

Association of single ultracold molecules in optical tweezers

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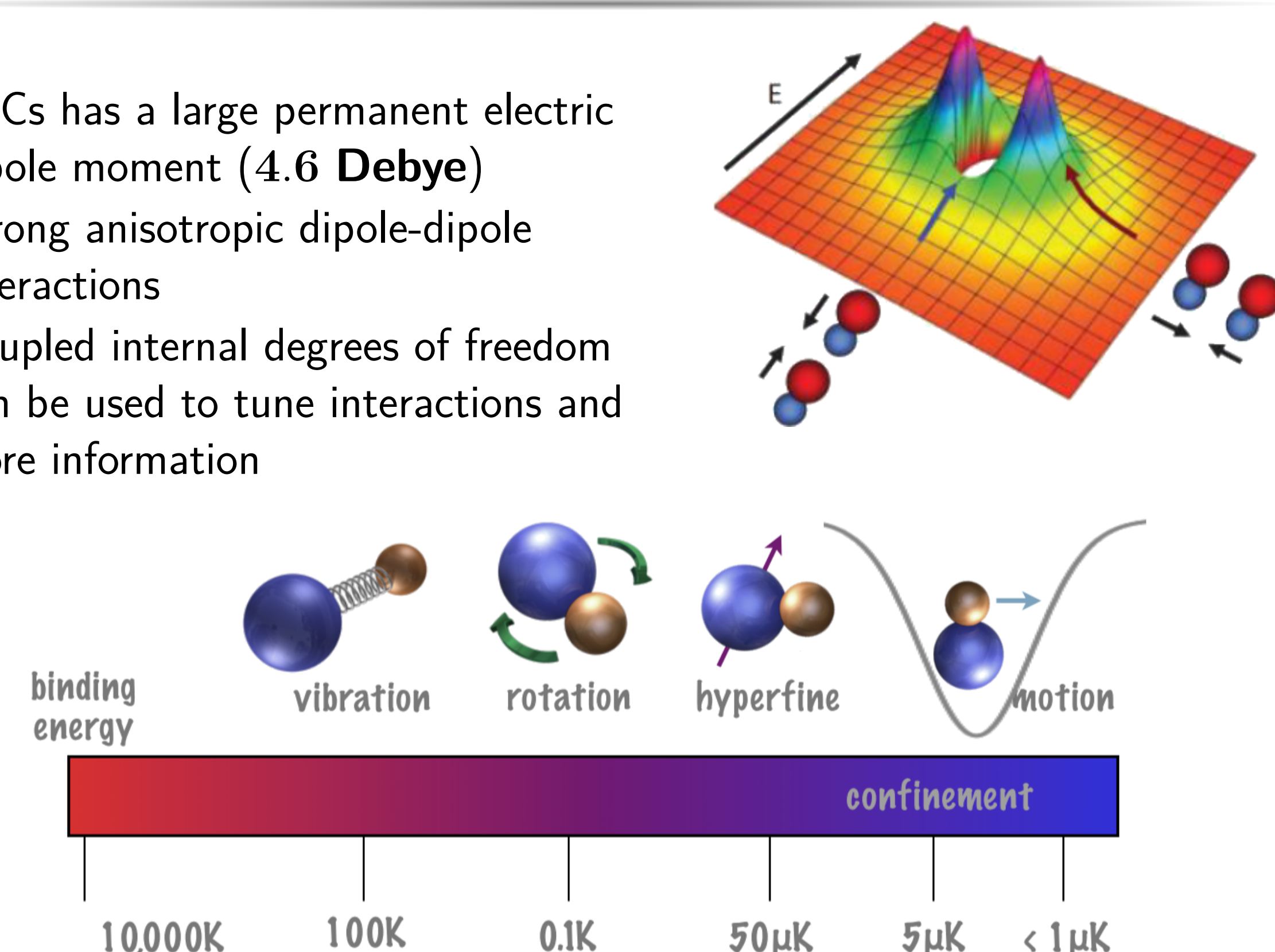
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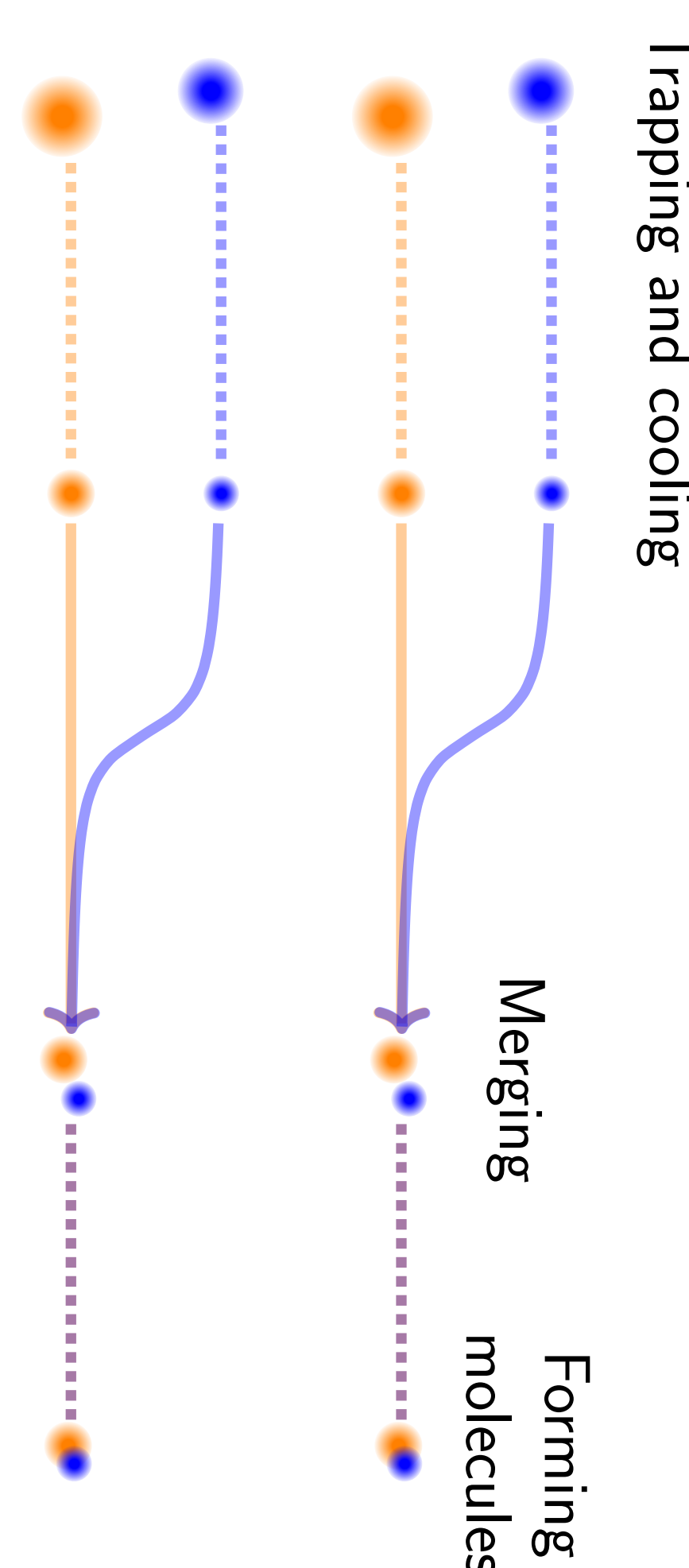
Ultracold Molecules

