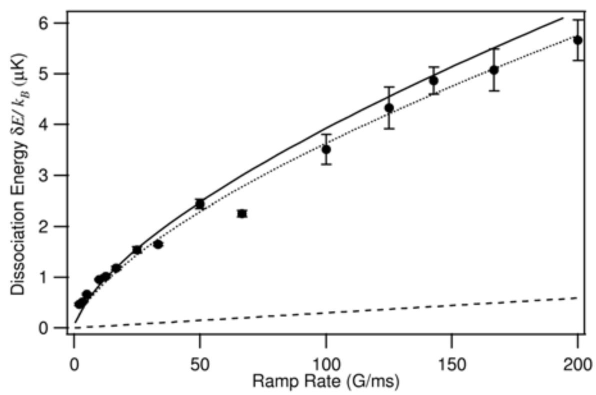
Dissociation and Decay of Ultracold Sodium Molecules

We have studied the dissociation and decay of ultracold molecules. Sodium molecules were formed in a highly excited vibrational state by recombining two ultracold atoms [1]. An external magnetic field "tuned" the molecular binding energy close to zero (Feshbach resonance) allowing resonant recombination.

By ramping up the magnetic field, the molecular level was moved into the continuum, and the molecule dissociated. When the magnetic field ramp is very slow, the molecules follow adiabatically and end up in the lowest energy state of the atoms. The dissociation products will populate higher-lying atomic states if the ramp is fast (compared to the strength of the coupling between the molecular and atomic states). Therefore, from the observed dissociation energies, the strength of the atom-molecule coupling could be determined.

The non-linear dependence of the dissociation energy on the ramp speed reflects the Wigner threshold law for the onset of dissociation: The dissociation lifetime decreases when the molecular energy is higher above threshold. Furthermore, inelastic molecule-molecule and molecule-atom collisions were characterized. The rapid inelastic decay imposes a severe limit to further evaporative cooling.



Dissociation energy of sodium molecules as a function of magnetic field ramp rate. The dashed line represents a theoretical prediction of a linear relation, the solid line shows the result of our theory with no free parameters (using a theoretical value for the width ΔB of the Feshbach resonance), and the dotted line shows a curve with ΔB as a fitting parameter.

1. Y. Shin, M. Saba, A. Schirotzek, T.A. Pasquini, A.E. Leanhardt, D.E. Pritchard, and W. Ketterle, *Distillation of Bose-Einstein condensates in a double-well potential*, preprint cond-mat/0311514.