dipole moments forming a certain angle with the plane that contains their movement. In a previous work the superfluid properties of the different phases that appear in the phase diagram in this system were studied at zero temperature (T=0), showing that both the gas and stripe phase can sustained a superfluid flow. In this work we use Path Integral Monte Carlo technique to extend this study to finite temperature in order to determine the critical temperature T_c at which the transition form superfluid to normal phase occurs. In two dimensional systems this transition is know to be driven by topological vortex that destroy the superfluid signal and follows the Berezinskii–Kosterlitz–Thouless (BKT) scaling. We show that, despite of the anisotropy present when dipoles are tilted, both the gas and the stripe phase follow the BKT scaling allowing us to extract the critical temperature across the phase diagram. We also evaluate the One-Body-Density-Matrix at different temperatures in the stripe phase to show the existence of a quasicondensate below the critical temperature , which is characteristic of the BKT scenario. Finally the melting point of the stripe and solid phase is estimated.

*Speaker

Towards a new generation of density functionals

Kilian Fraboulet*[1], Jean-Paul Ebran[1], and Elias Khan[2]

[1]CEA-DAM-DIF – CEA, CEA – France
[2]Institut de Physique Nucléaire, Université Paris-Sud, IN2P3-CNRS, 91406 Orsay Cedex, France – Université Paris Sud - Paris XI – France

Abstract

Nuclear energy density functionals form currently the only theoretical method able to describe the majority of the nuclear chart with a reasonably good accuracy. However, such an approach suffers from important pathologies implying a violation of Pauli exclusion principle (self-interaction, self-pairing).

A possible solution consists in circumventing these problems by deriving density functionals via functional integral techniques, and more specifically via the effective action formalism. Several methods aiming at constructing the effective action were developed these past twenty years, some are based on functional renormalization group (e.g. the derivative expansion, the Blaizot-Mendez-Schwebor method, Kohn-Sham functional renormalization group) or follow the idea of perturbation theory (e.g. the inversion method).

In this work, we present results for toy models (e.g. 0D-ϕ4 theory), obtained from different approaches as well as from mixtures of them (in particular the merging of the inversion method with functional renormalization group techniques). A new splitting of the effective action, as well as applications to realistic nuclear models, are also discussed.

*Speaker

Auxiliary master equation approach to the pseudogap Anderson model out of equilibrium

Delia M. Fugger,[1,*] Daniel Bauernfeind,[1] Max E. Sorantin,[1] and Enrico Arrigoni[1]

[1] *Institute of Theoretical and Computational Physics, Graz University of Technology, Petersgasse 16/II, A-8010 Graz, Austria*

The auxiliary master equation approach[1,2] allows us to assess the time evolution and, in particular, the steady state properties of quantum impurities and small molecules in as well as out of equilibrium. It is based on a mapping of the physical system to an auxiliary open quantum system, whose dynamics is determined by a Lindblad master equation that we solve with Matrix Product States techniques.

In this poster we present results obtained for the single-impurity Anderson model, which can be used to describe the Kondo effect and Coulomb blockade in quantum dots and nanostructures, in a bath with a power-law pseudogap in the density of states. It is known from the literature[3] that, in equilibrium, this model shows an interesting phase transition from a local moment to a Kondo screened phase, depending on the interplay between the power-law exponent, the hybridization strength and the interaction strength.

We compute the spectral function $A(\omega)$, the self-energy $\Sigma(\omega)$ and the double occupancy in the local moment and in the Kondo phase, in as well as out of equilibrium and study the exponents of $A(\omega)$ and $\Sigma(\omega)$. In equilibrium we compare our results to the ones obtained within a Fork Tensor-Product States solver[4] and get a very good agreement. Further, we find a scheme to access the critical interaction strength, where the phase transition takes place, by extrapolating results for different interactions.[5]

---

* Electronic address: delia.fugger@tugraz.at

[1] E. Arrigoni, M. Knap, and W. von der Linden, Phys. Rev. Lett. **110**, 086403 (2013).
[2] A. Dorda, M. Ganahl, H. G. Evertz, W. von der Linden, and E. Arrigoni, Phys. Rev. B **92**, 125145 (2015).
[3] R. Bulla, M. T. Glossop, D. E. Logan, and T. Pruschke, Journal of Physics: Condensed Matter **12**, 4899 (2000).
[4] D. Bauernfeind, M. Zingl, R. Triebl, M. Aichhorn, and H. G. Evertz, Phys. Rev. X **7**, 031013 (2017).
[5] D. M. Fugger, D. Bauernfeind, M. E. Sorantin, and E. Arrigoni (in preparation).

