Introduction

Recent theoretical studies\(^1\)\(^-\)\(^3\) on the optical response of excitons in type-II quantum dots, where carriers are spatially separated, in the presence of the external magnetic field have shown that the excitons will acquire the Aharonov-Bohm (AB) phase as the electrical dipole, formed due to carrier separation, interacts with the field. Thus, the exciton energy as well as the intensity of the excitonic emission becomes field dependent\(^1\)\(^-\)\(^3\). Experimentally, the former has been recently observed\(^4\); however, the behaviors of the emission intensity are still not fully understood.

We investigate, by means of magneto-photoluminescence (PL), type-II ZnTe/ZnSe QDs (holes confined within ZnTe QDs) formed in a Zn-Se-Te multilayer system\(^5\). This ensured a required\(^1\)\(^-\)\(^3\) disk-like symmetry with the electron wavefunction “pushed” to the sides of the dots\(^3\), leading to a strong AB signature as the electrons rotate around QD stacks\(^3\).

Experimental

The experiments (\(T = 4.2K\)) were performed at the NHMFL 25T, 52mm bore, magnet (Cell 6), using the 351nm line of an Ar\(^+\) laser, a 1m monochromator, and a nitrogen cooled CCD camera.

Results and Discussion

Fig. 1 shows the integrated PL intensity as a function of the magnetic field. The overall intensity decrease is due to magnetic-field-induced carrier localization\(^6\). In addition, we observe strong oscillations in the intensity with peaks at \(B\sim 1.5T\) and \(\sim 3.1T\). We argue that these oscillations are due to the AB effect\(^1\)\(^-\)\(^3\). The decrease of the PL intensity occurs at the magnetic field\(^1\)\(^-\)\(^3\), \(B_1=\Phi_0/2\pi R^2\) (\(\Phi_0\) is the magnetic flux quantum), for which the ground state of the exciton will acquire non-zero total angular momentum, \(L\), resulting in the PL quenching. The peak at 1.5T is due to such an angular momentum transition. In the case of non-spherical dots the selection rules are relaxed and the dipole emission is allowed for \(L=2,4,...\), so more features can be observed at \(T\sim 0K\). For instance, a weak increase in the PL intensity at \(B_2=\Phi_0/\pi R^2=2B_1\) has been predicted\(^7\). We indeed observe such a feature at \(\sim 3.1T\). Finally, using the first angular momentum transition, we estimate that the QDs are \(\sim 22nm\) in radius.

Conclusions

We have observed, for the first time, the optical Aharonov-Bohm effect in the emission intensity of neutral excitons in quantum dots. A paper with complete results is in progress and will be submitted to PRL.

References