CO.CO.MAT

SFB/TRR 21 - Colloquium

4. November 2011, Tübingen

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Mechanical resonators in the quantum regime

I will describe recent experiments at UC Santa Barbara, representing about ten years' development of nanomechanical and quantum circuit technology, which culminated in our designing and then creating a mechanical resonator that could "easily" be operated in its quantum ground state, and further prepared in quantum (non-classical) states of mechanical vibration. Key requirements included a mechanical design that supported a microwave-frequency mechanical resonance; using a piezoelectric material in order to achieve very strong electromechanical coupling between the mechanical motion and an "electronic atom" we used to measure the resonator motion; and employing a Josephson junction, implemented as a phase quantum bit (aka an "electronic atom"), to measure and interact with the mechanical resonator. Operated at 25 mK on the mixing chamber of a dilution refrigerator, this integrated electromechanical system can be cooled to its quantum ground state without additional intervention. Then, employing the extraordinary nonlinearity provided by the Josephson qubit, and the coherent interactions of this qubit and the mechanical resonator, we were able to prepare and measure a single phonon (quantum of mechanical vibration) in the resonator, as well as a superposition state with zero and one phonons.

Reference: "Quantum ground state and single-phonon control of a mechanical resonator", A.D. O'Connell et al., Nature 464, 697-703 (2010)

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