Temperature dependence of photoluminescence and the role of dark excitons in SWCNTs

Ian B Mortimer, Robin J Nicholas

Clarendon Laboratory, Oxford University, Parks Road, Oxford, OX1 3PU, UK

Contact e-mail: *i.mortimer1@physics.ox.ac.uk*

We report experimental evidence for transfer between bright and dark exciton states in SWCNTs from a detailed study of the temperature dependence (1.5K to 250K) of the photoluminescence (PL) emission at both zero and high magnetic fields (19.5T). At zerofield PL emission is found to peak at temperatures between 20 and 100K, depending on the chiral indicies of the tube. At high temperatures the PL emission change is dominated by the temperature dependence of the radiative lifetime for a parabolic 1-D exciton ($T^{1/2}$), thus showing that dark excitons do not play a significant role in high temperature PL. At lower temperatures the emission falls due to an enhanced probability for excitons to populate the dark-exciton states. Analysis of the temperature dependence of the emission intensity suggest that the dark-light exciton splitting is strongly tube diameter dependent and is much smaller than has previously been suggested, with values in the range 1-5meV. This small splitting suggests that the majority of transfer to the dark exciton states takes place within the spin-singlet bands. When a high magnetic field is applied the PL is no longer suppressed at low temperatures, suggesting that the magnetic field acts to lower the probability of excitons populating the dark states.