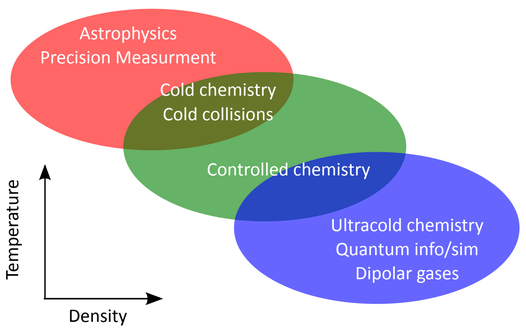
Evaporation of magnetically trapped dipolar molecules

Matthew T. Hummon, Benjamin K. Stuhl, Mark Yeo,
Hao Wu, David Reens, Alejandra Collopy, and Jun Ye

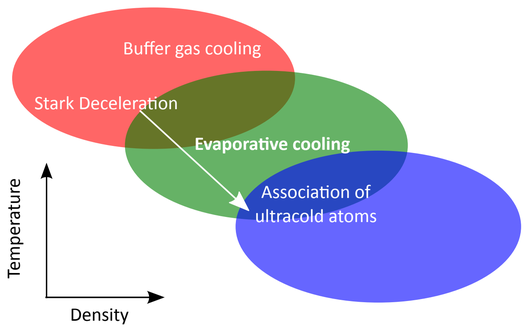
JILA, University of Colorado, Boulder, and NIST, Boulder, CO 80309

Cold polar molecules

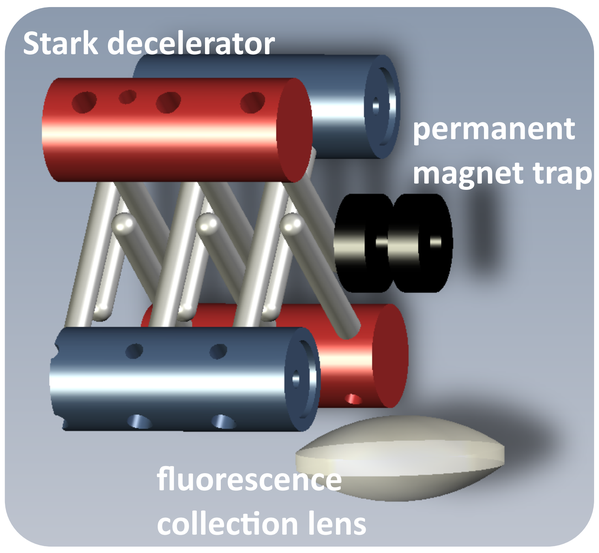
Applications



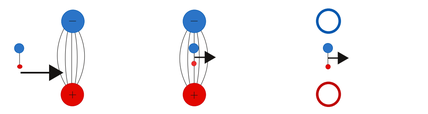
Production techniques



OH trapping apparatus



Stark-deceleration primer

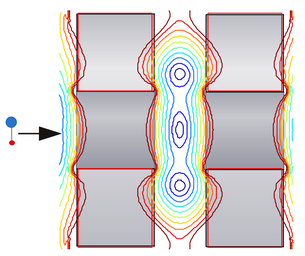


Low-field-seeking molecule flies into a region of large electric field

Molecule slows down as it rides up the potential hill

Electric field is synchronously turned off, permenently removing accumulated potential energy

