Recent work suggests that micron-scale particles trapped in focused laser beams should enable nano-g acceleration sensing and quantum superpositions of micron-scale objects, but blackbody radiation emitted by those particles, which are heated by the laser beams that trap them, limits accelerometry precision and quantum state decoherence time. The field of optical refrigeration has recently demonstrated methods of achieving cryogenic temperatures in solid-state objects interacting with laser beams. Merging the two fields to demonstrate cryogenic temperatures in levitated systems should enable unprecedented sensing precision as well as improved decoherence times. We propose to demonstrate a form of accelerometry that will achieve nano-g resolutions only possible using optically-refrigerated, micro-scale particles in the quantum harmonic oscillator ground state. If successful, this work will demonstrate a new technology for inertial navigation and serve as an important stepping stone to using quantum superpositions of micron-scale objects to probe the foundations of quantum mechanics and explore the extent to which gravity is quantized.