NER: Torque Spectroscopy for Nanosystem Characterization and Fabrication

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The purpose of this research is to develop the technology to deliver regulated torques to nanosystems; such torques would be on the order of piconewton nanometers. Helically structured light possessing angular momentum will be used in an optical trapping arrangement to deliver angular momentum to trapped particles thereby applying a torque to the trapped object. Position and orientation of a trapped object will be achieved with a trapping beam constructed from the interference of a helical wave front and a plane wave. This research focuses on developing an optical trap using a conventional single-beam trap architecture; constructing the requisite helically-structured laser beam modes as Laguerre-Gaussian (LG) beam modes; and constructing an interference pattern between LG beam modes and plane-wave beam modes. Torque spectroscopy experiments of biomolecules will be performed. Candidate molecules are coiledcoil proteins like myosin, modular matrix proteins like fibronectin and tenascin, and the DNA double helix.

This research program will have a broad impact in the advancement of knowledge, education, industry and technology. An optical torque-trap is an enabling technology for the comprehensive development of nanoscience and engineering, and will have wide application in nanotechnology from characterization to fabrication. In nanoscale biosystems, it would be used to provide an understanding of the behavior of single molecules. For nanoscale structures, it would enable the characterization of novel nanoscale structures and phenomena which depend upon rotary motion. Finally for nanoscale manufacturing processes, it would enable new nanofabrication processes which would depend upon the manipulation of particles in six-dimensions. Other applications include measuring the torque and power output of rotary nanomotors, measuring the bending strength of molecules, measuring the drag on nanobearings, and driving nanosystems by photonic components.

This program will also have impacts in new curriculum for graduate students, combining elements of engineering and physics for nanoscience and engineering; the study of nanosystems and nanobiosystems; training opportunities for undergraduate students in nanotechnology through participation in research projects; and industrial collaboration providing technology transfer and training opportunities for faculty, research associates, and students.