OPTICAL AHARONOV-BOHM EFFECT IN STACKED TYPE-II QUANTUM DOTS

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Introduction

The properties of charged quantum particles in a magnetic field are periodic with the flux quantum due to the Aharonov-Bohm (AB) phase. The AB phase should [1] also reveal itself for such neutral excitons in type-II QDs via the changes in the excitonic energy and the photoluminescence intensity (PLI). The former was reported in Ref. [2]. The magnetic field dependence of the PLI is not well understood. We show the results of experimental and theoretical studies on magneto-excitons in multiple type-II ZnTe/ZnSe QDs, for which we report the oscillatory behavior of the PLI with the magnetic field.

Experimental

Experiment was done on a 31 T resistive magnet (Cell # 5). The PL was excited by either a HeCd or a frequency doubled Ti:Sapphire laser, for resonant excitation, and was detected through 1m monochromator coupled with a CCD detector.

Results and Discussion

Fig. 1 shows integrated magneto-PL for three samples. The major feature for all samples is a strong peak in the intensity at $B \approx 1.8$ T. Sample 3 also shows a second feature at $B \approx 3.1$T. Theoretically, we explain results as motion of an electron around an entire stack of QDs, one of which is occupied by a hole (Fig. 2(a)). The stack is modeled as a superlattice with each period consisting of a single large dot and seven smaller dots. Fig. 2(b, c) show the lowest electron and heavy hole states vs magnetic field, respectively. The first angular momentum transition is due to electrons and is at $B_1 \approx 1.8$T in excellent agreement with experiment. The difference between electron and hole localization is seen in Fig. 2(d). The computed exciton binding energy (B =0T) is 7.3meV, in agreement with measured 8meV. The 3.1T feature is due to elongated shape of the dots (stacks), for which the dipole emission is allowed for an arbitrary angular momentum.

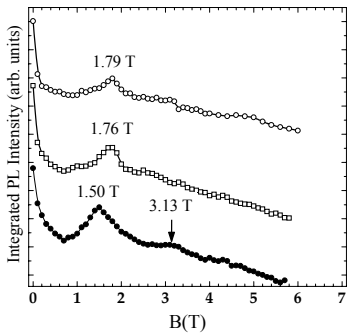

Fig. 1. Integrated magneto-PL from three ZnTe/ZnSe type-II QD samples grown with increasing Te content (from top to bottom).

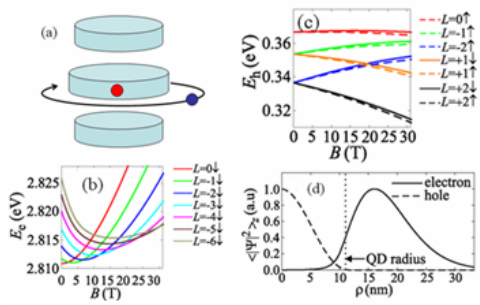

Fig. 2. (a) Model of stacked QDs; (b) The electron levels vs magnetic field. (c) The heavy hole levels vs magnetic field. (d) The probability densities of the ground electron and hole states averaged over z, B = 0 T.

Conclusions

In multiple type-II ZnTeSe/ZnSe QDs with thin spacers the electron wavefunction is localized around the radial periphery of QD stack, resulting in a favorable situation for the occurrence of the AB oscillations, which we have indeed observed.

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References

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[2] E. Ribeiro, et al., Phys. Rev. Lett. **92**, 1264021 (2004).