Quench dynamics of strongly correlated Bosons using the time dependent VMC method

Gartner Mathias*[1,2] and Robert E. Zillich[1]

[1]Institute for Theoretical Physics, Johannes Kepler University Linz (JKU) – Austria
[2]Max Planck Institute of Microstructure Physics – Germany

Abstract

We use the time dependent variational Monte Carlo (t-VMC) method [1] to investigate the dynamics of bosonic systems in three dimensions, subjected to an interaction quench. By using highly flexible trial wavefunctions we demonstrate that the t-VMC method is applicable to strongly correlated, continuous systems, driven out of equilibrium. The temporal evolution of the pair distribution function is compared to quench simulations obtained by time dependent HNC-EL calculations. We additionally simulate interaction quenches in bosonic mixtures, which were observed to form self bound liquid droplets in recent experiments [2,3]. Furthermore, we show that the t-VMC method can be reformulated in imaginary time, which allows for ground state projection of the trial wavefunction. For these ground state calculations weakly bound clusters are studied in the framework of few-body systems, which point out the versatility of the t-VMC method. [1] G. Carleo, F. Becca, M. Schiró, and M. Fabrizio, "Localization and glassy dynamics of many-body quantum systems", Scientific Reports 2, 243 (2012)

C. R. Cabrera, L. Tanzi, J. Sanz, B. Naylor, P. Thomas, P. Cheiney, L. Tarruell, "Quantum liquid droplets in a mixture of Bose-Einstein condensates", Science 359, 301–304 (2018)

G. Semeghini, G. Ferioli, L. Masi, C. Mazzinghi, L. Wolswijk, F. Minardi, M. Modugno, G. Modugno, M. Inguscio, and M. Fattori, "Self-Bound Quantum Droplets of Atomic Mixtures in Free Space", Physical Review Letters 120, 235301 (2018)

*Speaker

Hall effect and transport phenomena in the chiral kagome lattice

Flavia Gómez Albarracín*[1], Héctor Diego Rosales[1], and Pierre Pujol[2]

[1]Instituto de Física de Líquidos y Sistemas Biológicos - (CONICET - UNLP) – Argentina
[2]Laboratoire de Physique Théorique - IRSAMC – Université Toulouse III - Paul Sabatier, Centre National de la Recherche Scientifique – France

Abstract

In this work, we present transport phenomena (anomalous Hall effect, thermal Hall effect) that emerge due to the chiral nature of the magnetic ground state of the extended Heinsenberg model in the kagome antiferromagnet. First, we discuss a model for a "spontaneous" Chern insulator. We consider a 2D electron gas coupled to a classical magnetic background via a strong Hund's coupling. The chosen magnetic background has spontaneous net chirality, which arises from introducing an XXZ anisotropy and an external magnetic field in the Hamiltonian. We analyze the phase diagram as a function of the Fermi energy and the temperature of the classical spins by computing the Density-of-States and the Hall conductance. Second, we propose to explore the effect of the electron gas in the properties of the magnetic background through an autoconsistent method, combining updates of the electronic states and Monte Carlo simulations for the magnetic background. Finally, we discuss the possibility of magnon transport in the anisotropic XXZ model.

*Speaker

Ab initio theory for electroweak properties nuclei

Jason Holt*[1]

[1]TRIUMF – Canada

Abstract

In this talk I will discuss recent advances in the valence-space formulation of the in-medium similarity renormalization group, an ab initio many-body method which expand the scope of ab initio calculations to essentially all properties of light, medium-mass nuclei and beyon. When based on consistently derived two- and three-nucleon forces, as well as two-body currents, these powerful approaches allow first predictions of the limits of nuclear existence and the evolution of magic numbers far from stability. In particular I will focus on recent extensions to fundamental problems in nuclear-weak physics, including a proposed solution of the long- standing gA-quenching puzzle in beta decays, calculations of neutrinoless double-beta decay nuclear matrix elements, and WIMP-nucleus scattering cross sections relevant for dark matter direct detection searches.