- 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

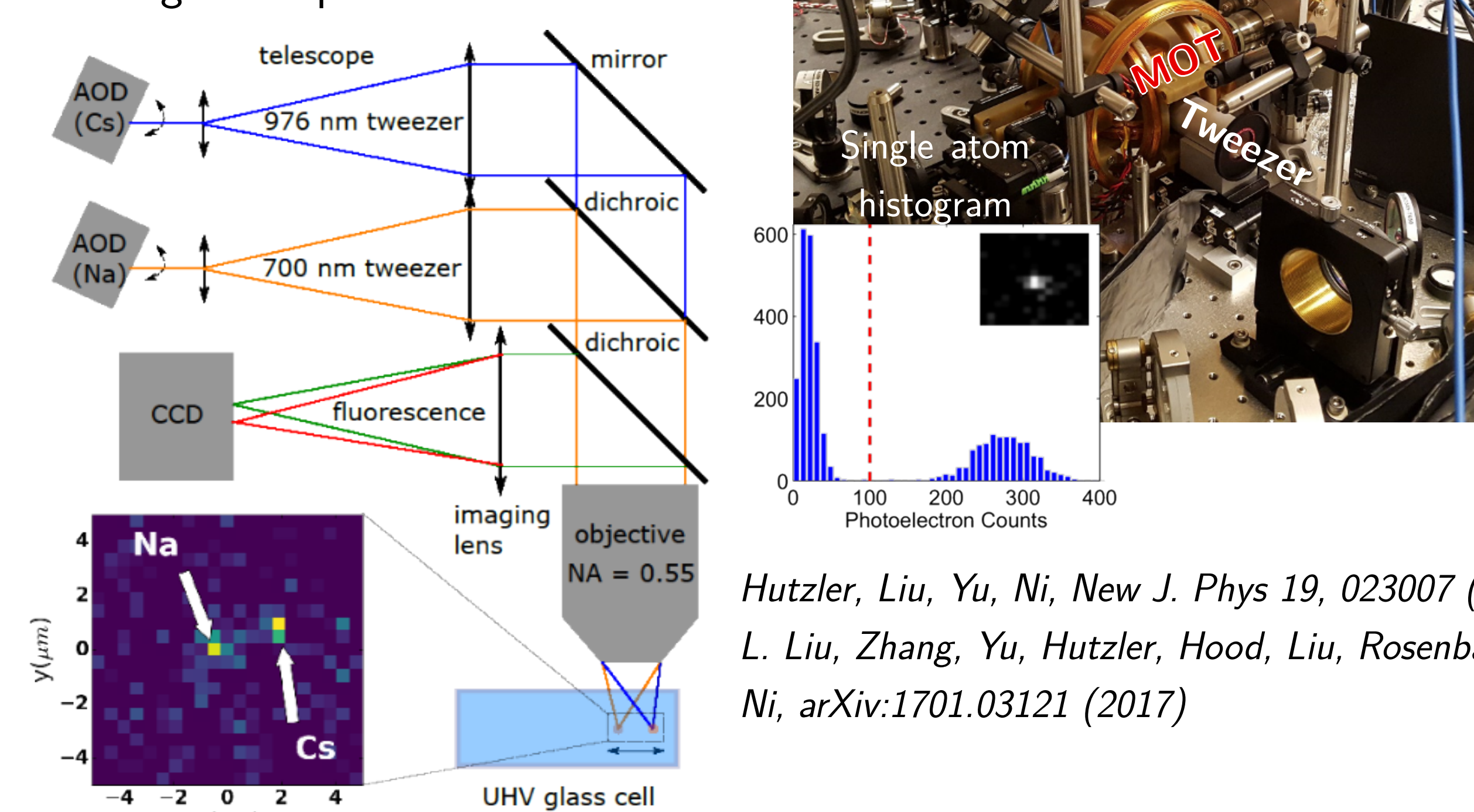
- Fast cycle time (<1s), small vacuum chamber
- Dynamically configurable trapping geometry
- All optical cooling and state-manipulation

