MDD States in 2D Quantum Dots of Non-circular Symmetry

E. Räsänen, H. Saarikoski, A. Harju, M. J. Puska, and R. M. Nieminen

Laboratory of Physics, P.O.B. 1100, FIN-02015 Helsinki University of Technology, Finland

We study the effects of an external magnetic field on two-dimensional non-circular quantum dots by using the (current) spin-density-functional theory. The dot geometry is determined by an infinite hard-wall confining potential, and the electronic structure is solved with a symmetrically unrestricted real-space technique. We investigate how the reduction of the symmetry from circular to polygonal or rectangular geometry changes the behavior of the electron structure as a function of the magnetic field perpendicular to the dot plane. To estimate the role of the interactions, we compare the development of the different spin states to the corresponding non-interacting single-electron spectra.

The emphasis is laid on studying the formation of a maximum-density-droplet (MDD), i.e., a fully-polarized state with the electron occupancy on adjacent orbitals that corresponds to the filling factor $\nu = 1$ in two-dimensional electron gas. Despite the fact that the angular momentum in not a good quantum number in our systems, we find an MDD window at a certain range of the magnetic field in both polygonal and rectangular geometries. The phase is observable between cusps in the chemical potentials for a fully-polarized state, corresponding to Coulomb blockade peaks measured in the experiments. In the MDD regimes, the total angular momentum grows particularly slowly and the electron density remains relatively smooth. However, the hard-wall confinement prevents the formation of constant density distributions in the MDD phase found in parabolic systems, as well as vortices in the electron currents at higher magnetic fields.
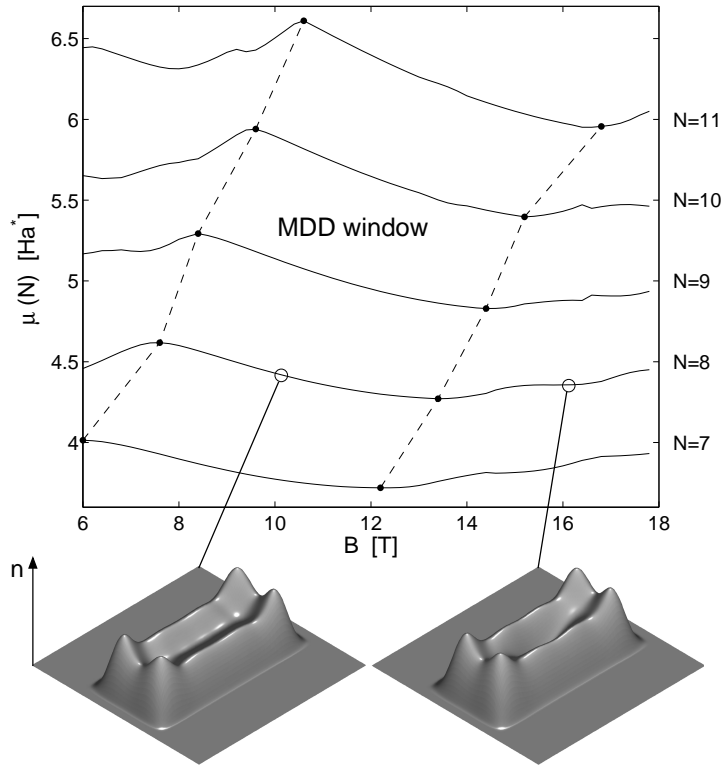

Figure 1: Chemical potentials for the fully-polarized states of a rectangular quantum dot as a function of the magnetic field. The electron densities shown for an eight-electron dot at $B = 10$ T and 16 T correspond to MDD and beyond-MDD regimes, respectively.