*Speaker

Transport and Phonon Damping in He-II

Eckhard Krotscheck*[1], Ketty Beauvois , Henri Godfrin , and Robert Zillich

[1]State University of New York at Buffalo – United States

Abstract

The dynamic structure function $S(k,\omega)$ $inform sabout the dispersion and damping of excitations. We have recently (Phys. Rev. B {97}, 184520 (2018)) compared experimental results for $S(k,\omega)$ from high − precision neutron scattering experiments and theoretical results using the "dynamic many − body theory" (DMBT), showing excellent agreement over the whole experimentally accessible pressure regime. This paper focuses on the specific aspect of the propagation of flow − energy phonons. We report calculations of the phonon mean − free path and phonon lifetime in liquid 4 as a function of wavelength and pressure. Historically, the question was of interest for experiments of quantum evaporation. More recently, there is interest in the potential use of 4 as a detector for low − energy dark matter (K. Schulz and Kathryn M. Zurek, Phys. Rev. Lett. {117}, 121302 (2016)). While the mean free path of long wavelength phonons is large, phonons of intermediate energy can have a short mean free path of the order of μm. Comparison of different levels of theory indicate that reliable predictions of the phonon mean free path can be made only by using the most advanced many − −body method available, namely, DMBT.

*Speaker

Accurate finite PEPS algorithm and gapless spin liquid ground states of spin-1/2 J1-J2 Heisenberg model on square lattices

Wenyuan Liu*[1]

[1]Department of physics,the Chinese University of Hong Kong – Hong Kong SAR China

Abstract

The spin-1/2 square J1-J2 Heisenberg model is one of the most interesting and also challenging quantum spin models, due to the strongly frustrated interactions. It is of the primary candidate models to study quantum spin liquid (QSL). Despite intensively studied in the past 30 years, the nature of the intermediate nonmagnetic phase is still under great debates. Especially, whether the intermediate phase is a QSL is currently a matter of great concern to the community. A recent DMRG calculation suggests that the intermediate region is a valence bond state. However, the DMRG method is essentially a one-dimensional method. Recently, we developed an effiicent and accurate finite projected entangled pair states (PEPS) method, which can deal with a very large system in high precision. Results for benchmark are in excellent agreement with available QMC and DMRG results. With this method, we find the intermedate phase is a spin liquid state without any spin and dimer orders in the thermodynamic limit. By comparing with DMRG in details, we find the spin and dimer correlations both deacy in a power law form, indicating the spin liquid is gapless.

*Speaker

Universality of size-energy ratio in four-body systems

Leandra Vranješ Markić*[1], Petar Stipanovic[2], Andrii Gudyma[3], and Jordi Boronat[4]

[1]University of Split, Faculty of Science (PMFST) – R. Boškovića 33, HR-21000 Split, Croatia
[2]University of Split, Faculty of Science – Croatia
[3]Max Planck Institute of Microstructure Physics – Germany
[4]Universitat Politècnica de Catalunya [Barcelona] (UPC) – Universitat Politècnica de Catalunya C. Jordi Girona, 31. 08034 Barcelona, Spain

Abstract

We present the relationship of scaled size and scaled energy for four-body systems in their ground state, which has been examined using Quantum Monte Carlo simulations. We study in detail the halo region, in which systems are extremely weakly bound. Strengthening the interparticle interaction we extend the exploration all the way to classical systems. Universal size-energy law is found for homogeneous tetramers in the case of interaction potentials decaying predominantly as $r\hat{}\{-6\}$. In the case of mixed tetramers, we also show under which conditions the universal line can approximately describe the size-energy ratio. The universal law can be used to extract ground-state energy from experimentally measurable structural characteristics, as well as for evaluation of theoretical interaction models.

*Speaker

Pair correlations in the normal phase of an attractive Fermi gas

Michele Pini*[1], Pierbiagio Pieri[1], and Giancarlo Calvanese Strinati[3,2,1]

[1]University of Camerino, School of Science and Technology, Physics Division, Camerino (MC) – Italy
[3]CNR-INO, Sede di Firenze (FI) – Italy
[2]Istituto Nazionale di Fisica Nucleare, Sezione di Perugia (PG) – Italy

Abstract

The self-consistent t-matrix approach has been used with success to describe the thermodynamic properties of an attractive Fermi gas throughout the BCS-BEC crossover [1,2,3]. Here, we show its application to the study of pair correlations in the normal phase of the Fermi gas, where a local order persists even if the long-range order of the superfluid phase is lost. A direct evidence of this local order can be extracted from the opposite-spin correlation function, that is computed as a function of coupling and temperature. We also develop a scheme to calculate the number of preformed pairs across the crossover within the same diagrammatic structure. Excellent agreement is found with recent experimental data for the same quantity [4].

