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Advanced Characterization and Sensing with Squeezed Optomechanical Systems

Wednesday, 19 February 2020 08:30 (30 minutes)

In this talk I will outline quantum-enhanced sensing modalities for nanoscale displacement and phase sensing. Optomechanical devices use optical readout of micro/nano-electromechanical systems (MEMS) displacement in order to transduce displacement and phase signals. New detection modes that focus on ultrasonic measurements have brought the shot noise of the optical field into play when transducing signals near resonance, allowing for shot noise limited measurements even at room temperature. However, state of the art approaches to date have been unable to leverage the lower noise floor away from the mechanical resonance frequency because minimum resolvable signals fall below the noise floor off-resonance. As a result, many MEMS measurement techniques can only probe the RF responses of materials or fields at discrete mechanical frequencies, with slow measurements associated with micromechanical ringdown times that are highly susceptible to nonlinear dynamics. In the shot noise limited regime, far below the back-action limit, these devices are good candidates for quantum sensing, where quantum effects like entanglement are used to enhance the readout of optical beam displacements, revealing signals that were previously buried in the noise. For example, in the case of atomic force microscopy, the ability to lower the noise floor beyond current classical limits enables broadband materials characterization critical to describing electronic dynamics in complex materials with orders of magnitude faster acquisition times than are currently available. I will compare and contrast two common readout techniques, with added quantum enhancement: direct detection readout and interferometric readout. I will outline a new scheme that relies on squeezed light and nonlinear interferometry to move nanoscale displacement sensing, phase sensing, and quantum imaging below the shot noise limit.

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