UNIVERSITY OF TEXAS AT DALLAS - DEPARTMENT OF PHYSICS

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The First, Low Temperature, Photoluminescence and Photoluminescence Excitation Studies of Individual Carbon Nanotubes

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Semiconducting, single walled carbon nanotubes that emit light in near infrared spectral regime have great potential for a wide variety of optoelectronic applications. A detail understanding on intrinsic nature of fundamental optical excitation in nanotubes is essential to fully exploit this potential. Here in this talk, I will present the first single nanotube, low temperature photoluminescence (PL) and PL excitation (PLE) studies conducted to attain this understanding.

In our PL spectra, we observed sharp (from sub-meV to a few meV), symmetric spectral lines of 1D excitons together with asymmetric peaks that show strong thermal broadening only on their steep high-energy sides. The asymmetric shape as well as the strange thermal behavior of these peaks could be explained in terms of the Fermi edge singularity effect that arises from many-body interaction of carriers that are unintentionally introduced into some nanotubes during sample preparation.

Our PLE spectra show features related to direct excitations to the second electronic states as well as those related to strong phonon-assisted transitions involving excitations of one or more phonon modes together with the first electronic state. Surprisingly, these phonon replicas are as intense as the direct excitations of the second electronic state, which involve no phonons. In contrast to a small width of emission lines, most of the PLE features are characterized by tens of meV linewidths. All of these observations suggest that strong electron-phonon coupling gives rise to a significantly more complex structure of nanotube absorption spectra than it is assumed in a simple picture of optical transitions dominated by singularities in the one-dimensional energy spectrum.