R. Haussmann, Phys. Rev. B 49, 12975 (1994).

R. Haussmann, W. Zwerger, Phys. Rev. A 78, 063602 (2008).

M. Pini, P. Pieri, G. Calvanese Strinati, Physical Review B 99, 094502 (2019).

T. Paintner et al., Physical Review A 99, 053617 (2019).

*Speaker

Saturation properties of helium drops from a leading-order description

Artur Polls*[1]

[1]University Barcelona – Spain

Abstract

Saturation properties are directly linked to the short-range scale of the two-body interaction of the particles.
The case of helium is special; on one hand, the two-body potential has a strong repulsion at short distances. On
the other hand, the extremely weak binding of the helium dimer locates this system very close to the unitary limit
allowing for a description based on an effective theory. At leading order of this theory a two- and a three-body
term appear, each one characterized by a low-energy constant. In a potential model this description corresponds to
a soft potential model with a two-body term purely attractive plus a three-body term purely repulsive constructed
to describe the dimer and trimer binding energies. Here we analyze the capability of this model to describe the
saturation properties making a direct link between the low-energy scale and the short-range correlations.We will
show that the energy per particle, EN/N, can be obtained with reasonable accuracy at leading order extending
the validity of this approximation, characterizing universal behavior in few-boson systems close to the unitary
limit, to the many-body system.

*Speaker

Spiral Spin-Liquid and Topological Textures in MnSc2S4

Diego Rosales*[1], Flavia Gómez Albarracín[1], Shang Gao[2], Daniel Cabra[1], and Oksana Zaharko[3]

[1]Instituto de Física de Líquidos y Sistemas Biológicos (CONICET-UNLP), Argentina. – Argentina
[2]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland – Switzerland
[3]Laboratory for Neutron Scattering and Imaging [Paul Scherrer Institute] – Switzerland

Abstract

In recent years, there has been an increasing interest in the emergence of topological phases in condensed matter physics. In particular the magnetic skyrmion, a vortex-like spin structure, is at the center of these studies due to their important role in electronic transport in connection with technological devices. Periodic arrangements of skyrmions, named skyrmion crystal (SkX) phases, have been observed experimentally, and have given rise to a large number of theoretical works. The most simple situation where SkX phases are stabilized corresponds to a ferromagnetic system including Dzyaloshinskii-Moriya (DM) interactions under a magnetic field . Also, it has been shown that the SkX phase can be induced by competing interactions in ferromagnetic and mixed ferro/antiferromagnetic systems. MnSc2S4 is a compound that crystallizes in the normal spinel structure, where the magnetic ions Mn2+ form a diamond lattice, consisting of two interpenetrating fcc lattices. Due to the possible presence of frustrating interactions, this magnetic compound is an excellent example for study exotic states such as spiral spin liquid and and multiple-q structures under applied magnetic fields. Recent experimental results unravel evidence of a spiral spin liquid at low temperature which can be obtained by a J1-J2 model on the diamond lattice, for specific a ratio of the ferromagnetic (J1) and antiferromagnegtic (J2) couplings [1]. However, neutron single crystal diffraction measurements suggest the presence of a triple-q state that can not be explained by such a simple model. Here we present preliminary results obtained by Monte-Carlo simulations and the Luttinger-Tisza approximation, with the aim to explore additional interactions in the microscopic spin Hamiltonian, and establish a minimal model where skrmion-like structures can be stabilized. [1] S. Gao, O. Zaharko, V. Tsurkan, et al. Nature Physics, 13, 157 (2016).

*Speaker

Some new exact results for delta-interacting bosons in one dimension

Zoran Ristivojevic*[1] and Aleksandra Petkovic

[1]Laboratoire de Physique Théorique - IRSAMC (LPT) – CNRS : UMR5152, Université Paul Sabatier [UPS] - Toulouse III, Université Paul Sabatier (UPS) - Toulouse III – 118 route de Narbonne, 31062 Toulouse Cedex 4, France

Abstract

The spectrum of elementary excitations in one-dimensional quantum liquids is generically linear at low momenta. It is characterized by the sound velocity that can be related to the ground-state energy. Here we study the spectrum at higher momenta in Galilean-invariant integrable models. Somewhat surprisingly, we show that the spectrum at arbitrary momentum is fully determined by the properties of the ground state. We find general exact relations for the coefficients of several terms in the expansion of the excitation energy at low momenta and arbitrary interaction and express them in terms of the Luttinger liquid parameter. We apply the obtained formulas to the Lieb-Liniger model and obtain several new exact results.

