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Ultracold Polar Molecules

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Abstract:

Polar molecules - molecules exhibiting a permanet electric diplole moment- have bright perspectives as systems with long-range and anisotropic interaction. These interactions have been the basis for numerous exciting theoretical proposals ranging from ultra-cold chemistry, precision measurements, quantum phase transitions to novel systems for quantum control with external magnetic and electric fields. We will present our recent work on the creation and characterization of a near-quantum degenerate gas of absolute ground-state polar 40K87Rb molecules. Starting from weakly bound heteronuclear KRb Feshbach molecules, we implement precise control of the molecular electronic, vibrational, and rotational degrees of freedom with phase-coherent laser fields. In particular, we coherently transfer the weakly bound molecules across a 125 THz frequency gap in a single step into the absolute rovibrational ground state of the electronic ground molecular potential. We achieve transfer efficiencies of 92% with no measurable heating in the transfer process. The ground state molecules have a permanent electric dipole moment, which we measure with Stark spectroscopy to be 0.566 (17) Debye. Given the large electric dipole moment of the KRb molecules, the study of quantum degenerate molecular gases interacting via strong dipolar interactions is now within experimental reach.