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Coherent Quantum Engineering of Laser Cooling JOSH W. DUNN, CHRIS H. GREENE, JILA, University of Colorado and NIST, and Department of Physics, University of Colorado, Boulder, Colorado, J. W. THOMSEN, The Niels Bohr Institute, Copenhagen, Denmark, FLAVIO C. CRUZ, Instituto de Fisica Gleb Wataghin, Universidade Estadual de Campinas, Campinas, Brazil — Doppler laser cooling of two-level atoms is well understood, and has been utilized extensively for decreasing phase-space density of atomic gases. The temperature limit of Doppler cooling is on the order of the excited-state spectral linewidth, and cooling below this limit requires, for example, atomic sublevel degeneracy. Here we present a means of cooling that consists of three internal states of an atom and two lasers of distinct frequency. Employing sparse-matrix techniques, we find numerical solutions to the fully quantized master equation in steady state, allowing straightforward determination of laser-cooling temperatures. We develop a qualitative picture of the mechanism, related to the phenomenon of electromagnetically induced transparency, yielding a cooling scheme in which a dressing laser can be tuned to coherently engineer a two-level quantum system that has desirable Doppler-cooling properties. Effects of the induced asymmetric Fano-type lineshapes affect the detunings required for optimum cooling, as well as the predicted minimum temperatures which can be lower than the Doppler limit for either transition. This work was supported in part by the NSF.

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