*Speaker

Electron-hole superfluid condensation in double quantum wells in GaAs-AlGaAs heterostructures

Samira Saberi-Pouya*[1], Sara Conti[1,2], Andrea Perali[2], Andy. F. Croxall[3], A.r Hamilton[4], Francois Peeters[1], and David Neilson[1]

[1]Department of Physics, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerpen, Belgium – Belgium

[2]Supernano Laboratory, School of Pharmacy, Universita di Camerino, 62032 Camerino (MC), Italy – Italy

[3]Cavendish Laboratory, University of Cambridge, J.J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom – United Kingdom

[4]ARC Centre of Excellence for Future Low Energy Electronics Technologies, School of Physics, The University of New South Wales, Sydney, New South Wales 2052, Australia – Australia

Abstract

The development of closely spaced double quantum-well structures in GaAs-AlGaAs heterostructures has led to suggestions that these systems could be used to generate electron-hole superfluidity. Excitonic systems were the first to be proposed for the BCS-Bose Einstein Condensation (BEC) crossover. Pairing spatially separated electrons and holes in adjacent quasi-2D layers in a semiconductor heterostructure avoids the fast electron-hole recombination that usually inhibits formation of coherent equilibrium phases in the bulk. The BCS-BEC crossover has been observed in trapped Fermi ultracold atoms, but technological applications to exploit superfluidity are likely to rely on semiconductor heterostructure devices. In this respect, the recent observation of dramatically enhanced tunneling at equal densities in electron-hole double bilayer sheets of graphene separated by a thin insulating barrier [1] is highly significant. The enhanced tunneling strongly points to an electron-hole superfluid condensate in this system. However, in the electron-hole GaAs quantum well system the experimental results remain less conclusive.
In a series of papers we have demonstrated that electron-hole superfluidity in double layer systems does exist at accessible temperatures, but only at low densities[2]. A striking result is that strong screening of the long-range Coulomb interactions [3] completely suppresses all weak-coupled BCS superfluidity at higher carrier densities. A recent complete DQMC calculation [4] has confirmed the original theoretical predictions which were based on mean field.

Using a self-consistent mean field approach, we determine the ranges for the experimental parameters needed to generate electron-hole superfluidity in GaAs/AlGaAs heterostructures. We find that the required experimental parameters lie within currently attainable values. Because of the very different effective masses of the electrons and holes, the superfluid phase diagram in GaAs is asymmetric with respect to unequal electron and hole densities.

References:

*Speaker

Burg, G. W., et al. *Strongly enhanced tunneling at total charge neutrality in double bilayer graphene-WSe2 heterostructures.* Phys. Rev. Lett. 120 177702 (2018).

Perali, A., et al.,*High-temperature superfluidity in double-bilayer graphene.* Phys. Rev. Lett. 110, 146803 (2013).

Neilson, D., et al., *Excitonic superfluidity and screening in electron-hole bilayer systems.* Phys. Rev. B 89, 060502 (2014).

López Ríos, P., et al. *Evidence from quantum Monte Carlo of large gap superfluidity and BCS-BEC crossover in double electron-hole layers.* Phys. Rev. Lett. 120 177701 (2018).

Inter-component correlations in one-dimensional mass-imbalanced ultra-cold few-fermion mixtures

Tomasz Sowiński*[1]

[1]Institute of Physics of the Polish Academy of Sciences (IF PAN) – Al. Lotnikow 32/46 02-668 Warszawa, Poland

Abstract

With recent experiments on several particles confined in one-dimensional optical traps (fermions as well as bosons), quantum engineering has entered a completely new, so far unexplored, area of strongly correlated quantum systems. In these extremely sophisticated experiments, it is possible to control the total number of particles, their mutual interactions, and the shape of external potential with very high accuracies. Apart from a few exceptions, it has commonly been assumed that particles of different kinds have the same mass and the main impact on properties of the system comes from an imbalance of the number of particles. In my talk, I will discuss the ground-state properties of two-component mixtures of a few fermions of different masses. I will show that in the regime of strong repulsions, independently on the number of particles, a mass difference between fermionic species induces a specific spatial separation in one of the component. Depending on the shape of the external confinement, spatial separation is present in heavier or in the lighter component. Consequently, the ground-state of the system undergoes a specific transition between different orderings when the confinement is changed adiabatically.