Acknowledgements

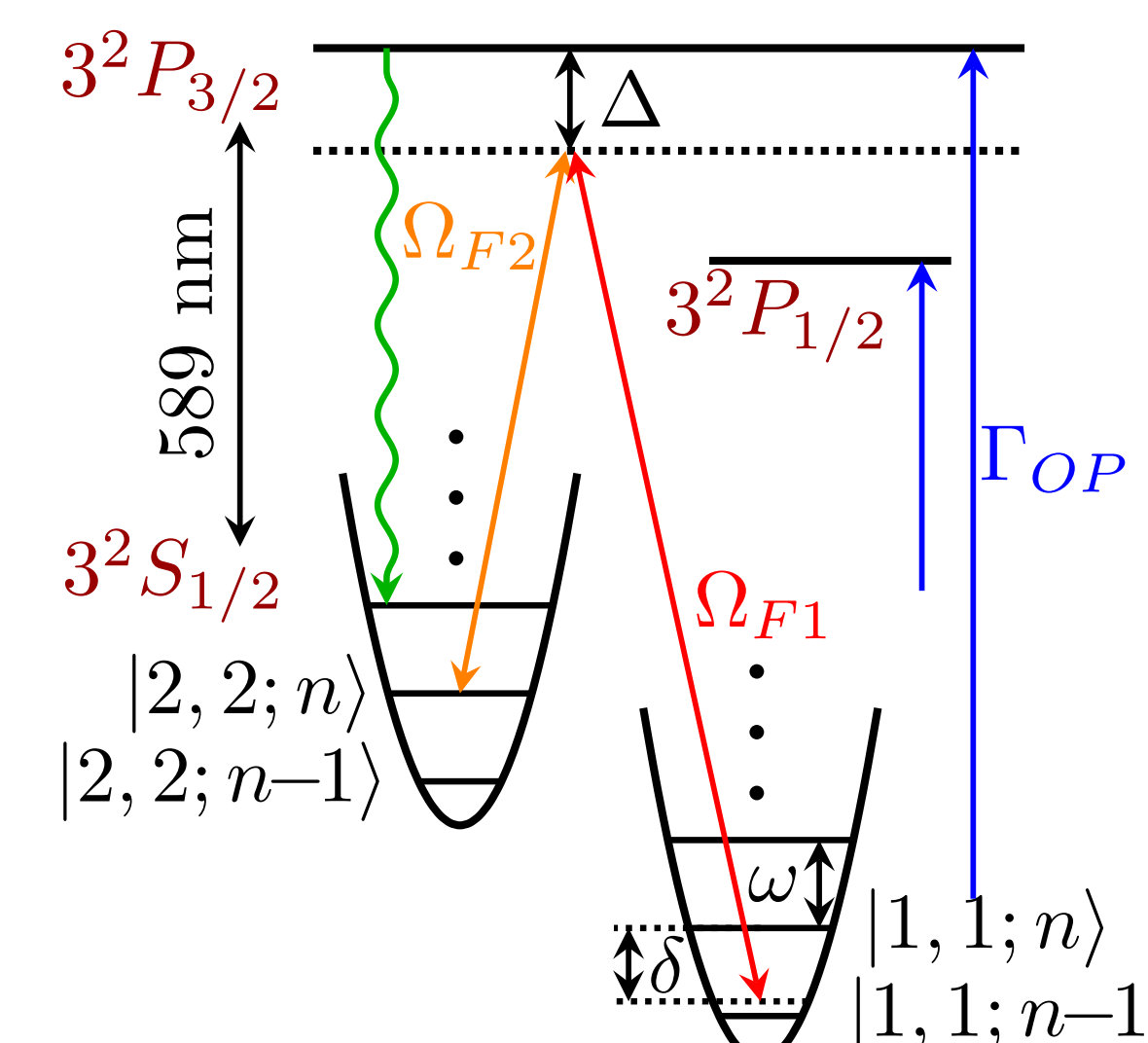
