NEW YORK CITY COLLEGE OF TECHNOLOGY
Physics Department
Center for Theoretical Physics

Excitonic Aharonov-Bohm Effect in Type-II Quantum Dots

Presented by:

Prof. Igor L. Kuskovsky
Queens College of CUNY
Queens, NY

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Abstract

The Aharonov-Bohm (AB) effect is typically discussed for a quantum charged particle moving along a trajectory enclosing a magnetic flux. There, however, exists a possibility of the AB effect associated with an overall neutral quasi-particle that possesses a radial electric dipole moment (e.g., an exciton in quantum ring or cylindrical type-II quantum dot (QD)). Excitons in type-II QDs are particularly interesting, due to relatively larger spatial separation of charged particles. We present results of magneto-photoluminescence (magneto-PL) studies on stacked submonolayer type-II ZnTe/ZnSe QDs. The AB phase reveals itself in magneto-PL of type-II QDs since, due to the cylindrical symmetry, the exciton ground state initially has a zero orbital angular momentum, which changes to higher values with increasing magnetic field. This transition of the angular momentum to a non-zero value with increasing magnetic field is observed in two ways: (i) in the changes of the exciton ground state energy and (ii) in the quenching of the excitonic PL intensity due to PL selection rules. In the figure we show effects of the applied magnetic field on the integrated intensity of the PL as a function of the magnetic field. The broad peak at ~1.42 T is assigned to the AB transition. To explain the observations, we first point out that single electron density calculations show that the electron, in the absence of strain, will be located either above or below the dot and, therefore, no AB signature is expected. In our case, the stacked character of the systems ensures that the electron's wave-function is "pushed" to the side of the dot due to electron-electron interaction, independent of stress, whereas cylindrical geometry nicely defines the ring-like trajectory for an electron. We thus explain the results as a motion of an electron around an entire stack of QDs, one of which is occupied by a hole (see inset in the figure). In addition we shall also show how the excitonic AB effect can be used to measure size of type-II excitons with sub-nanometer precision and discuss the role of the built-in electric field. Finally, we will show some very recent results of temperature dependent magneto-PL, which we use to investigate quantum phase coherence, without 'worrying about contacts' and show that decoherence is perfectly explained by 1-D ballistic theories.

Light refreshments will be served.