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Superconducting tunneling spectroscopy in carbon nanotubes

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In this talk I will discuss measurements of electron energies and interactions in carbon nanotubes using superconducting tunneling probes. Carbon nanotubes (CNTs) can act as model one-dimensional or zero-dimensional (quantum dot) systems, and are often considered leading candidates for nanoscale electronics applications. We developed techniques to perform tunneling spectroscopy on nanotubes using non-invasive superconducting probes placed over the bulk of the tubes. The superconducting probe enhances weak spectroscopic features: measurements of a CNT quantum dot shows clear signals of co-tunneling and weak inelastic scattering. We are also able to measure the shape of the electron energy distribution functions in CNTs that have bias voltages applied between their ends (non-equilibrium tunneling spectroscopy). The distribution functions are related to energy relaxation rates, and we find that at low temperatures electrons interact weakly in nanotubes of a few microns channel length, independent of end-to-end conductance values. In general, tunneling spectroscopy with a superconducting probe may be a powerful new tool for characterizing electron behavior in molecular systems.