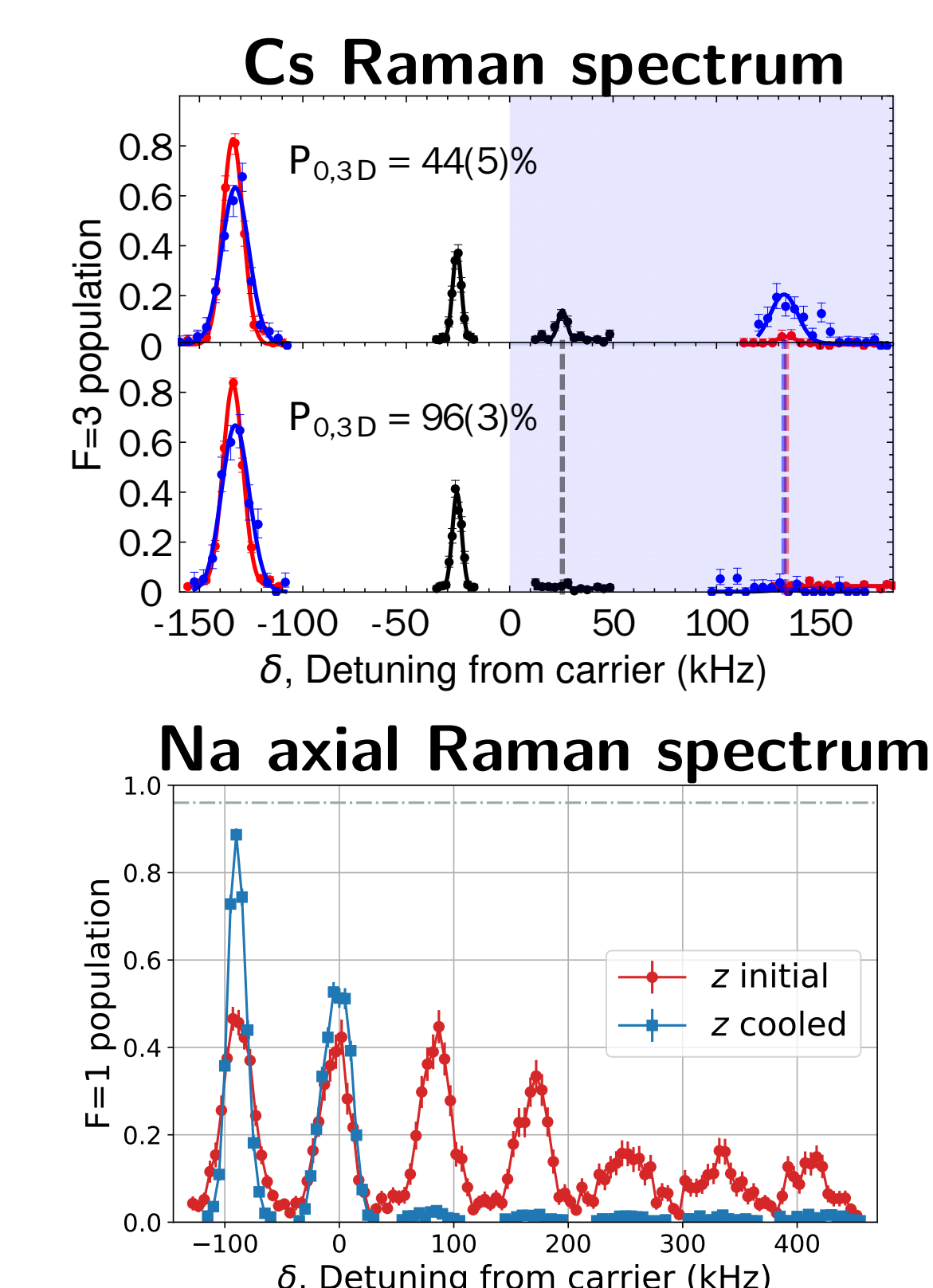


