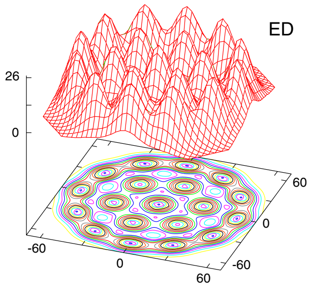

STRONGLY CORRELATED ELECTRONS IN QUANTUM DOTS AND REPELLING BOSONS IN HARMONIC TRAPS

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A two-step method [1] of symmetry breaking at the unrestricted Hartree-Fock (UHF) level and of subsequent post-Hartree-Fock restoration of the broken symmetries via projection techniques is reviewed for the case of two-dimensional (2D) semiconductor quantum dots (QDs; often referred to as artificial atoms and molecules). The general principles of the two-step method can be traced to nuclear theory (Peierls and Yoccoz) and quantum chemistry (Löwdin); in condensed-matter nanophysics, it constitutes a novel many-body approach.

In conjunction with exact diagonalization calculations [2,3] and recent experiments [3,4], it will be shown that this method can describe a wide variety of strongly correlated phenomena in QDs in both the zero and strong-magnetic-field (B) regimes. These include:

(I) Chemical bonding, dissociation, and entanglement in quantum dot molecules [5] and in electron molecular dimers formed within a single elliptic QD [2,3,4], with potential technological applications to solid-state quantum logic gates [6];

(II) Electron crystallization along the vertices of concentric polygonal rings and formation of rotating Wigner molecules (RWMs) in parabolic QDs. At zero B, the RWMs rotate rigidly [7]; at high B, the RWMs are “supersolid”-like, i.e., they exhibit [8] a non-rigid rotational inertia [9], with the rings rotating independently of each other [8].

At high magnetic fields, the two-step method yields analytic many-body wave functions [10], which are an alternative to the composite-fermion and Jastrow-Laughlin approaches, offering a new point of view of the fractional quantum Hall regime in QDs (with possible implications for the thermodynamic limit).

The two-step method can be used [11] to describe crystalline phases of strongly repelling ultracold bosons (impenetrable bosons/ Tonks-Girardeau regime) in 2D harmonic traps. Recent results for rotating toroidal and harmonic traps will be discussed [12].

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