Motion-selective coherent population trapping by Raman sideband cooling in a Λ configuration

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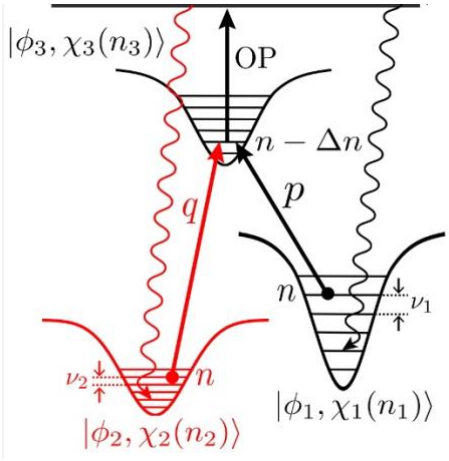
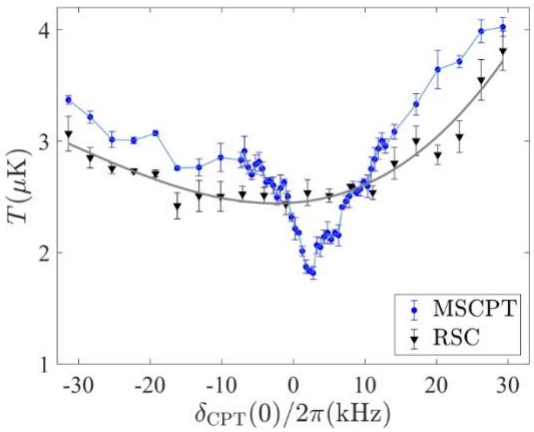
We report our experiment on sideband cooling with two Raman transitions in a Λ configuration that allows selective coherent population trapping (CPT) of the motional ground states. The cooling method is applied to ^{87}Rb atoms in a circularly polarized one-dimensional optical lattice. Owing to the vector polarizability, the vibration frequency of a trapped atom depends on its Zeeman quantum number and the CPT resonance for a pair of bound states in the Λ configuration depends on their vibrational quantum numbers. We call this scheme motion-selective coherent population trapping (MSCPT) and it is a trapped-atom analog of the velocity-selective CPT developed for free He atoms.



Level schemes for RSC (black) and MSCPT (with the addition of red). OP: optical pumping.

We observe a pronounced dip in temperature near a detuning for the Raman beams to satisfy the CPT resonance condition for the motional ground state. Although the lowest temperature we obtain is ten times the recoil limit owing to the heat load from motion along an axis, which is left uncooled, and the large Lamb-Dicke parameter of 2.3 in our apparatus, the experiment demonstrates that MSCPT enhances the effectiveness of Raman sideband cooling and enlarges the range of its application. Discussions of design parameters optimized for MSCPT on ^{87}Rb atoms and opportunities provided by diatomic polar molecules, whose Stark shift shows a strong dependence on the rotational quantum number, are to be presented.



Temperature vs. detuning from the CPT resonance for the motional ground state for RSC by alternating *p* and *q* Raman beams (black triangles) and MSCPT with *p* and *q* beams on simultaneously (blue circles).

References:

1. S. Park, M. H. Seo, R. A. Kim, and D. Cho, Motion-selective coherent population trapping by Raman sideband cooling along two paths in a Λ configuration. Phys. Rev. A **106**, 023323 (2022).
2. H. G. Lee, S. Park, M. H. Seo, and D. Cho, Motion-selective coherent population trapping for subrecoil cooling of optically trapped atoms outside the Lamb-Dicke regime. Phys. Rev. A **106**, 023324 (2022).