Low Temperature Magneto-Photoluminescence of SWCNTs

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In this abstract we report low temperature photoluminescence (PL) data using selective polarized excitation and collection of emission from nanotubes both parallel and perpendicular to an applied magnetic field (up to 19.5T). We report findings on both alignment-dependent intensity changes and band gap shifts.

In order to study nanotubes aligned with different geometries with respect to an applied field a solution of polyvinylpyrolidone (PVP)-wrapped suspended HiPCO SWCNTs (from Carbon Nanotechnologies) in D_2O was first quenched in liquid nitrogen, and then transferred to the magnet bore, at a constant temperature of 4.2K. The initial quenching of the SWCNT solution sample fixes an isotropic geometric distribution of the nanotubes and prevents preferential axial alignment of the tubes with increasing applied magnetic fields. It has been shown [1] both that for PL excitation and emission the intensity is a maximum when the electric field of the radiation light source is along the tube axis. The samples were illuminated in the Voigt configuration with k ? B. A rotateable linear polarizer was placed between the excitation source and the frozen solution and the luminescence collected back through the polarizer. With this arrangement tubes with different alignments to the field were able to be both selectively excited and then their luminescence preferentially observed.

The PL intensities were found to be strongly enhanced by magnetic field, with the largest enhancement (by factors of up to 2.5 in 19.5T) observed for tubes aligned perpendicular to the field. The magnetic field enhancement was also strongly diameter dependent, with the smallest diameter tubes showing the largest increase in intensity. We attribute this behaviour to changes in the electron-hole transport in the tubes, with the additional Lorentz force acting to reduce the probability of carrier diffusion away from the original excitation point.

There has been considerable interest in the possibility that the additional Aharanov-Bohm flux threading tubes aligned parallel to the field could cause a red-shift of the band gaps of semiconducting nanotubes. Our results are consistent with this suggestion, with the red shifts observed being comparable to the values estimated using the A-B assumptions and being significantly larger for nanotubes oriented parallel to the field. Nevertheless tubes aligned perpedicular to the magnetic field still show significant red-shifts, suggesting that other factors such as exciton binding energies may also need to be taken into account.

References:

[1] J. Lefebvre, et al *Phys. Rev. B* **69**, 075403 (2004)