Association of single ultracold molecules in optical tweezers

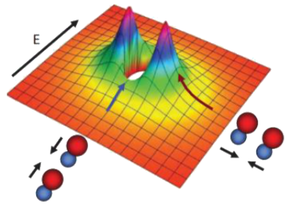
Yichao Yu, Jonathan Hood, Lee R. Liu, Jessie T. Zhang, Yen-Wei Lin, Kenneth Wang, Remý Vatré, Till Rosenband, Kang-Kuen Ni

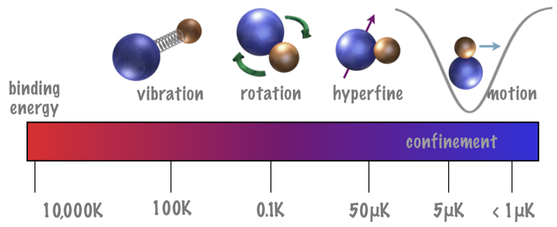
Harvard-MIT Center for Ultracold Atoms

Department of Chemistry and Chemical Biology and Department of Physics, Harvard University

Ultracold Molecules

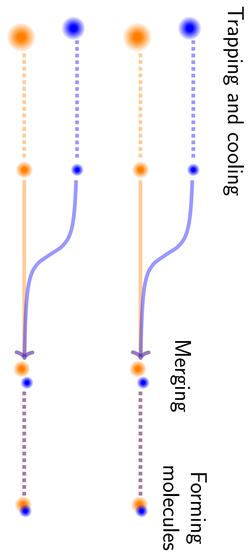
- NaCs has a large permanent electric dipole moment (4.6 **Debye**)
- Strong anisotropic dipole-dipole interactions
- Coupled internal degrees of freedom can be used to tune interactions and store information





Our Approach

- Assemble and trap individual molecules in optical tweezers from laser-cooled atoms
- Raman transition from atoms to weakly-bound molecules
- STIRAP to ground state molecules

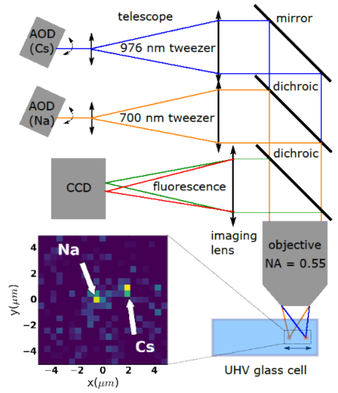


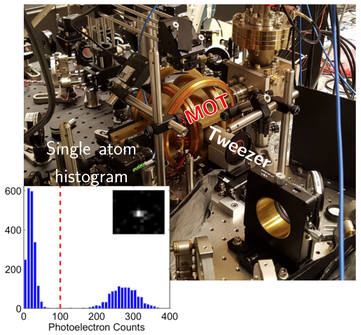
Advantages

- Fast cycle time (<1s), small vacuum chamber
- Dynamically configurable trapping geometry
- All optical cooling and state-manipulation

Trapping and Cooling of Atoms

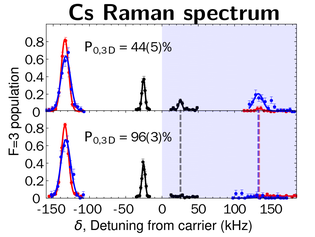
Laser-cooled and trapped single Cs and Na atoms < 100 uK in separate rearrangeable optical tweezers.

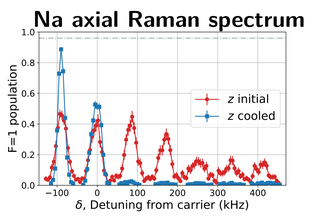


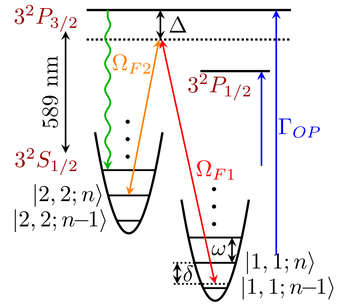


Hutzler, Liu, Yu, Ni, New J. Phys 19, 023007 (2017)
L. Liu, Zhang, Yu, Hutzler, Hood, Liu, Rosenband, Ni, arXiv:1701.03121 (2017)

Cooled into motional ground states in the tweezers with Raman sideband cooling. Cooling fidelities are 96% for Cesium and 94% for Sodium.



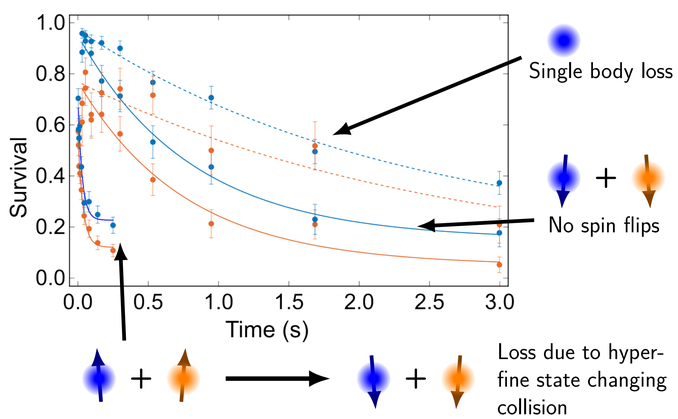




Yu, Hutzler, Zhang, L. Liu, Rosenband, Ni, arXiv:1708.03296 (2017)

Merging Tweezers

- Na and Cs tweezers are merged together into a single trap with little heating
- Observe hyperfine spin changing collisions when atoms in same trap



Photoassociation

Coherent molecule formation *(Preliminary)*

Acknowledgements

Arnold and Mabel Beckman Foundation
NSF
AFOSR Air Force Office of Scientific Research
Alfred P. Sloan Foundation 1934