Decoherence of Aharonov-Bohm Excitons in Type-II Quantum Dots

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Introduction

The Aharonov-Bohm effect (ABE) is one of the most important manifestations of quantum phase coherence, with wide use in mesoscopic transport measurements, where, however, contacts play a significant role. The ABE is also observed in magneto-photoluminescence (PL) of polarized excitons in type-II quantum dots (QD) – this is so-called 'excitonic ABE' [1]. Magneto-PL is a contactless technique, which can directly probe the phase coherence without complication associated with contacts and contact configurations. We thus investigate ABE decoherence via temperature dependent magneto-PL studied on several samples consisting of stacked type-II ZnTe/ZnSe QDs.

Experimental

The experiments were performed at the NHMFL on the 18/20 T Superconductor SCM-2 Magnet equipped with specially designed optical probe.

Results and Discussion

In Fig. 1 we show the magnitude of the AB peak as a function of temperature (solid circles) for one of the samples. Assuming that this magnitude is directly proportional to the decoherence time, we fitted (the dashed line) the data for $T > 3$ K using the model of a 1D ballistic electron, undergoing scattering due to both electron-phonon and electron-electron interactions. The equation we employed and fitting parameters are shown in the figure. For $T < 3$ K additional studies are required to account for the sample heating by a laser beam, and these are in the future plans.

Next we report 'unexpected' results for samples grown using one Zn-Te-Zn cycle; these samples in addition to type-II QDs PL show emission due isoelectronic bound excitons (IBE) [2]. The integrated magneto-PL intensity at 0.35 K for the IBE spectral range is shown in Fig. 2. It is clearly seen that in addition to the 'standard' AB peak (~2.07 T) two other peaks appear. These peaks have never been observed at $T > 5$ K [2]. Two causes are considered: (i) formation of 2D IBE due to multilayer nature of the samples and (ii) a spin-orbit coupling or electron-hole exchange interaction at strongly bound excitons. If the case of the former, it would be the first observation of the ABE at point defect

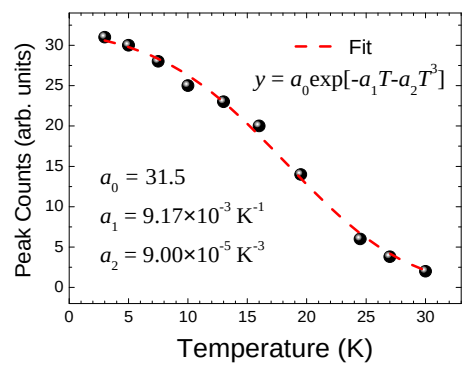

Fig. 1: The AB 'peak' as a function of temperature

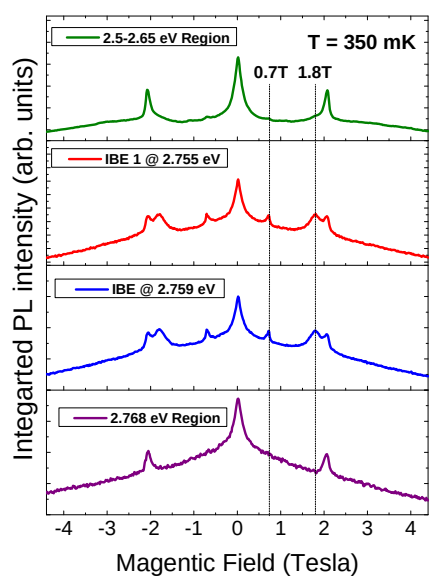

Fig. 2 Integrated PL intensity vs magnetic field for the IBE spectral region

Conclusions

It was found that above 3 K, decoherence of excitonic ABE occurs via electron-phonon scattering. We also discovered the AB-like peaks in IBE emission, which we attributed to formation of two-dimensional bound excitons as well as strong spin-orbit coupling in ZnTe QDs.

Acknowledgements

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References

[1] Kuskovsky, I. L., *et al.*, Phys. Rev. B, **76**, 035342 (2007)
[2] Roy B., *et al.*, Phys. Rev. B, **86**, 165310 (2012)