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**Levitated Quantum Nano-Magneto-Mechanical Systems** MAURO CIRIO, JASON TWAMLEY, GAVIN K. BRENNEN, Centre for Engineered Quantum Systems, Macquarie University, Sydney Australia, GERARD J. MILBURN, Centre for Engineered Quantum Systems, University of Queensland, Brisbane, Australia — Quantum nanomechanical systems have attracted much attention as they provide new macroscopic platforms for the study of quantum mechanics but may also have applications in ultra-sensitive sensing, high precision measurements and in quantum computing. In this work we study the control and cooling of a quantum nanomechanical system which is magnetically levitated via the Meissner effect. Supercurrents in nano-sized superconducting loops give rise to a motional restoring force (trap), when placed in an highly inhomogenous magnetic field and can yield complete trapping of all translational and rotational motions of the levitated nano-object with motional oscillation frequencies $\nu \sim 10 - 100\text{MHz}$. As the supercurrents experience little damping this system will possess unprecendented motional quality factors, with $Q_{motion} \sim 10^9 - 10^{13}$, and motional superposition states may remain coherent for days. We describe how to execute sideband cooling through inductive coupling to a nearby flux qubit, cooling the mechanical motion close to the ground state.

Mauro Cirio
Centre for Engineered Quantum Systems,
Macquarie University, Sydney Australia

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