Quantum Mechanics Tackles Mechanics
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*Science* **342**, 702 (2013);
DOI: 10.1126/science.1245797

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Quantum theory describes the physical cosmos at atomic and smaller scales, but can we apply quantum mechanics to large, distributed mechanical structures? Several recent experiments have shown that we can observe quantum dynamics of nano- and micro-mechanical oscillators. On page 710 of this issue, Palomaki et al. (1) report the controlled generation and verification of quantum entanglement of a mesoscopic mechanical device (a mechanical oscillator) with an electromagnetic microwave field. Entanglement is considered to be the distinguishing feature that separates quantum from classical physics. Only the properties of the entire system have precise values, and the mechanical resonator and the microwave field must be described by one compound quantum-mechanical wave function. No such wave functions can be assigned to either of the subsystems separately.

In the experiment performed by Palomaki et al., a thin circular aluminum membrane (100-nm thick and 15 mm in diameter) was suspended in a fixed frame and was free to oscillate like a drumhead. The fundamental mode of this mechanical oscillator is the one that became entangled with the microwave field. The aluminum also served as one end of a parallel plate capacitor that was integrated into a resonant circuit with a characteristic frequency in the microwave domain at a frequency of $2\pi \times 8$ GHz (see the figure, panel A). The mechanical motion of the drum mode changed the capacitance and with it the resonance frequency of the microwave cavity. This mechanism resulted in an extremely strong mutual coupling between the mechanical and the microwave resonator.

The coupling happened on a time scale faster than the characteristic time scale on which quantum states of the two resonators could be destroyed by uncontrolled interactions with their respective environments. At the experimental temperature of 20 mK, the

A micromechanical oscillator can only be described with quantum mechanics after it is entangled with microwave fields.
cold-atom thermoelectrics

THERMODYNAMICS

The microscopic theory of the Peltier and Seebeck effects (10) indicates that the generation of Peltier and Seebeck effects in cold-atom systems could be a promising avenue for achieving high thermoelectric performance. This is because the Peltier and Seebeck effects in cold-atom systems are temperature-dependent, whereas in traditional thermoelectric materials, these effects are almost constant. Moreover, the Peltier and Seebeck effects in cold-atom systems can be controlled by external parameters such as the temperature and magnetic field, which can be used to optimize the performance of the thermoelectric devices.

Two coupled reservoirs of cold atoms can be used as a model system to study the thermoelectric effect.

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10.1126/science.1245797

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