Optical Spectroscopy of Single Nanostructures

Alper Kiraz
Department of Physics, Koç University

Study of single nanostructures provides an exciting new field promising a wide range of interdisciplinary applications between atomic physics, chemistry and molecular biology. In this talk I will discuss the results of our experiments at cryogenic temperatures on single self-assembled InAs quantum dots and single dye molecules during my PhD and post-doctoral works respectively. I will also present an outlook of the research objectives of the Nano-Optics Research Laboratory in the Physics Department.

Single InAs quantum dots constitute isolated single quantum emitters that can be investigated without the stringent trapping requirements that limit their atomic counterparts. The inherent two-level nature of the single-excitonic transition of a quantum dot allows the observation of photon antibunching under continuous wave excitation, and triggered single photon emission under pulsed excitation conditions. By tuning the quantum dot single excitonic transition into resonance with a high quality factor microdisk whispering gallery mode, we demonstrate lifetime reduction due to the Purcell effect in the weak coupling cavity-QED regime. Three-level nature of the ground state of single quantum dots also allows an experimental quantum optical analysis of a prototype three-level system. From such an analysis cascaded emission of photons is demonstrated.

Single dye molecules are exquisite probes in monitoring conformational changes at low temperatures. We show that in contrast to the established technique of zero phonon line excitation, vibronic excitation provides a much larger range of observable conformational changes. This technique can be applied to unravel protein folding mechanisms.