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Negative absolute temperature for mobile particles SIMON BRAUN, PHILIPP RONZHEIMER, MICHAEL SCHREIBER, SEAN HODGMAN, IMMANUEL BLOCH, ULRICH SCHNEIDER, Ludwig Maximilians University Munich, Max Planck Institute of Quantum Optics Garching — Absolute temperature is usually bound to be strictly positive. However, negative absolute temperature states, where the occupation probability of states increases with their energy, are possible in systems with an upper energy bound. So far, such states have only been demonstrated in localized spin systems with finite, discrete spectra. We realized a negative absolute temperature state for motional degrees of freedom with ultracold bosonic ^{39}K atoms in an optical lattice, by implementing the attractive Bose-Hubbard Hamiltonian. This new state strikingly revealed itself by a quasimomentum distribution that is peaked at maximum kinetic energy. The measured kinetic energy distribution and the extracted negative temperature indicate that the ensemble is close to degeneracy, with coherence over several lattice sites. The state is as stable as a corresponding positive temperature state: The negative temperature stabilizes the system against mean-field collapse driven by negative pressure. Negative temperatures open up new parameter regimes for cold atoms, enabling fundamentally new many-body states. Additionally, they give rise to several counterintuitive effects such as heat engines with above unity efficiency.

[1] S. Braun *et al*, *Science* 339, 52 (2013).

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