Trapping and Cooling of Atoms

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



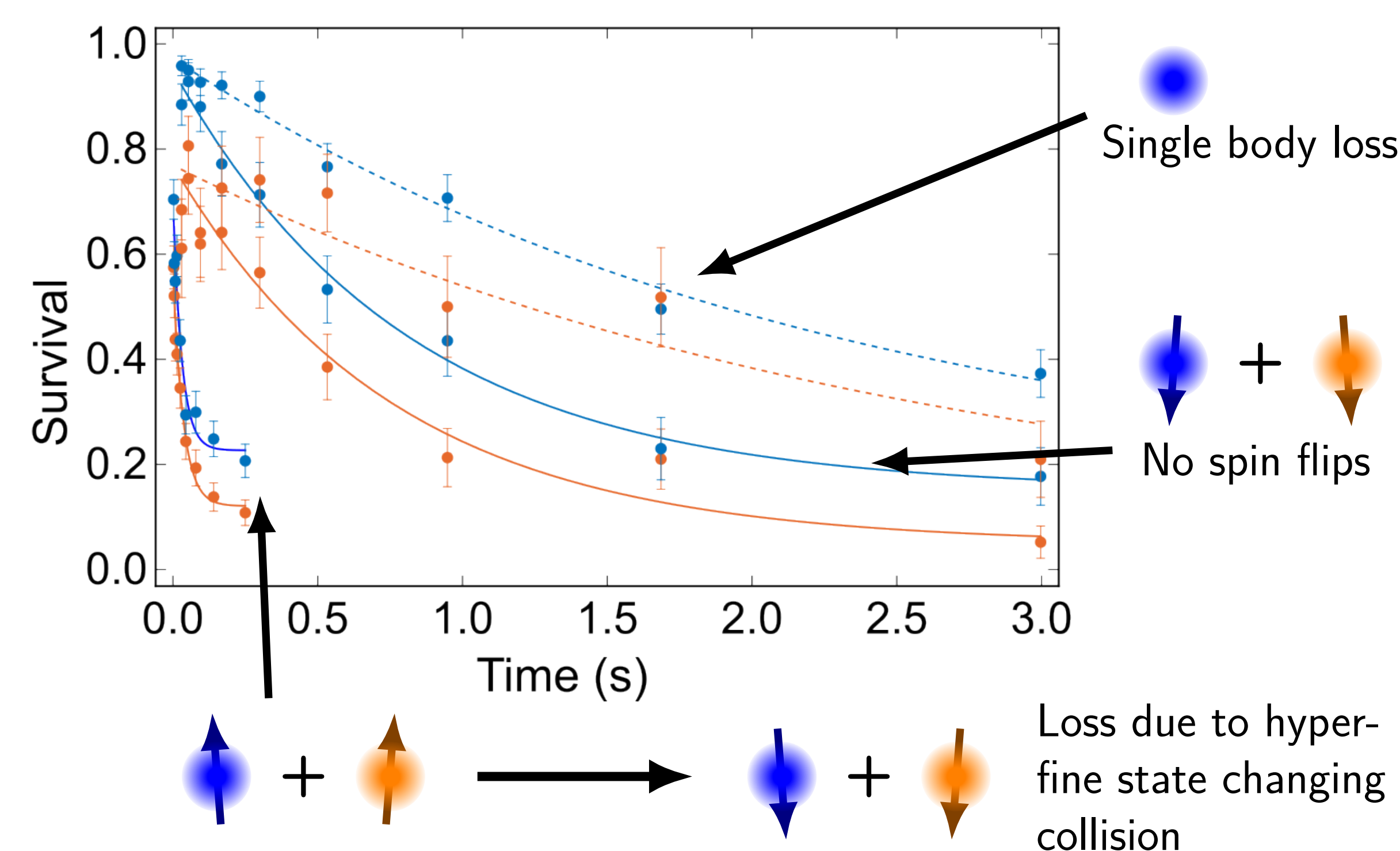
Cooled into motional ground states in the tweezers with Raman sideband cooling. Cooling fidelities are 96% for Cesium and 94% for Sodium.



