Trionic Instability in CdTe Quantum Wells at High Magnetic Field

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Introduction

Two-dimensional electron gases (2DEGs) in semiconductor quantum wells (QWs) provide a robust ensemble spin system with relatively long decoherence times. In contrast to other solid-state ensemble spin systems, such as quantum dots, 2DEGs exhibit low inhomogeneous broadening and high optical density. We have previously demonstrated optical spin control [1,2] and electromagnetically induced transparency (EIT) using 2DEGs in a modulation-doped CdTe QW.

Optical access to this spin system is possible because of the formation of trions, which provide a shared excited state for electron spins. In Voigt-oriented magnetic fields up to 5T, the spins may be split by up to 0.5 meV (g=1.6) and linked by cross-polarized dipole couplings to a mixed trion state [3, **Figure 1**]. However, this splitting is much smaller than the transition's intrinsic linewidth, limiting its viability for efficient EIT.

In this report we investigate the behavior of the trion resonance at magnetic fields of up to 25T, seeking a regime where the spin splitting is on the order of the trion linewidth.

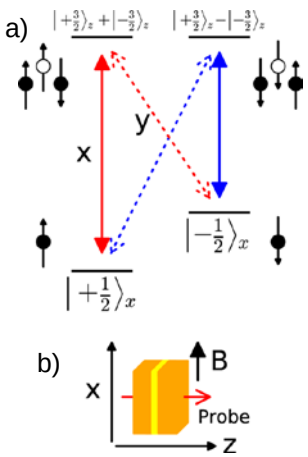

Figure 1: a) Optical selection rules for trion resonances in CdTe quantum wells.
b) Sample geometry.

Experimental

Absorption spectra of a CdTe QW were measured using attenuated pulses from a broadband Ti:Sapphire laser. In-plane magnetic fields (Voigt geometry) were applied using the 25T split-bore magnet in the DC field facility in Tallahassee. The sample was cooled to 6K using the new cryogenic insert.

Results and Discussion

Figure 2 shows the CdTe absorption spectrum as a function of the applied field. The oscillator strength of the trion is observed to reduce as the field is increased. A splitting in the exciton resonance leads to a greater overlap with the trion, indicating that the trion binding energy is reduced at high Voigt fields. This behavior is independent of polarization of the probing field.

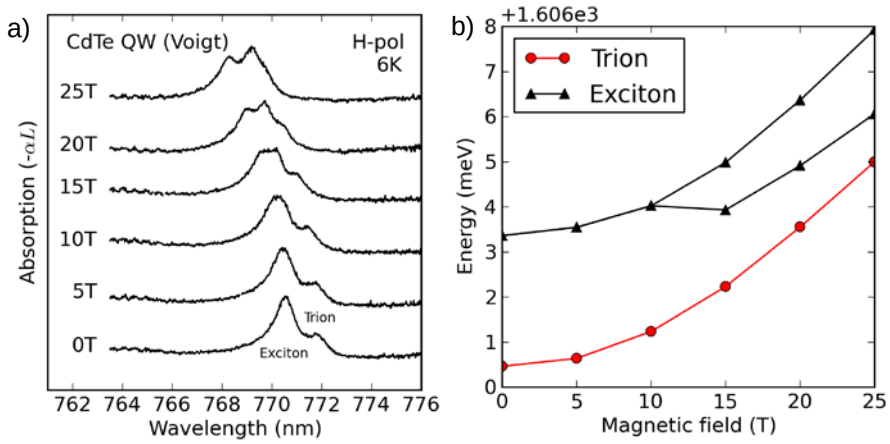

Figure 2: a) Absorption spectra of the CdTe QW show trion oscillator strength diminishes in high magnetic field. b) Binding energies of excitons and trions as a function of magnetic field strength.

Conclusions

We find that the trion complex becomes unstable at high magnetic fields, before splittings of the desired magnitude are achieved. For this reason, CdTe QWs in high fields are likely not a viable candidate for high-magnitude EIT. Even at intermediate field strengths (e.g. 15T), the strongly overlapping exciton would likely mask optical access to the trion via manybody effects.

Acknowledgements

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References

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