Magneto-Photoluminescence Spectroscopy of Carbon Nanotube Films

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Introduction

Recent experiments confirm the existence of an optical inactive ("dark") exciton in micelle-suspended single-walled e carbon nanotubes, which is energetically situated below the first optically active ("bright") exciton state and explains the observation of relatively low photoluminescence (PL) in SWNT's[1,2]. At low temperatures, the magnetic field results in a dramatic brightening of the photoluminescence, while, at higher temperatures, magnetic brightening was found to be much less pronounced at higher temperatures. This has been attributed to the small energy splitting, Δ_x, of the dark-bright state, which results in a finite population in the bright state at higher temperatures even in zero applied magnetic field, leading to a proportionate reduction in the amount of brightening. Current models describing the effects of these dark and bright exciton states in carbon nanotubes rely on parameters such as Δ, the effects of disorder, defects, and the effects of the local electronic environment, which are currently poorly understood. In this experiment, we have performed a comparative study of SWNT in several films in order to help ascertain the effects of disorder on the observation of PL in SWNT and to provide a clearer picture of the electronic structure of the dark and bright exciton states in semiconductor SWNT's.

Results and Discussion

We have measured the photoluminescence spectrum of several samples of carbon nanotubes in the 45 T hybrid magnet at NHMFL. These samples all derive from the same single-strand DNA (ss-DNA) wrapped CoMoCAT solution. The first sample is suspended in poly acrylic acid (PAA) and divided into two pieces; one is stretched in order to orient the carbon nanotubes while the other is left unstretched with a random tube orientation. Figure 1 shows the amplitude of the photoluminescence emission from the (6,5) SWNT peak as a function of magnetic field strength. In the aligned SWNT sample, the magnetic brightening is larger than in the unaligned film, consistent with magnetic brightening due to the Ahraonov-Bohn phase in both ordered and unordered carbon nanotubes films[3].

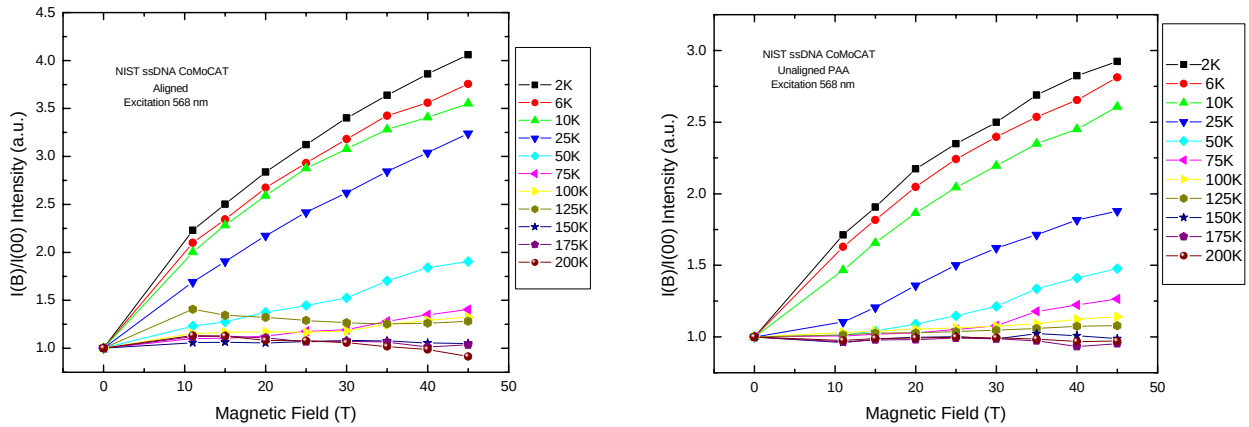

Figure 1: Photoluminescence intensity as a function of applied magnetic field at temperatures ranging from 2 K to 200 K.

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