Possibilities for Bose-Einstein condensation in individual carbon nanotubes

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We show that carbon nanotubes (CNs) offer a testing ground to study the fundamentals of condensed matter physics in one dimension (1D). Specifically, we discuss possibilities for the 1D Bose-Einstein condensation (BEC) phenomenon that originates from the strong coupling of excitons and low-energy inter-band plasmons enabled via the quantum confined Stark effect by using an external electrostatic field applied perpendicular to the CN axis. This affects the exciton-plasmon coupling in individual semiconducting CNs [1], mixing excitons and inter-band plasmons of the same band, to result in strongly coupled hybridized excitations – exciton-plasmons in one individual nanotube [2]. Such hybridized excitations are strongly correlated collective Bose-type quasi-particles and, therefore, could likely be condensed under appropriately created external conditions – in spite of the well-known statements of the BEC impossibility in ideal 1D/2D systems [3] and experimental evidence reported earlier for no exciton BEC effect in carbon nanotubes [4]. Possibilities for achieving BEC in 1D/2D systems are theoretically demonstrated earlier in the presence of an extra confinement potential [5]. We show that the strongly correlated exciton-plasmon system in the semiconducting CN presents such a special case. We find the critical BEC temperature, as well as the condensate fraction and its exciton contribution as functions of temperature and electrostatic field applied. We discuss how the effect can be observed experimentally.

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