In the case of attractive interactions, the mass imbalance also strongly influences the properties of the system. Namely, when the mass ratio is large enough, the many-body ground state of the system changes its structure and it can be viewed as an almost perfect product of the non-interacting ground state of the heavier component and some well-defined state of the lighter particles. In a consequence, inter-component correlations are strongly suppressed and they are almost insensitive to the strength of attractive mutual interactions.

Daniel Pecak, Mariusz Gajda, and Tomasz Sowiński: *Two-flavor mixture of a few fermions of different mass in a one-dimensional harmonic trap*, New J. Phys. **18**, 013030 (2016).

Daniel Pecak and Tomasz Sowiński: *Few strongly interacting ultracold fermions in one-dimensional traps of different shapes*, Phys. Rev. A **94**, 042118 (2016).

D. Pecak and T. Sowiński: *Inter-component correlations in attractive one-dimensional mass-imbalanced few-body mixtures*, Phys. Rev. A **99**, 043612 (2019).

*Speaker

From unique few-body structural properties to the prediction of many-body structures

Petar Stipanović*[1], Leandra Vranješ Markić[1], Jordi Boronat[2], and Andrii Gudyma[3]

[1]University of Split, Faculty of Science (PMFST) – R. Boškovića 33, HR-21000 Split, Croatia
[2]Universitat Politècnica de Catalunya [Barcelona] (UPC) – Universitat Politècnica de Catalunya C. Jordi Girona, 31. 08034 Barcelona, Spain
[3]Max Planck Institute of Microstructure Physics – Germany

Abstract

Few-body exact ground-state estimates are obtained by the diffusion Monte Carlo method and pure estimators [1]. Pure-estimator-algorithm is optimized for usage of large number of walkers and large blocks of steps.

Relationships between $(N+1)$- and (N)-body structural characteristics are analyzed, for model and realistic systems consisting of light atoms and alkali and alkaline earth isotopes [2-5].

Among structural properties we emphasize helium dimers and trimers which can be compared [6] with the most recent experimental results [7-9] obtained by Coulomb explosion imaging of diffracted clusters, and helium-alkali pentamers [10] which already indicate behavior noticed in nanodroplets.

References:

J. Casulleras and J. Boronat, Phys. Rev. B 52, 3654 (1995).

P. Stipanović, L. Vranješ Markić, I. Bešlić, J. Boronat, Phys. Rev. Lett. 113, 253401 (2014).

P. Stipanović, L. Vranješ Markić, D. Zarić, J.Boronat, J. Chem. Phys. 146, 014305 (2017).

P. Stipanović, L. Vranješ Markić, J. Phys. B - At. Mol. Opt. Phys. 51, 155101 (2018).

P. Stipanović, L. Vranješ Markić, A. Gudyma, J. Boronat, Sci. Rep. 9, 6289 (2019).

P. Stipanović, L. Vranješ Markić, J. Boronat, J. Phys. B: At. Mol. Opt. Phys. 49, 185101 (2016).

J. Voigtsberger et al., Nature Communications 5, 5765 (2014).

M. Kunitski et al., Science 348, 551 (2015).

S. Zeller et al., PNAS 113, 14651 (2016).

P. Stipanović, L. Vranješ Markić, Few-Body Syst. 59, 45 (2018).

*Speaker

Turnstile operation for nano-electromechanical systems in the quantum regime

B. Tanatar*[1], V. Moldoveanu[2], R. Dragomir[2], and S. Stanciu[2]

[1]Bilkent University [Ankara] – Turkey
[2]National Institute of Materials Physics – Romania

Abstract

The existing theoretical studies on nano-electromechanical systems (NEMS) rely mostly on i) the non-interacting single-level Anderson-Holstein (SLAH) model and ii) on a markovian master equation [1,2]. As expected, this approach turned out to be very useful when discussing the steady-state transport properties and features like Frank-Condon blockade and vibrational cooling. Recent work [3,4] emphasized that NEMS driven by smooth periodic potentials applied on the electronic system itself reveal new interesting features (e.g. the lifting of the FC blockade).

