Abstract Submitted
for the DAMOP13 Meeting of
The American Physical Society

Parametric feedback cooling of a single atom inside an optical cavity HAYTHAM CHIBANI, CHRISTIAN SAMES, CHRISTOPH HAMSEN, ANNA-CAROLINE ECKL, PAUL ALTIN, TATJANA WILK, GERHARD REMPE, Max-Planck-Institute of Quantum Optics, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — When an oscillator is excited at twice its resonance frequency, its phase locks to the drive and its energy increases exponentially. Such parametric energy increase occurs for all phase differences between oscillator and drive, and can therefore be used to determine the mechanical frequency of a trapped atom. However, by appropriately adjusting the phase of the drive, one can as well use parametric modulation to remove energy from the system. Here, we demonstrate parametric feedback cooling of a single atom trapped in an intra-cavity standing wave dipole trap. The interaction strength between the atom and the cavity field, which determines the resonance condition of the coupled system, depends on the atomic position which hence governs the intensity of a transmitted probe beam. The detected photon stream is demodulated at twice the trap frequency, and the extracted amplitude and phase are then used to continuously vary the modulation of the trap intensity to cool the atomic motion. This feedback strategy enabled us to increase the average storage time of an atom in the cavity by a factor of 60 to more than 2 seconds. Moreover, this new cooling method is applicable not only to the radial but also to the axial motion of the atom, which is in our case 2 orders of magnitude faster.

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Date submitted: 25 Jan 2013 Electronic form version 1.4