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Approaching the motional ground state of a 10 kg object CHRIS WHITTLE, EVAN HALL, Massachusetts Institute of Technology MIT, SHEILA DWYER, LIGO Hanford Observatory, NERGIS MAVALVALA, VIVISHEK SUDHIR, Massachusetts Institute of Technology MIT, LIGO DETECTOR TEAM —
Studying the effect of gravity on massive quantum systems calls for the preparation of quantum states of objects massive enough to be noticeably susceptible to gravity. However, quantum behavior in macroscopic systems is greatly impeded by interactions with the thermal environment. Traditional techniques, such as laser sideband cooling, that are able to realize quantum states of motion of atomic and nano-scale objects do not work for kilogram-scale objects. We employ the exceptional displacement sensitivity of Advanced LIGO to resolve the zero-point motion of a 10 kg mechanical oscillator with a precision sufficient to feedback cool its motion to 10.8 phonons on average. The reduction in oscillator temperature, from room temperature to 77 nK, represents a 100-fold improvement in the reduction of temperature of a solid-state mechanical oscillator—commensurate with a 11 orders-of-magnitude suppression of quantum back-action by feedback—and a 10 orders-of-magnitude increase in the mass of an object prepared close to its motional ground state.

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