

Semiconductor and Graphene Quantum Dots

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We describe here recent theoretical and experimental results on both lateral gated and self-assembled semiconductor quantum dots and on graphene quantum dots. Using LCHO-CI, extended Hubbard, CI and DMRG methods we describe lateral quantum dot molecules with controlled electron numbers in each dot and discuss potential use of such molecules as building blocks of a field effect transistor with a macroscopic quantum state based on artificial Haldane gap material, of a coded qubit based on chirality, GHZ maximally entangled state and Berry's phase generators[1]. We also describe topological phases driven solely by e-e interactions in a quadruple quantum dot molecule[2] and by spin orbit interaction in InAs [3] and HgTe based quantum dots[4]. We next turn to CdTe quantum dots containing single magnetic ions and discuss quantum interference and Kondo-like effects in fine structure of Mn ions interacting with excitons[5] and bi-excitons[6]. Finally, we describe one atom thick semiconductor quantum dots made of graphene and compare them with semiconductor quantum dots. Using a combination of DFT, tb, HF, CI and GW-BSE approaches we show that their electronic, optical and magnetic properties can be engineered by the size, shape, type of edge, topology and number of layers [7-11]. We focus on their optical and magnetic properties, and their control with external gate, carrier density, electric field and light. A possibility of realizing a fully integrated carbon-only quantum circuit will be discussed.

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