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Spinning Photons and Twisting Oscillators

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Optomechanics is the study of the interaction between optical radiation and mechanical motion. Typically, an optomechanical system is composed of an optical resonator coupled to a mechanical degree of freedom. Some of the most striking experimental achievements include the quantum ground state preparation for a macroscopic oscillator, the detection of optomechanical quantum back-action, and generation of optomechanically induced transparency and slow light. Most optomechanical systems depend on linear coupling between the optical field and the displacement of the mechanical oscillator. In this talk, I will start instead by discussing the basic quantum mechanics of a generic quadratically coupled optomechanical system, followed by our efforts towards extending optomechanics to torsional and rotational systems. Specifically, I will describe our theoretical proposal to couple a windmill-shaped dielectric to cavity Laguerre Gaussian modes. In addition, I will present an optoacoustic system, composed of a LG mode coupled t surface acoustic waves of a spherical mirror, as a new platform for storage of photons carrying orbital angular momentum. Finally, I will discuss our most recent investigation of the prospects of cooling full rotational motion to the quantum regime.