Saturation, spectroscopy and time correlated studies of single-walled carbon nanotubes

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Singled-Walled Carbon Nanotubes (SWNTs) are a 1D model system that can be used to study exciton photophysics. High binding energies suggest that excitonic effects may dominate all aspects of the optical properties of carbon nanotubes [1]. Theoretical calculations predict 4 singlet states, one of which can radiatively recombine with the ground state (a bright state). Although progress has been made in the study of the excitonic states in SWNTs, there is still much to investigate. In particular, the dynamics and decay of various excitonic states (between dark and bright states) is still unclear as well as the environmental effects on the band edge structure [2].

We investigate individual SWNT optical properties through continuous wave and time resolved micro-photoluminescence (PL). This technique avoids complications due to inhomogeneous broadening in ensemble measurements. Our CW experiments focus on power dependence and saturation behavior of the lowest energy bright exciton state (Fig. 1). This is explained by multi-excitonic effects, namely Auger recombination and exciton-exciton annihilation [3]. Interestingly, at high excitation intensities, side-band peaks are observed (Fig.1. This side-band has been associated with a exciton-phonon coupling to a higher energy, finite angular momentum dark-state [4,5]. Our time resolved experiments were performed as a function of temperature and give insight to bright-dark state coupling at low temperatures. We observe a bi-exponential behavior with temperature dependant decay rates (Fig. 2) .

In summary, we have used different approaches to obtain information on the exciton dynamics in a 1D system through the optical properties of SWNTs.

References:

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[3] Heinz T.F. *et al*, Ultrafast Phenomena XV, **88** (2007), 683-685
[4] Y. Murakami *et al*, Phy Rev B, **79** (2009), 195407
[5] O.N. Torrens et al, Phys. Rev. Lett., **101** (2008), 157401

Figures:

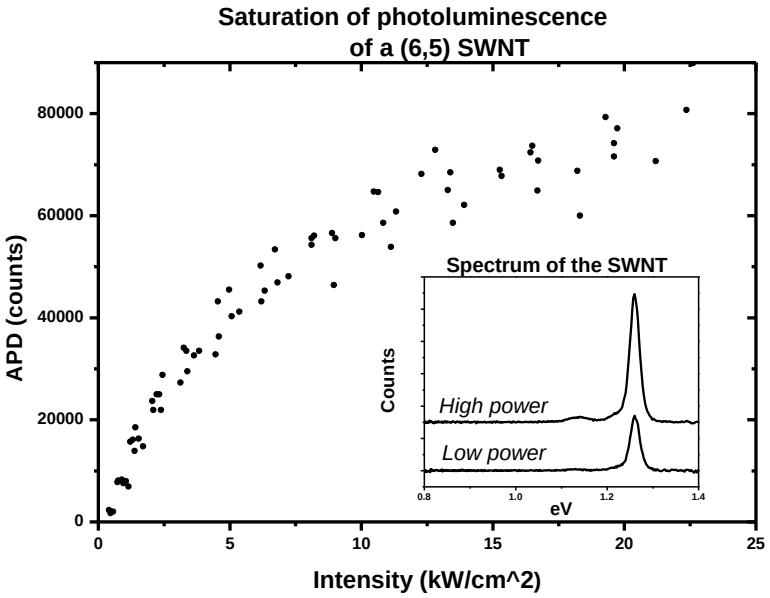

Fig 1: Saturation curve and spectrum of a SWNT

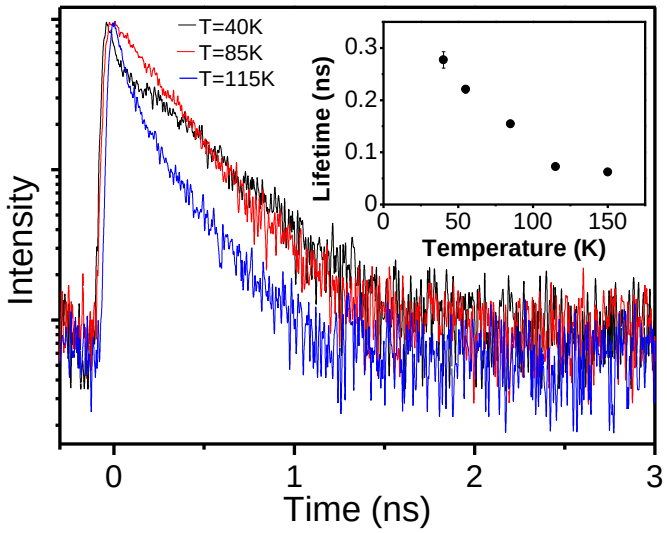

Fig.2: Normalized decay curves at different temperatures