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Optical Spectroscopy of Individual Single-Walled Carbon Nanotubes by Rayleigh Scattering

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Optical spectroscopy of *individual* nanostructures has greatly enhanced our understanding of nanoscale physics. For single-wall carbon nanotubes (SWNTs), there is a particularly strong motivation for such techniques, since the properties of SWNTs vary enormously with their precise physical structure. To date, both fluorescence and Raman scattering have shown the sensitivity to probe individual SWNTs. While fluorescence is an excellent experimental method, it is limited to semiconducting nanotubes displaying reasonable fluorescence efficiency. Raman scattering provides complementary information, but is weak and requires the identification of an electronic resonance to observe a signal. In this paper, we describe a new spectroscopic approach for investigating individual SWNTs and other nanostructures.[1] The method is based on Rayleigh scattering. The approach has the advantage of relying on the ubiquitous linear polarizability of the material, a response present for fluorescing and non-fluorescing species alike and displaying resonances at the transition energies of the system. This method has yielded high-quality spectra over the visible and near-IR spectral range from both individual semiconducting and metallic SWNTs. A key element in the experiment is use of supercontinuum radiation as the light source. This source, produced by passing femtosecond laser pulses through a microstructured fiber, provides radiation with the broad spectrum of a light bulb, but with the brightness of a laser. The experiment also employs SWNTs suspended across slit structures and viewed in a dark-field configuration to eliminate background scattering. Rayleigh scattering spectra of electronic transitions in semiconducting and metallic nanotubes will be presented, as will be results on the polarization dependence of the transitions. The method will be shown to be appropriate for the characterization of different spatial segments of a given SWNT and for the examination of tube-tube interactions in small bundles of SWNTs. This work is supported by the NSF NSEC at Columbia University, NYSTAR, and the DOE-BES. It was performed in collaboration with Feng Wang, Matthew Y. Sfeir, Limin Huang, Chia-Chin Chuang, James C. Hone, Stephen P. O'Brien,and Louis E. Brus. [1]M. Y. Sfeir, F. Wang, L. Huang, et al., Science **306**, 1540 (2004).