Using nonequilibrium thermodynamics to optimize the cooling of a dilute atomic gas

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Optimizing thermodynamic processes far from equilibrium is a challenge. We report the experimental optimization of cooling and thermalization of a gas of few noninteracting Cesium atoms confined in a nonharmonic optical dipole trap. To this end, we combine degenerate Raman sideband cooling and nonequilibrium thermodynamics. We determine the axial phase-space distribution of the atoms after each Raman pulse by following the evolution of the gas with position-resolved fluorescence imaging. We further minimize the entropy production to a target thermal state to specify the optimal spacing between a sequence of pulses, thus achieving optimal thermalization. We finally study the dynamics of the cooling process by measuring the statistical distance between each cooling steps. Our results provide a method to systematically optimize the cooling of nonharmonically trapped dilute gases and illustrate the power of nonequilibrium thermodynamics [1].

[1]D. Mayer, F. Schmidt, S. Haupt, Q. Bouton, D. Adam, T. Lausch, E. Lutz, and A. Widera, Using nonequilibrium thermodynamics to optimize the cooling of a dilute atomic gas, arXiv:1901.06188.