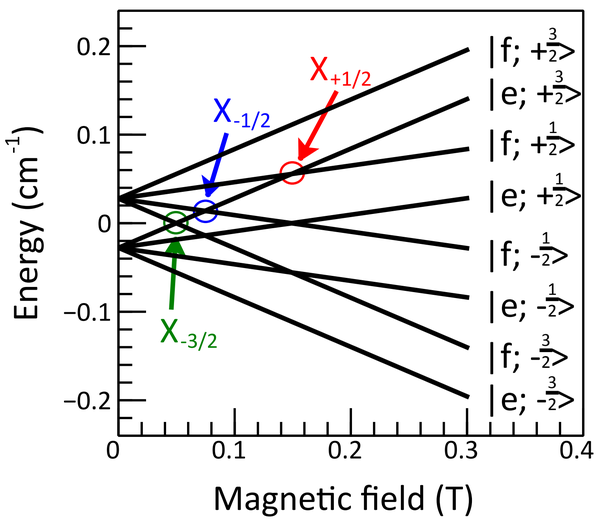
Magnetic trap B-field contours

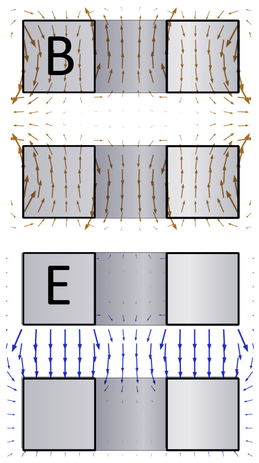


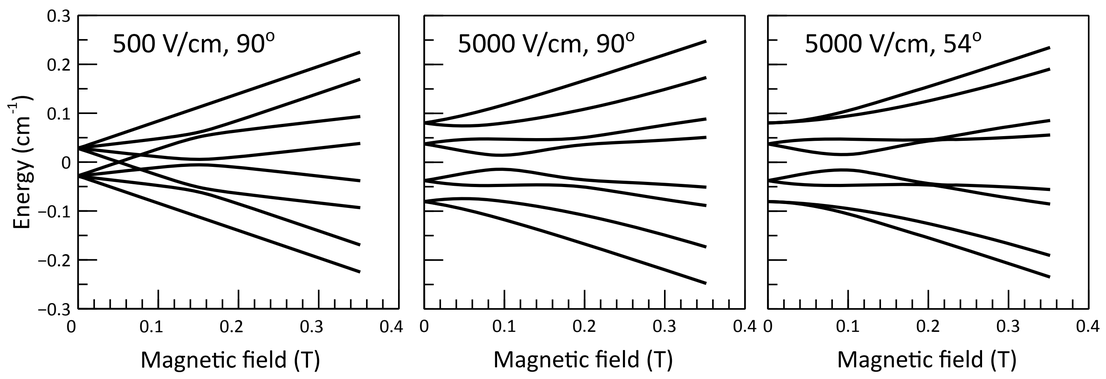
dB/dz ~ 1.5 T/cm

trap depth
0.27 T
200 mK

OH in mixed electric and magnetic fields

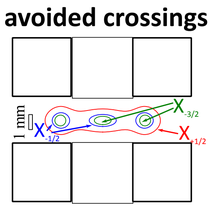




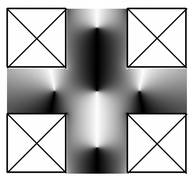


With zero electric field, the |e; +3/2> state is magnetically trappable. However, even electric fields of only a couple hundred V/cm are sufficient to open the avoided crossings X_M enough to make the entire |e> manifold untrappable.

