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Abstract for an Invited Paper
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Breaking Quantum and Thermal Limits on Precision Measurements[1]

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I will give an overview of our efforts to use correlations and entanglement between many atoms to overcome quantum and thermal limits on precision measurements. In the first portion of my talk, I will present a path toward a 10000 times reduced sensitivity to the thermal mirror motion that limits the linewidth of today's best lasers. By utilizing narrow atomic transitions, the laser's phase information is primarily stored in the atomic gain medium rather than in the vibration-sensitive cavity field. To this end, I will present the first observation of lasing based on the mHz linewidth optical-clock transition in a laser-cooled ensemble of strontium atoms. In the second portion of my talk, I will describe how we use collective measurements to surpass the standard quantum limit on phase estimation $1/\sqrt{N}$ for N unentangled atoms. We achieve a directly observed reduction in phase variance relative to the standard quantum limit of as much as 17.7(6) dB.

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