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

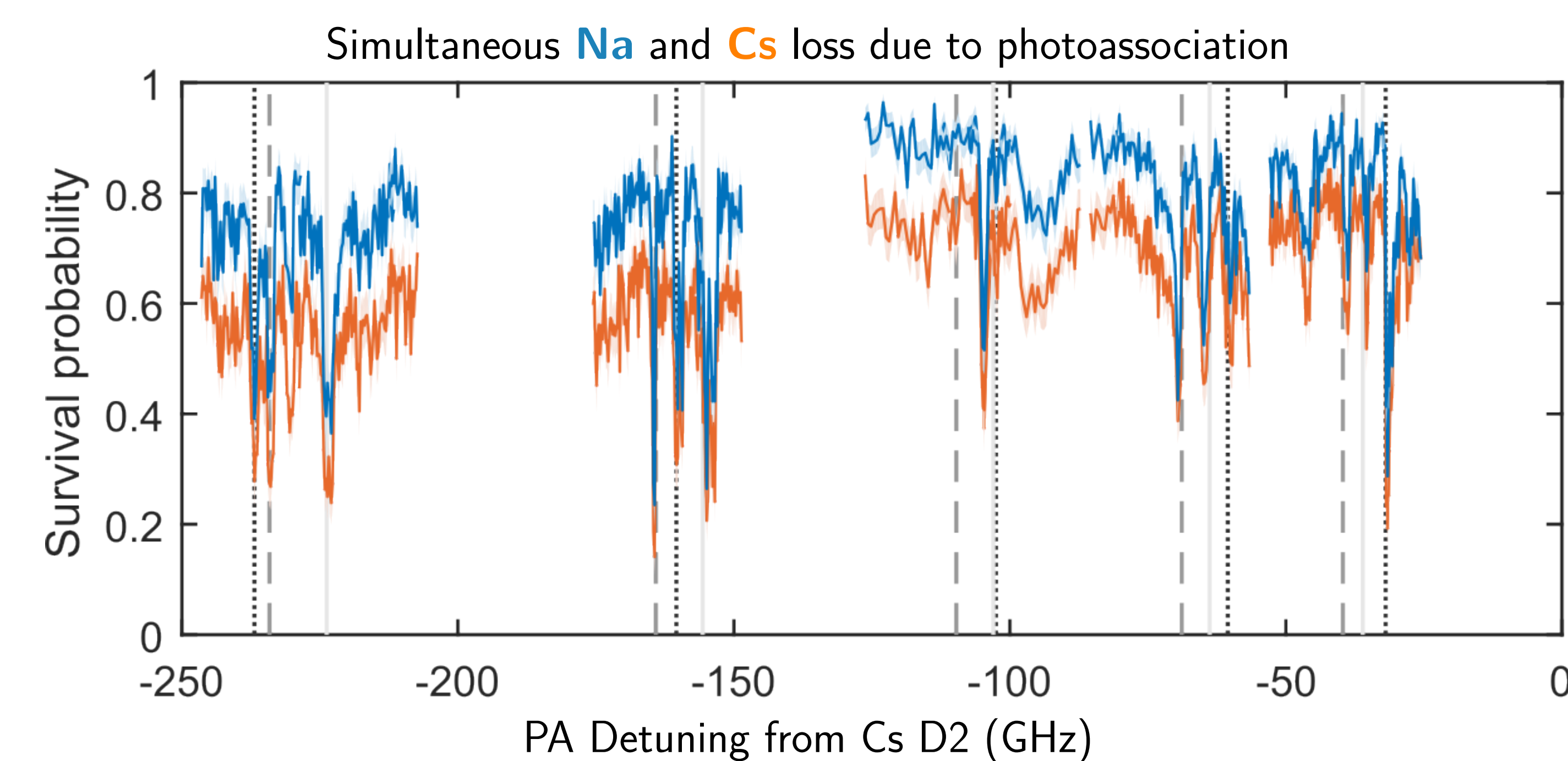
Merging Tweezers

- 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

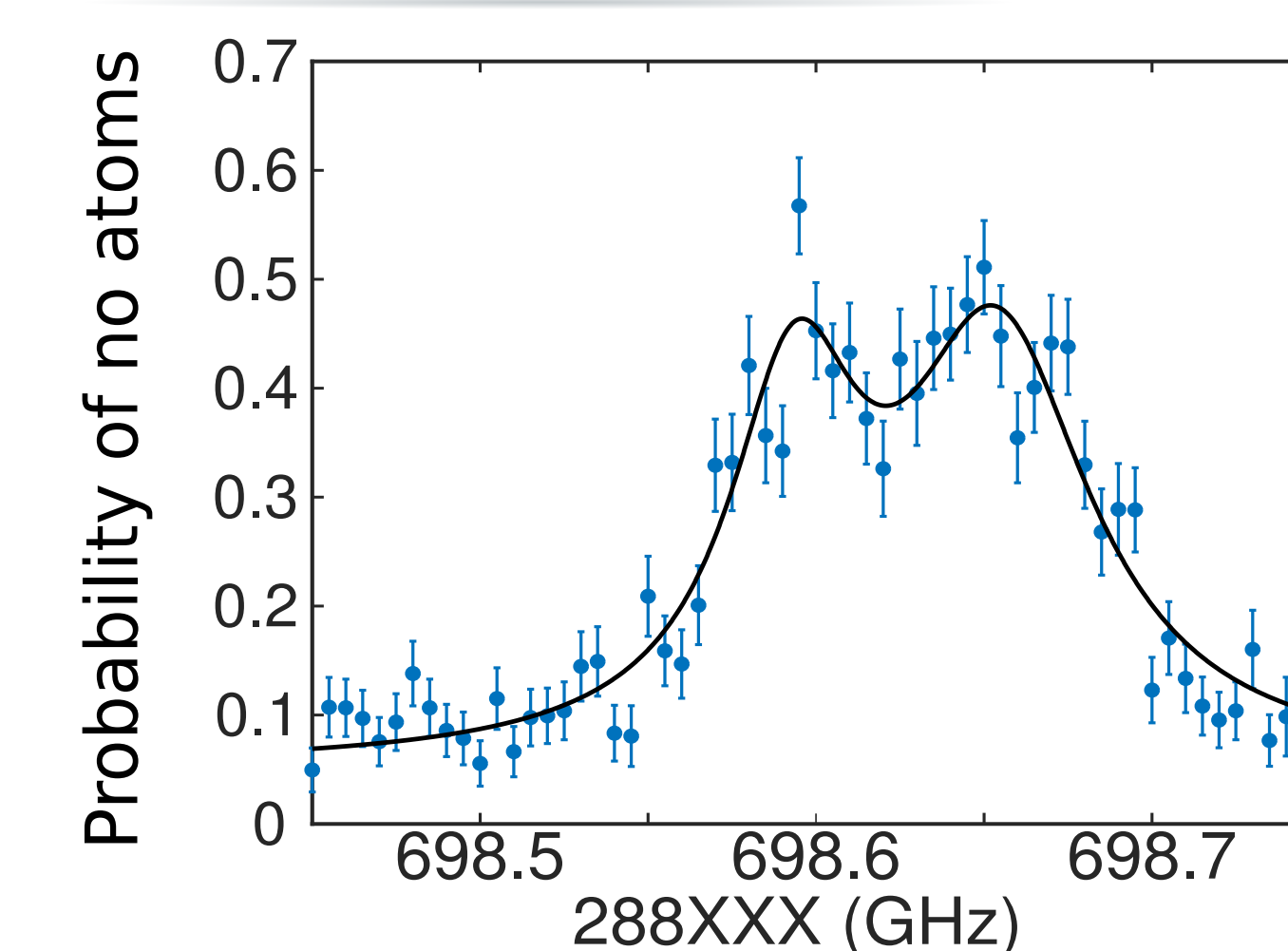
Near threshold photoassociation



- First photoassociation of a single molecule in an optical tweezer.
- Observation of new NaCs excited state vibrational lines near threshold.
- Vertical lines are fits to the LeRoy long range dispersion model,

$$\Delta E \propto \frac{1}{\sqrt{C_6}}(v_D - v)^3$$

v = 0 photoassociation



Coherent molecule formation (Preliminary)