Contribution ID: **90** Type: **Invited Talk**

Cavity-Optomechanical Torque Sensors

Thursday, 23 February 2017 17:30 (36 minutes)

Reducing the moment of inertia improves the sensitivity of a mechanically-based torque sensor, the parallel of reducing the mass of a force sensor, yet the correspondingly small displacements can be difficult to measure. To resolve this, we incorporate cavity optomechanics, which involves co-localizing an optical and mechanical resonance. With the resulting enhanced readout, cavity-optomechanical torque sensors are now limited only by thermal noise. Further progress requires thermalizing such sensors to low temperatures, where sensitivity limitations are instead imposed by quantum noise. By cooling a cavity-optomechanical torque sensor to 25 mK, we have demonstrated a torque sensitivity of 2.9 yNm Hzˆ(-1/2). At just over a factor of ten above its quantum-limited sensitivity, such cryogenic optomechanical torque sensors will enable both static and dynamic measurements of integrated samples at the level of a few hundred spins.

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