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Sisyphus Cooling of Polyatomic Molecules MARTIN ZEPPENFELD, BARBARA G.U. ENGLERT, ROSA GLOECKNER, ALEXANDER PREHN, GERHARD REMPE, MPI for Quantum Optics — The long-range dipole-dipole interactions between polar molecules and their rich internal structure offer a multitude of experimentally unexplored possibilities for fundamental investigations at ultracold temperatures, ranging from many body physics to quantum information processing. Towards this end, a general approach to cool molecular ensembles akin to laser cooling for alkali atoms has been a much sought-after goal. In this talk, we present the experimental realization of opto-electrical cooling,[1] a general Sisyphus-type cooling scheme for polar molecules. As a first result, an ensemble of 10^6 methyl-fluoride molecules has been cooled by more than a factor of 4 to 77mK, resulting in an increase in phase-space density by a factor of 7. The scheme proceeds in an electric trap, and requires only a single infrared laser with additional RF and microwave fields. The cooling cycle depends on generic properties of polar molecules and can thus be extended to a wide range of molecule species. Ongoing improvements in our trap design will allow cooling to sub-mK temperatures and beyond, opening wide-ranging opportunities for fundamental studies with polyatomic molecules at ultracold temperatures.

[1]M. Zeppenfeld *et al.*, Phys. Rev. A **80**, 041401 (2009)

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