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Quantum optomechanics with superfluid helium density waves

ALEXEY SHKARIN, ANNA KASHKANOVA, CHARLES BROWN, Yale University, NATHAN FLOWERS-JACOBS, NIST, Boulder, LILIAN CHILDRESS, McGill University, SCOTT HOCH, Yale University, LEANDER HOHMANN, KONSTANTIN OTT, SEBASTIEN GARCIA, JAKOB REICHEL, Laboratoire Kastler Brossel, Paris, JACK HARRIS, Yale University — The field of optomechanics deals with the interaction between light and mechanical objects. One of the challenges in this field is to coherently manipulate mechanical states with single-quantum precision and to interface these states with electromagnetic radiation without loss. To achieve this goal, one generally aims to create a system with strong coupling between optical and mechanical systems, while maintaining low optical and mechanical losses and low temperature. Superfluid helium is a material which is uniquely well-suited to meet these requirements. In this talk I will describe a cavity optomechanics system in which we couple infrared light to a standing acoustic wave in superfluid helium. With this system, we used light to coherently excite acoustic vibrations and manipulate their frequency and damping rate using the dynamic back-action effect. In addition, we measured thermal fluctuations of the mechanical mode corresponding to mean phonon number of five. These measurements had sufficient precision to reveal quantum signatures in the motion of the acoustic waves and in their interaction with light. Specifically, we measure the quantum asymmetry and correlations between the motional sidebands.

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