DAMOP13-2013-000616

Abstract for an Invited Paper
for the DAMOP13 Meeting of
the American Physical Society

Mechanical Oscillators and Itinerant Microwave Fields

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We demonstrate two types of coherent control of a mechanical oscillator using itinerant microwave fields. In the first protocol, the state of an itinerant microwave fields is coherently transferred into a mechanical oscillator, stored and retrieved on demand. The mechanical oscillator is coupled to a microwave resonator such that the coupling Hamiltonian is capable of exchanging microwave photons and mechanical phonons by applying a detuned microwave pulse. By shaping the envelope of the detuned microwave pulse, we can capture and release itinerant microwave fields with a particular temporal mode. Here we demonstrate protocols for optimal transfer and measure their efficiency using coherent states with energy at the single quantum level. In the second protocol, we use microwave fields to displace the mechanical oscillator in phase space. Crucially, the interaction time for these protocols can be made shorter than the quantum state lifetime of the mechanical oscillator. Finally, we discuss prospects for creating entanglement between itinerant microwave fields and a mechanical oscillator.