Multi-Particle Excitations in Doped Single-Walled Carbon Nanotubes

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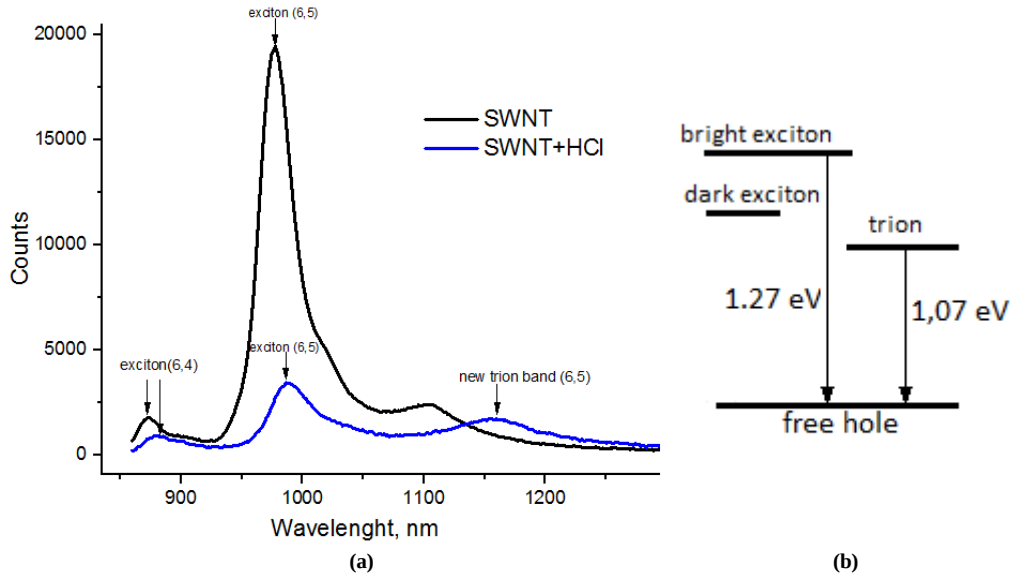
Doping of single-walled carbon nanotubes leads to spectacular changes of their optical and electronic properties. Commonly used doping technique via filling of nanotubes with dopants deal with films or powder of nanotubes making photoluminescence studying complicated due to fast irradiative relaxation of electronic excitations in bundles. However, doping can also be performed via adding of dopants to the solution of individual nanotubes.

We report a comprehensive study of changes of optical properties of single-walled carbon nanotubes caused by doping in acid medium. In this work, hydrochloric acid was added to an aqueous solution of nanotubes wrapped with sodium cholate. Besides the suppression of RBM modes in a Raman scattering spectrum and the suppression of the first optical transition in an optical absorption spectrum, we observed the emergence of a new band in a photoluminescence spectrum at approximately 200 meV below the main photoluminescence band (Fig.1a). This new band was assigned to trions, quasiparticles consisting of two holes and one electron [1]



(a) **(b)**

Fig.1 (a) Photoluminescence spectrum of initial SWNT suspension (black line) and SWNT suspension with added HCl (blue line). Excitation wavelength is 570 nm (b) Energy level diagram.

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[1] Matsunaga, Ryusuke, Kazunari Matsuda, and Yoshihiko Kanemitsu. "Observation of charged excitons in hole-doped carbon nanotubes using photoluminescence and absorption spectroscopy." *Physical review letters* 106.3 (2011): 037404.