Highly correlated systems and general field theory applications

5 - 1 – von Neumann entropy of the Bose-Hubbard model at half-integer densities

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Using the Density Matrix Renormalization Group (DMRG) method, we investigated the entanglement in a one-dimensional boson chain with nearest-neighbors interactions. The measures of entanglement calculated were: one-site, two-site and block von Neuman entropy in order to investigate the quantum phase transition of the Charge Density Wave (CDW) to the Superfluid phase (SF) for half-integer densities. It was observed that the behavior of the block entropy as a function of the number of sites changes from a critical value of the hopping parameter (t), which represents the kinetic energy of the bosons. For values above this critical point, the block entropy tends to behave logarithmically, which agrees with the mean field theory and shows us the presence of the Superfluid phase. For values below that critical hopping this entropy shows an increasing behavior which saturates near the last sites of the chain and therefore represents the Charge Density Wave phase. The one-site entropy as a function of the number of sites also give us information about the quantum phase transition. For the superfluid phase this entropy saturates rapidly while the CDW phase grows smoothly until it reaches a maximum value. Finally we studied the two-site entropy which did not give us information about the phase transition. We found that the von Neumann entropy is a useful quantity to determine the CWD-SF quantum phase transition, which happens at $t_c = 0.1$.

5 - 2 – Quantum Phase Transitions and Kondo Effect in Parallel Double Quantum Dots.

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Semiconductor quantum dots offer the possibility to explore strongly correlated phenomena as well as quantum phase transitions in a highly controllable system. A double quantum dot geometry, in which dot 1 is in the Kondo regime and dot 2 acts as a non-interacting resonant level, can be tuned to access a quantum phase transition between Kondo-screened and free-local-moment phases [1]. Using the numerical renormalization-group technique, we explore the effect of nonzero Coulomb interactions U_2 in dot 2, taking into account two different configurations. In the first one, the dot-2 on-site energy ε_2 is fixed at the Fermi energy. For this instance, a critical value of U_2 separates local-moment and Kondo-screened phases. In the second configuration, the value of U_2 is changed in such a way that dot 2 is always at particle-hole symmetry. In this case, as U_2 is increased, the system evolves from a local-moment to an underscreened spin-1 regime. In both configurations, the on-site energy in dot 1 can be tuned to access a quantum phase transition of the Kosterlitz-Thouless type. Signatures of these behaviors are also reflected in the linear conductance of the system. By calculating the spin-spin correlation functions between the dots and between each dot and the leads, we are able to identify how the Kondo effect develops in each dot and how the spin-spin interactions are distributed throughout the system [2].

[1] L.G.G.V. Dias da Silva, N.P. Sandler, K. Ingersent, and S.E. Ulloa, Phys. Rev. Lett. 97, 096603 (2006). [2] A. Wong, W. Brian Lane, L.G.G.V. Dias da Silva, K. Ingersent, N.P. Sandler and S.E. Ulloa (in preparation).

5 - 3 – The solution of the nonlinear Schrödinger equation using Lattice-Boltzmann

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We present the solution of the nonlinear Schrödinger equation using the lattice Boltzmann method. We show results for one and two dimensions, with several kinds of nonlinear terms. To implement the expansion B.G.K. (Bhatnagar-Gross-Krook), we assume the distribution function as a complex function that satisfies the Boltzmann equation. Moreover, we contrast our simulation results with previous theoretical developments, finding good results.

5 - 4 – 1/2-spin Anderson Model out of equilibrium: conductance and Kondo's Temperature

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We calculate conductance through a quantum dot weak coupled to metallic contacts by means of Keldysh out of equilibrium formalism. We model the quantum dot with 1/2-spin Anderson Model and consider the limit of infinite Coulomb repulsion. We solve the interacting system with the numerical diagrammatic Non-crossing Approximation (NCA) and its extension out of equilibrium. We obtain conductance as a function of temperature and gate voltage, from differential conductance (dI/dV) curves. We discuss this results in comparison with those from the linear response approach which can be performed directly in equilibrium conditions. Comparison shows that out of equilibrium numerical results are in good agreement with the ones from linear response regime supporting reliability to the method employed. The discussion becomes relevant when dealing with general transport models through interacting regions. Left and right couplings could be not proportional preventing the application of linear response approach. We also analyze the dependence of conductance vs gate voltage curve with temperature. We find that it presents a plateau for low temperatures as a consequence of Kondo Effect. Related to this, we discuss different ways to determine Kondo's temperature and compare the values obtained in and out of equilibrium.

5 - 5 – Transport phenomena in a mesoscopic ring threaded by a harmonically time-dependent magnetic flux

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We consider a mesoscopic ring threaded by a harmonically time-dependent magnetic flux in contact to particle reservoirs. We study the behavior of the induced currents between the ring and the reservoirs, as well as the influence of the magnetic flux in the conductance when a small bias is introduced by different chemical potentials of the two reservoirs. We consider a model of non-interacting electrons and solve the problem by recourse to non-equilibrium Green functions.

5 - 6 – Transition between SU(4) and SU(2) Anderson models

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Motivated by experiments in nanoscopic systems, we study a generalized Anderson, which consists of two spin degenerate doublets hybridized to a singlet by promotion of an electron to two conduction bands, as a function of the energy separation δ between both doublets. For $\delta = 0$ or very large, the model is equivalent to an SU(4) or SU(2) Anderson model respectively. We study the evolution of the spectral density and its width in the Kondo limit, for several values of δ using the non-crossing approximation (NCA). As δ increases, the Kondo peaks splits and the Kondo temperature (determined by the half width at half maximum of the peak at the Fermi energy in the spectral density) decreases drammatically.