MAR08-2007-003393

Abstract for an Invited Paper
for the MAR08 Meeting of
the American Physical Society

Cold and ultracold polar molecules

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Study of ultracold molecules promises important benefits such as novel control of chemical reactions and molecular collisions, precision measurement of fundamental physical properties, and new methods for quantum information processing and quantum simulations. We undertake two approaches aimed to produce cold, polar molecular samples. In the first approach, we work directly with ground-state polar molecules such as hydroxyl radicals (OH) or formaldehyde molecules (H_2CO). After Stark deceleration through an inhomogeneously distributed electric field, OH molecules are loaded into a magnetic trap at a density $\sim$3 x 10^5 cm^{-3} and temperature of 50 mK. An important advantage of magnetically trapping OH molecules is the freedom in applying an external electric field without significantly affecting the trap dynamics. The open geometry of the trap will enable experimental studies of cold, dipolar collisions subject to an external electric field. We will report our latest progress towards this goal. In the second approach we explore the possibility of producing ultracold polar molecules via association of two different atoms from ultracold atom gas mixtures near quantum degeneracy. Specifically, an interspecies Feshbach resonance between bosonic ^{87}Rb and fermionic ^{40}K permits efficient creations of heteronuclear Feshbach molecules. Subsequent optical spectroscopy reveals promising paths to efficiently transfer populations from the weakly bound to more deeply bound states. Progress on the production of these ultracold fermionic polar molecules will be reported.