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Ultracold Polar Molecules[1]

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Ultracold polar molecules are new model quantum systems that promise study of quantum phase transitions, quantum simulations of condensed matter spin systems, and new schemes for quantum information. These proposals require a high phase-space-density gas of polar molecules where the electric dipole-dipole interaction is significant. We have recently created a gas of absolute ground-state polar molecules from a near quantum degenerate gas of KRb Feshbach molecules using a single step of STImulated Raman Adiabatic Passage (STIRAP) state transfer. With no measurable heating in the transfer process, we created $4x10^4$ ultracold polar molecules trapped in an optical dipole trap. The polar molecular gas has a peak density of 10^{12} per cubic centimeter at a temperature of 350 nanoKelvin. The KRb molecules in the absolute ground state possess a permanent electric dipole moment that we measure to be 0.566(17) Debye. Currently, we are investigating the collisional stability of these molecules and seeing evidence for ultracold chemical reactions. This ability to create a quantum gas of ground-state molecules paves the way for future studies of dipolar Fermi gases and dipolar Bose-Einstein condensates.

[1]In collaboration with S. Ospelkaus, D. Wang, M. Miranda, B. Neyenhuis, A. Pe'er, J. Zirbel, S. Kotochigova, P. Julienne, J. Bohn, J. Ye, D. Jin.