# 行政院國家科學委員會專題研究計畫　期中進度報告

## 自聚型半導體量子點中多激子問題的研究(1/3)

計畫類別： 個別型計畫
計畫編號： NSC93-2112-M-009-020-
執行期間： 93 年 02 月 01 日至 93 年 07 月 31 日
執行單位： 國立交通大學電子物理學系

計畫主持人： 鄭舜仁

報告類型： 精簡報告

處理方式： 本計畫可公開查詢

中　華　民　國 93 年 5 月 24 日

In the past three months, the following tasks required in this project have been done:
**(1)** the set-up of the computation facility and environment at NCTU, Hsinchu, has been completed.
**(2)** the numerical codes that developed by me at national research council of Canada are successfully executed on that computation system.
**(3)** the calculation of the electronic structures (Fig.1) and the emission spectra (Fig.2) of Exciton quantum Hall droplet (QHD) in self-assembled quantum dot, a cooperative work with Pawel Hawrylak and Weidong Sheng at national research council of Canada, has been finished. A journal paper based on the calculation is in preparation.
**(4)** An abstract based on the work **(3)** (see attachment) has been submitted and accepted by the committee of the international conference, the *27th International Conference on the Physics of Semiconductors* (icps-27), which will be held in Flagstaff, Arizona, from July 26 to July 30, 2004.

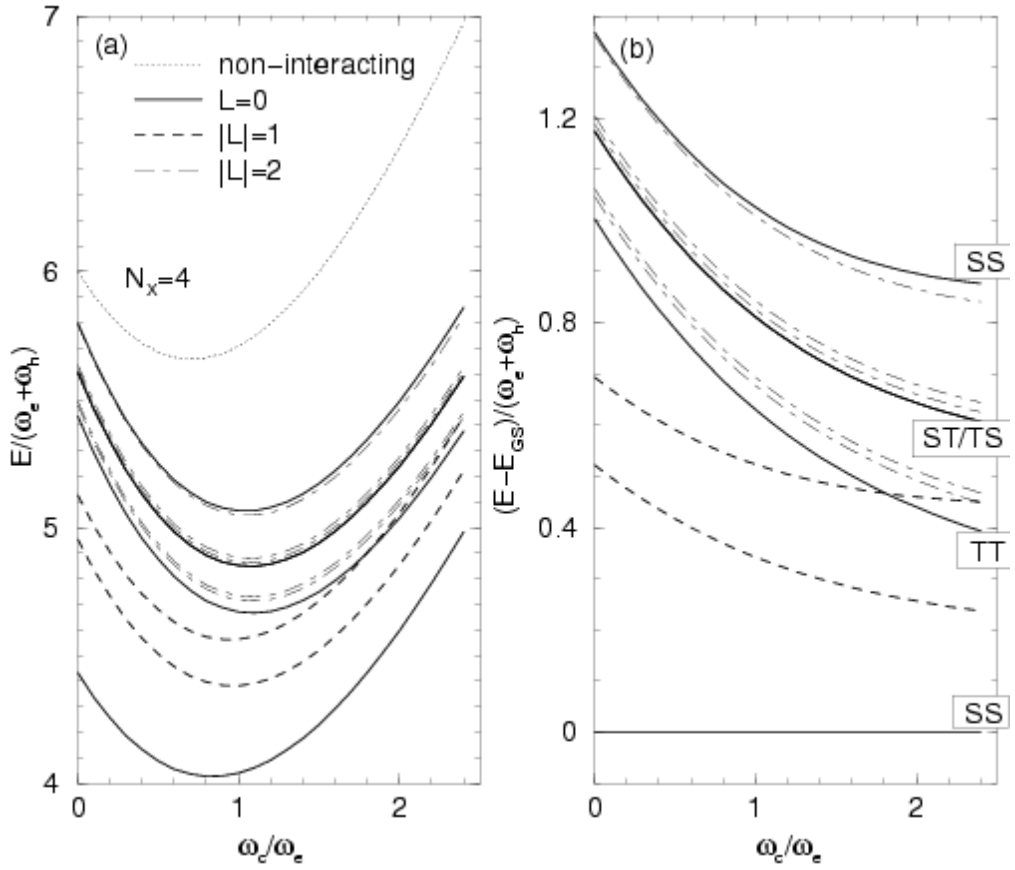


Fig.1 Numerically calculated spectrum of the energy of the QHD with $N_X = 4$ versus magnetic field.

