UNIVERSITY OF TEXAS AT DALLAS - DEPARTMENT OF PHYSICS

PHYSICS COLLOQUIUM

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Ultrafast Nonlinear Spectroscopy and Fluorescence Microscopy Using Quantum Dots and Biomolecules

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Semiconductor quantum dots are thought to be the next generation of materials for the development of future optoelectronic devices able to fulfill ever-growing quest for miniaturization and demand for new functionalities. Quantum dot is often described as the solid-state analog of an atom since three dimensional confinement results in a discrete energy spectrum and allows for an opportunity to tailor QD's emission properties via the manipulation of the confinement. Here I report our work that studied single photon emission from individual InGaAs quantum dots as well as studies of ultrafast population dynamics in colloidal CdSe QDs. Under cw and pulsed optical excitation, quantum dots exhibit nearly perfect antibunching of the emission. In efforts to further pursue the realization of a practical single photon source, we prepared single pyramidal structures with inserted micro-contacts and observed electrically pumped (dc current) single photon generation from a single QD. Moreover, single photon operation has been observed at temperatures higher than 77K for pyramidal QDs and at room temperature for colloidal dots, further indicating their applicability as solid-state single photon sources. In a separate study, we used an ultrafast transient absorption experiment and found the presence of the optical gain in colloidal CdSe QDs and the development of stimulated emission (SE) in solid-state QD films. Several processes, both intrinsic and extrinsic to QDs which complicate the development of SE are analyzed and various applications of colloidal QDs in photonics, such as lasers and optical switching elements are demonstrated. In addition, I describe our recent work and progress made toward sorting individual biomolecules and other nanosized entities in microfluidic channels. We demonstrated selective detection of small, dye-labeled beads and 2 different types of DNA and their electrophoretic switching and working toward the fluorescently activated sorting.