Interacting electrons and holes in quasi-2D quantum dots in strong magnetic fields

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Optical properties of interacting electrons in strong magnetic fields are controlled by hidden symmetries[1]. Hidden symmetries can be manipulated by confining electrons and holes in quantum dots. Recent experiments[2] show that it is now possible to examine electrons and holes in quantum dots in the quantum Hall regime. Here we review our work on optical properties of quantum dots with Ne electrons and Nh holes. We discuss the evolution of emission and absorption spectra as a function of the number of electrons Ne and magnetic field. This includes charged excitons, optical observation of Hunds rules, and emission from high filled shells[3-6]. We next move to optically excited dots where carrier population can be injected optically. We briefly discuss hidden symmetries at zero and low magnetic fields, in particular the symmetry associated with bi-excitons and spin, and its manipulation by magnetic field induced degeneracies[2,7]. In the regime of high magnetic field where only lowest Landau level orbitals matter, we discuss a theory of electronic and excitonic quantum Hall droplet (EQHD) at filling factor nu=2. The QHD is made of N=Ne+Nh confined electron-hole pairs which successively occupy the spin-up and spin-down states of the lowest Landau level (LLL). Using the configuration interaction method combined with both effective mass and 8 band k*p single particle energy levels, the electronic properties and optical emission spectrum of a filling factor 2 QHD, as a function of particle number N and magnetic field B, are discussed. For excitonic QHD the characteristic emission spectra are predicted to be related to the total spin of electron and hole configurations.

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