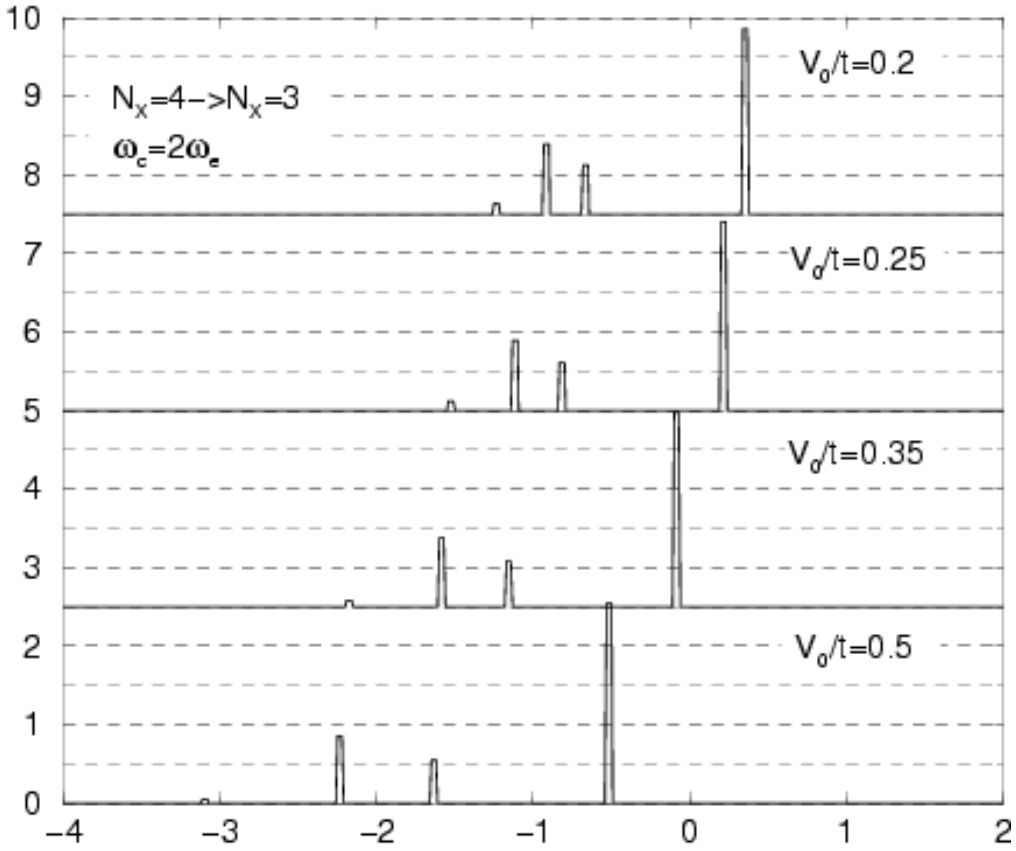


Fig.2 Calculated emission spectrum from QHD with $N_X = 4$ and various the ration of Coulomb interaction strength to the dot confinement, $V_0 / t$ ($t \equiv \eta\omega_e + \eta\omega_h$), in the magnetic filed with cyclotron frequency $\omega_c^e = 2\omega_e$

Attachment: the abstract for icps-27

# Theory of excitonic filling factor 2 quantum Hall droplet in self-assembled quantum dots

*Shun-Jen Cheng (Department of Electrophysics, National Chiao Tung University, Hsinchu 30050, Taiwan, Republic of China), Weidong Sheng, Pawel Hawrylak (Institute for Microstructural Sciences, National Research Council of Canada, Ottawa, Ontario K1A OR6, Canada)*

The integer and fractional quantum Hall effect in strongly interacting quasi-two dimensional and quasi-zero-dimensional electronic systems have been extensively studied.[1,2] Recent advances in self-assembled quantum dots (SAQDs) as well as experiments in high magnetic fields make it possible to examine electrons and holes in the quantum Hall regime. In this work we present a theory of excitonic quantum Hall droplet (EQHD) at filling factor nu=2 in a SAQD subject to a strong perpendicular magnetic field B.[2] The single particle properties of the dots calculated using eight-band k*p theory coupled via Bir-Pikus Hamiltonian with strain calculation are fitted to the harmonic oscillator basis.[3] Using the method of configuration interaction and the technique of exact diagonalization, the electronic properties and optical emission spectrum of a nu=2 EQHD, as a function of Nx and B-field, are calculated in both semi-analytical and numerical manner. For EQHD with even Nx, the topmost two particles can form singlet-singlet (SS), triplet-triplet (TT), or TS/ST states due to particle spin. With increasing B-field, the increasing strength of Coulomb interaction leads to the difference of the B-dependences of the corresponding energy levels. We show that the energy level of the SS ground state (GS) depends on B weakly while the energy level of TT state with zero total angular momentum strongly on B. For the spectrum from EQHD with Nx=2N, there is only one main peak with particularly high intensity, corresponding to the transition from the GS of (2N)-exciton to the GS of (2N-1)-exciton EQHD, while there are two main peaks (involving the SS and TT final states) simultaneously appearing in the spectrum from QHD with Nx=2N+1. Accordingly, we can identify the involved final states for a peak in a measured emission spectrum.[4] The issues of hidden symmetries and spin polarization or the lack with increasing magnetic field are also discussed. [1] L.Jacak, P.Hawrylak and A.Wojs, Quantum Dots (Springer-Verlag, Berlin, 1998). [2] A.Wensauer, M.Korkusinski, and P.Hawrylak, Phys. Rev. B 67, 035325 (2003) [3] W.Sheng and J.-P.Leburton, Phys. Rev. B 67, 125308 (2003) [4] S.Raymond et. al. to appear in Phys. Rev. Lett. (2004)