Entanglement-enhanced optomechanical sensing

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Optomechanical sensors allow ultrasensitive measurements of force, acceleration, and magnetic fields. Their optical readout offers high bandwidth, low noise, immunity to electromagnetic interferences, and long-range detection. Nonclassical resources such as the squeezed light have been harnessed to boost the performance of individual optomechanical sensors. Joint measurements undertaken with multiple optomechanical sensors would further improve the sensitivity in detecting weak signals, e.g., dark matter, but a pathway toward quantum enhancement in this multi-sensor regime has not been explored. In this work, we propose and experimentally demonstrate that entangled light can improve the sensitivity and bandwidth of an optomechanical sensor array. Specifically, we prepare entangled optical probes to jointly read out the displacements of two mechanical membranes. We observe entanglement-enhanced sensitivities at the shot-noise-dominated frequencies and increased bandwidth over thermal-noise-dominated frequencies, subject to a sensitivity-bandwidth tradeoff. Our work opens a new avenue for ultraprecise measurements with an array of quantum-enhanced sensors with applications ranging from inertial navigation and acoustic imaging, to searches for new physics.