# Strong Localization in Circular Quantum Dots

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We investigate the electronic properties of quantum dots in the low density regime up to $r_s \sim 55$ using variational and diffusion quantum Monte Carlo methods. Quantum dots are highly tunable systems that allow the study of the physics of strongly correlated electrons.[1] With decreasing electronic density, interactions become stronger and electrons are expected to localize at their classical positions, as in Wigner crystallization in an infinite two-dimensional system. We have studied several multi-determinantal Slater-Jastrow wave functions, where each Slater determinant is built from single-particle orbitals of very different nature – LDA, Hartree, or floating Gaussian orbitals – all optimized using an energy minimization technique. We study the density, pair-density, power spectrum, and addition energy as a function of increasing interaction strength. Our main findings are: (i) In contrast to the 2D bulk case, the nature of the single-particle orbitals has no significant effect on the fixed node DMC energies or the other quantities we investigate. (ii) For higher values of $r_s$, the configuration symmetry of the quantum dot becomes fully consistent with the classical ground state. (iii) The addition energy shows a clear progression from features associated with shell structure to those caused by commensurability of a Wigner crystal. This cross-over is, then, a signature of correlation-driven localization; it occurs near $r_s \sim 20$. As the addition energy is directly measurable in Coulomb blockade conductance experiments, this provides a direct probe of localization in the low density electron gas.

[1] For our previous work on the subject see A. Ghosal, A.D. Güçlü, C.J. Umrigar, D. Ullmo, and H.U. Baranger, Nature Phys. **2**, 336-340 (2006), and cond-mat/0702666.