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Optically Cooled Quantum Dots for Extreme Weak Force Sensing

PATRICK KELLEY, RICARDO DECCA, Indiana University - Purdue University Indianapolis — The electric potential induced by an optical tweezer about the focal point approximates a simple harmonic potential. An optically trapped nanoparticle in the ground state of this potential could provide a very valuable tool for ultrasensitive force detection, such as probing weak gravitational interaction. Primarily two cooling methods, parametric feedback cooling of the trapping laser and cavity sideband cooling, have been experimentally implemented to lower the harmonic energy state of the nanoparticle. Fundamental limitations place constraints to the effectiveness of these two methods. One such limitation occurs by increasing the trapping laser power, the strength of cooling increases but also consequently increases the internal temperature of the nanoparticle. The current project looks to trap a quantum dot while optically cooling it to address this effect. If placing this quantum dot in an ultrahigh vacuum environment, sequentially applying parametric feedback and then cavity sideband cooling proves successful, theoretically, this proposed scheme should cool to the ground state and provide a way to further the search for non-Newtonian forces and explore other short-range interaction physics.

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