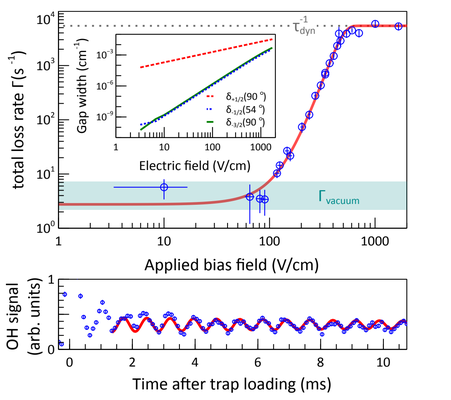
Loci of |e; +3/2> avoided crossings



θ_{EB}: white is 0°, black is 180°

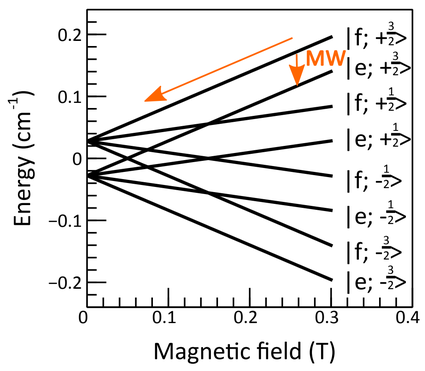


Loss rate of |e>-state molecules vs. electric field



Forced microwave evaporation of OH

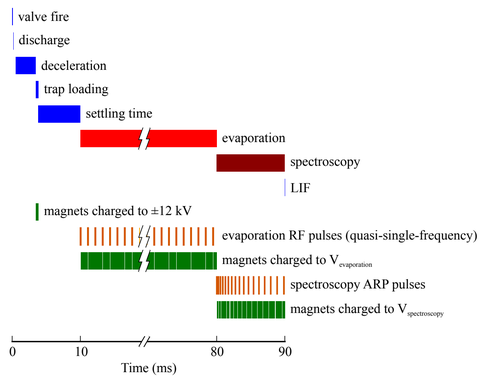
Evaporation sequence



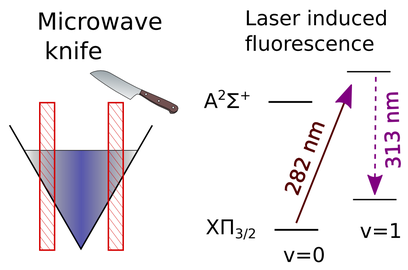
Microwave (MW) pulse transfers |f;3/2> population to |e;3/2>.

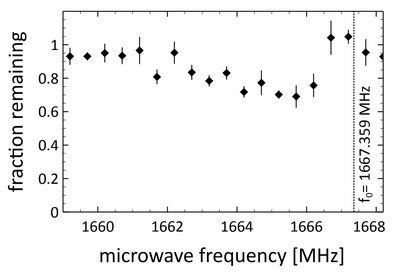
DC electric field (240 V/cm) ejects |e;3/2> molecules from trap.

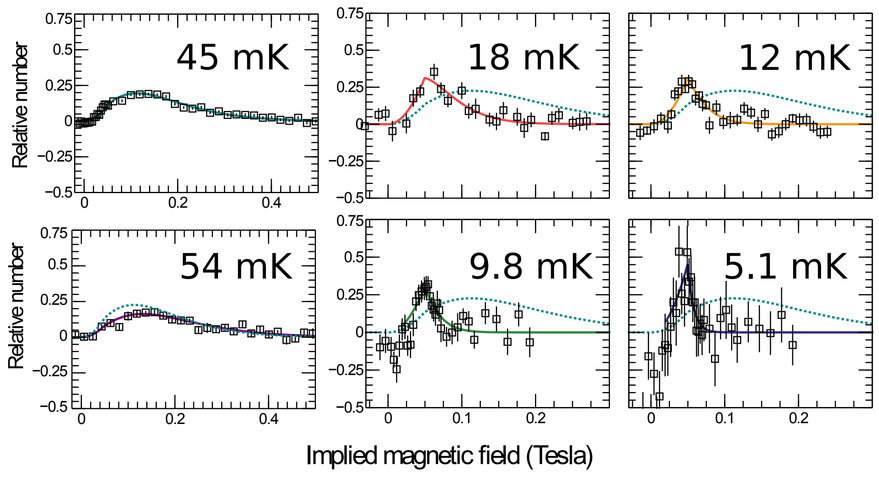
MW & DC fields alternate as MW frequency is swept to eject colder molecules.



