Ultracold Polar Molecules

Scientists at JILA have produced a dense sample of ultracold 300 nK $^{40}K^{87}Rb$ polar molecules in their ground state of vibrational and rotational motion. Theory developed in the Atomic Physics Division and Joint Quantum Institute guided these experiments by calculating the molecular properties needed to understand and control the formation of these molecules from ultracold atoms. The figure schematically illustrates the steps: (1) association of a ^{40}K atom and a ^{87}Rb atom to make a very weakly bound molecular state of the $^{40}K^{87}Rb$ molecule (green), (2) coherent optical transfer (blue) of this state to the ground vibrational and rotational state of the $^{40}K^{87}Rb$ molecule (red). Additionally the theory characterized the nuclear spin structure of the ground state molecules, a key element in the precise quantum control of molecular collisions. Polar molecules, which have much longer range forces than neutral atoms, open new vistas for controlled simulation of many-body phenomena and strongly correlated condensed matter phases, ultracold chemistry, precision measurement, and quantum information. This work provided the basis for a successful Multi-University Research Initiative (MURI) recently selected by the Air Force Office of Scientific Research for funding at the Joint Quantum Institute of NIST and the University of Maryland. This MURI, entitled "*Ultracold polar molecules: new phases of matter for quantum information and quantum control*" is a 5-year research initiative involving 9 research groups at 7 different institutions.

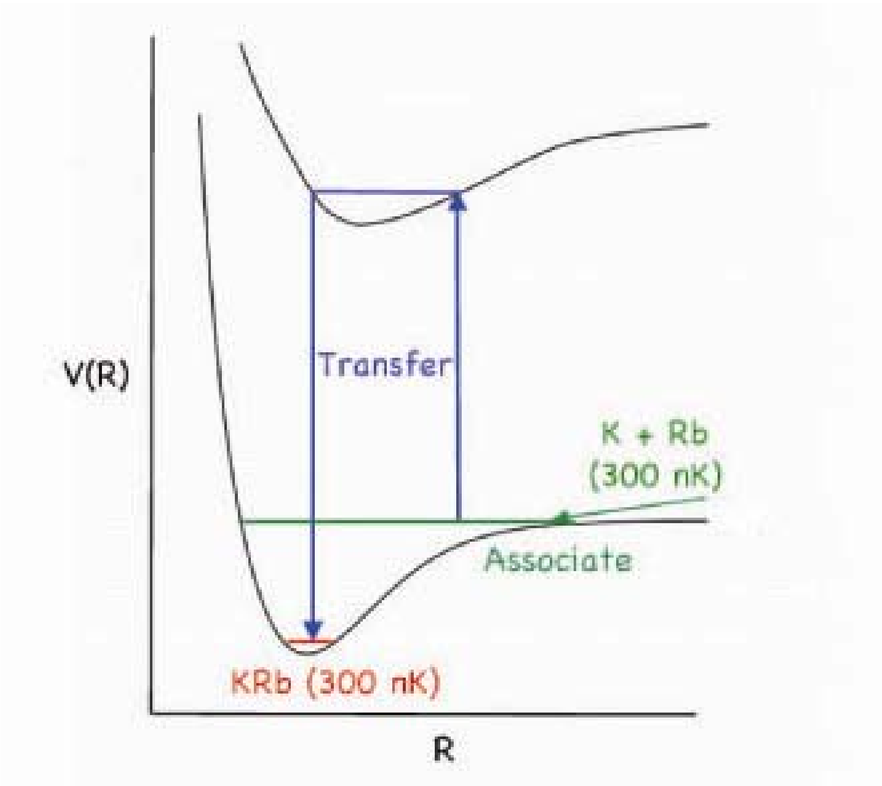

Figure 1.1: Schematic representation of the molecular potential energy curves V(R) of the KRb molecule, where R is inter-atomic separation, indicating the steps used to make ground state molecules.

Contact: Dr. Paul Julienne
(301) 975-2596
paul.julienne@nist.gov