PHYS4801 Seminar: Abstract and Outline

Group 1: Exciton in two-dimensional materials

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Abstract

Compared to 3-D semiconductors, atomically thin 2-D materials have several advantages. First, their $1\,nm$ scale thickness provides possibilities for more miniaturized devices. Second, due to the atomically thin nature, less electrical screening effect greatly enlarges the Coulomb interaction between electrons and holes such that the binding energy of 2-D semiconductors is usually one order of magnitude larger than that of 3-D. This allows diverse exciton devices at room temperature. However, light-emitting devices based on 2-D semiconductors suffer from low quantum yield, typically less than 1%. In this presentation, we introduce the formation of the excitons, and their energy structures. Moreover, one kinetic model is introduced to explain the luminescence behavior of excitons, and this model provides possible solutions for improving photoluminescence (PL) QY to near unity.

Outline:

1. Introduction and basic concept of exciton
    a. Quasiparticle, the entanglement of electron and hole
        i. Form of exciton
        ii. Bound state of excited electron and hole
    b. The “living” environment of exciton
        i. Special potential
    c. The energy of exciton in the Bohr model favor
        i. Typical 3-D energy levels
        ii. Special 2-D case
    d. Recombination behavior of different forms of exciton in the 2-D system
        i. Trion
        ii. Biexciton
2. Improving PL QY of 2-D material
    a. Kinetic model and parameter extraction from experimental data
    b. Experimental ways of improving PL QY
3. Conclusion