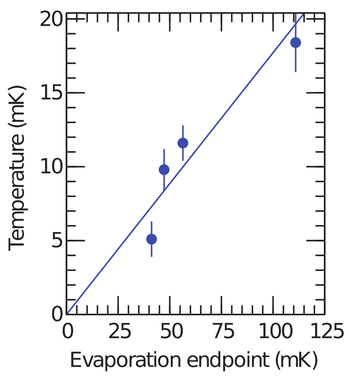
Microwave depletion spectroscopy

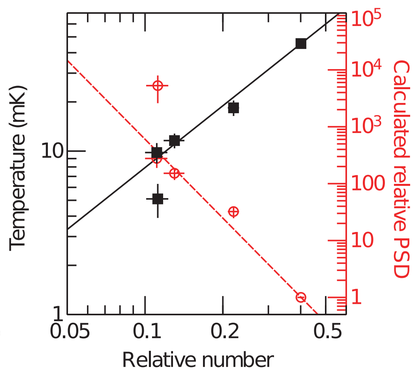


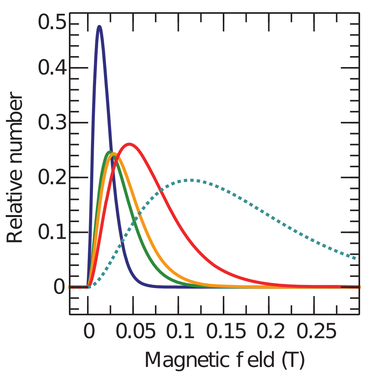




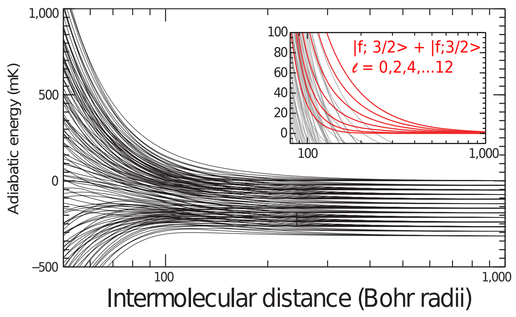
Evaporation efficiency





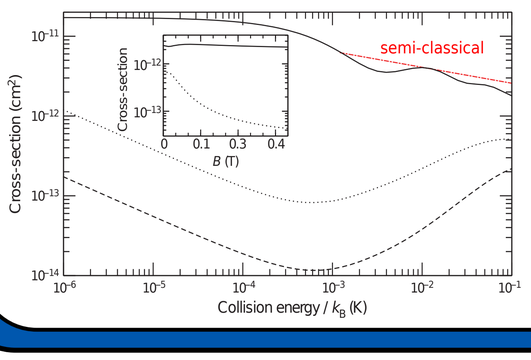


OH - OH Collisions

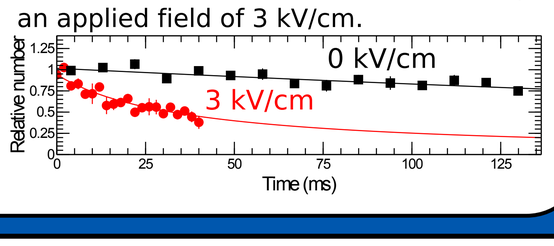


Quantum scattering calculaitons, performed by Goulven Quéméner and John Bohn, based on the long-range dipole-dipole interaction between molecules. Molecules in the entrance channel |f;3/2> | f;3/2> experience a *repulsive* van der Waals interaction, as shown in the inset in red.

This leads to favorable elastic - inelastic cross section ratios.

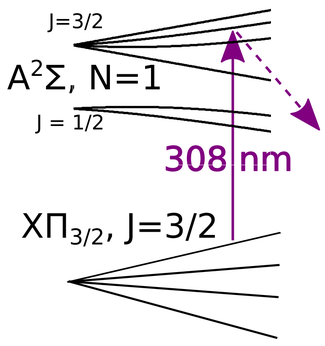


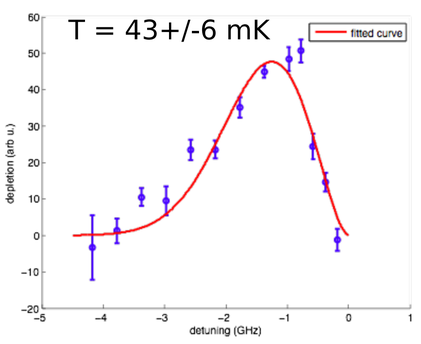
Below, we observe 2-body loss due to electric field induced inelastic collisions, at an applied field of 3 kV/cm.



Future work

Optical depletion spectroscopy





Conclusions

We have observed both dipolar inelastic collisions and evaporative cooling (yielding a 6x increase in phase space density) in our magnetically trapped OH molecules. The way is now open to much higher densities and lower temperatures!

B.K. Stuhl, et al., Nature **492**, 396 (2012)