Magnetic Brightening of Dark Excitons in Carbon Nanotubes

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To gain insight into the internal energy structure and radiative properties of excitons in single-walled carbon nanotubes, we have studied photoluminescence from individualized HiPco and CoMoCAT samples as a function of magnetic field (B) and temperature (T). In pulsed-field experiments (<60 T), we used film samples and varied T from 4.2 K to room temperature; photoluminescence intensity increased, or "brightened,"with B and the amount of brightening decreased with T. In steady-field experiments (<45 T), we used micelle-suspended nanotubes at room temperature; photoluminescence peaks showed B-induced splitting with B-dependent relative intensities. These results are consistent with the existence of a dark state below the first bright state [1]. Magnetic flux removes K-K valley degeneracy, producing two equally-bright states at high B [2,3]. We calculate photoluminescence spectra through B-dependent effective masses, populations of finite-k states, and acoustic phonon scattering.

References: [1] See, e.g., H. Zhao and S. Mazumdar, Phys. Rev. Lett. 93, 157402 (2004); V. Perebeinos et al., Nano Lett. 5, 2495 (2005); C. D. Spataru et al., Phys. Rev. Lett. 95, 247402 (2005). [2] T. Ando, J. Phys. Soc. Jpn. 75, 024707 (2006). [3] S. Zaric et al., Science 304, 1129 (2004); Phys. Rev. Lett. 96, 016406 (2006).