Here we present non-markovian theoretical calculations for a nano-electromechanical system under turnstile operations. In this setup a vibrational mode is coupled to electrons passing through an open mesoscopic system while the contacts of the latter to source (S) and drain (D) particle reservoirs is driven by square-like potentials $\chi_{L,R}$ oscillating out of phase. We find that both the average vibron number and the displacement associated to the vibrational mode mimic the turnstile driving signals. Moreover, when the system is fully depleted its reduced density matrix collects contributions from different vibronic Fock states. Our method takes into account the spin degree of freedom and the Coulomb interaction and therefore goes beyond SLAH model. The vibron dynamics is explained in detail starting from the time − dependent populations of the fully interacting states of the NEMS. We also point out the effect of the chemical potential of the leads.

Our study proves that the turnstile regime can be used to periodically switch on and off the electron − vibron coupling, as the latter is either present once the system is fully charged, or absent, following its depletion.

G. Piovano, F. Cavaliere, E. Paladino, and M. Sassetti, Phys. Rev. B 83, 245311 (2011).

M. P. Blencowe, Physics Reports 395, 159 (2004).

P. Haughian, S. Walter, A. Nunnenkamp, and T. L. Schmidt, Phys. Rev. B 94, 205412 (2016).

P. Haughian, H. H. Yap, J. Gong, and T. L. Schmidt, Phys. Rev. B 96, 195432 (2017).

*Speaker

Towards finite-temperature tensor network simulations of the two-dimensional Hubbard model

Alexander Wietek*[1] and Miles Stoudenmire

[1]Flatiron Institute – United States

Abstract

The phase diagram of the two-dimensional Hubbard model at finite temperature poses one of the most interesting conundrums in contemporary condensed matter physics. Tensor network techniques, such as matrix-product based approaches as well as 2D tensor networks (PEPS), yield state-of-the-art unbiased simulations of the 2D Hubbard model at zero temperature and are capable of giving unbiased results at finite temperature as well. A promising approach for applying tensor networks to study finite-temperature quantum systems is the minimally entangled typical thermal state (METTS) algorithm, which is a Monte Carlo technique that samples from a family of entangled wavefunctions, and which offers favorable scaling and parallelism. We demonstrate how the METTS algorithm in combination with modern time-evolution algorithms for matrix-product states allows simulating the Hubbard model at finite temperature for cylinder geometries approaching the two-dimensional limit.

*Speaker

Self-bound Bose mixtures

Robert Zillich*[1], Clemens Staudinger[2], and Ferran Mazzanti[3]

[1]Institut fuer Theoretische Physik, Johannes Kepler University Linz (JKU) – Altenberger Straße 69, 4040 Linz, Austria

[2]Institut fuer Theoretische Physik, Johannes Kepler University Linz – Austria

[3]Departament de Fisica i Enginyeria Nuclear, Universitat Politècnica de Catalunya (DFEN, UPC) – Campus Nord B4-B5, E-08034 Barcelona., Spain

Abstract

Under certain circumstances, Bose mixtures can form stable self-bound (liquid) droplets as confirmed experimentally [1,2]. We present our results for self-bound Bose mixtures obtained with the hypernetted-chain Euler-Lagrange (HNC-EL) many-body method, which accounts for correlations non-perturbatively. We discuss the spinodal instability, stability against evaporation and the limits to universality, i.e. our results depend not just on the intra- and interspecies scattering lengths, but also on the associated effective ranges [3]. Furthermore we generalize our treatment to inhomogeneous geometries as realized in experiments. Based on the homogeneous HNC-EL resuls correlations are included in a local density approximation, leading to simple effective mean-field equations for Bose mixtures.

C. R. Cabrera, L. Tanzi, J. Sanz, B. Naylor, P. Thomas, P. Cheiney, and L. Tarruell, Science 359, 301 (2018).

G. Semeghini, G. Ferioli, L. Masi, C. Mazzinghi, L. Wolswijk, F. Minardi, M. Modugno, G. Modugno, M. Inguscio, and M. Fattori, Phys. Rev. Lett. 120, 235301 (2018).

C. Staudinger, F. Mazzanti, R. E. Zillich, Phys. Rev. A 98, 023633 (2018).

*Speaker