

# Ultracold molecule assembly

Yichao Yu

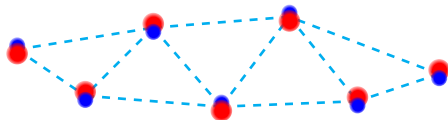
Ni Group/Harvard

Aug 11, 2017

# Molecules in optical tweezer

## Features

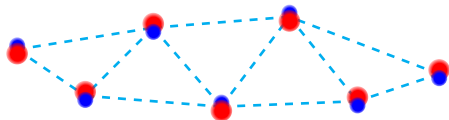
- Strong and tunable interaction
- Rich internal energy levels
- High filling fraction
- Single site detection and manipulation



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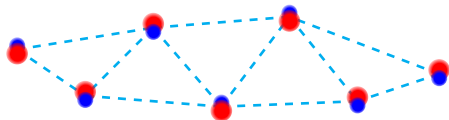
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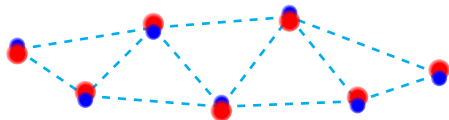
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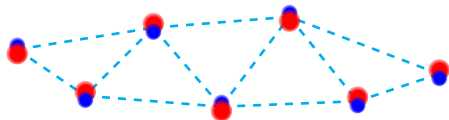
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## Simulation of many-body system

## Quantum computation



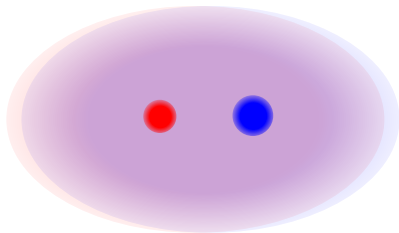
# Making molecules from atoms

- MOT (Na + Cs)
- Loading single atoms
- Raman sideband cooling
- Merge traps
- Make molecules!



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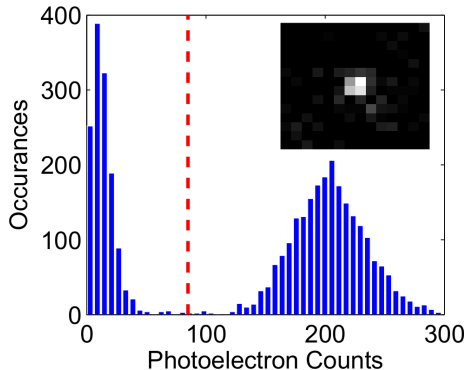
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# Atom loading and cooling

## Cesium

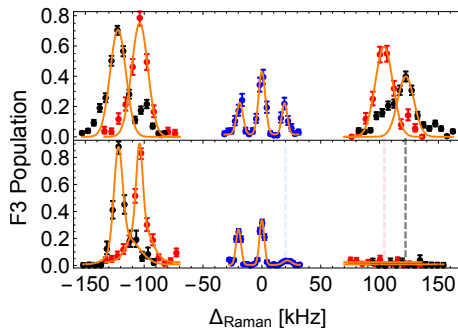
- Single atom
- 85% Ground state



# Atom loading and cooling

## Cesium

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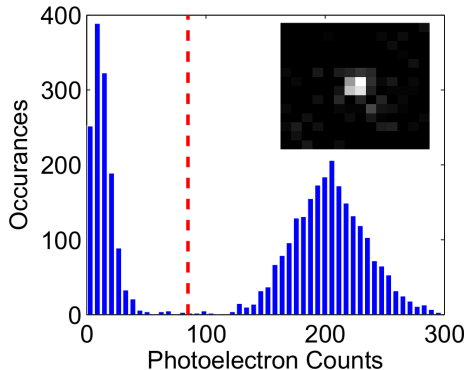




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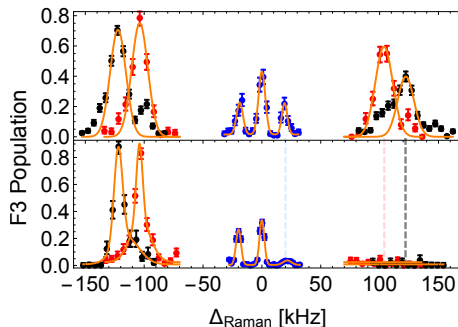
- Single atom
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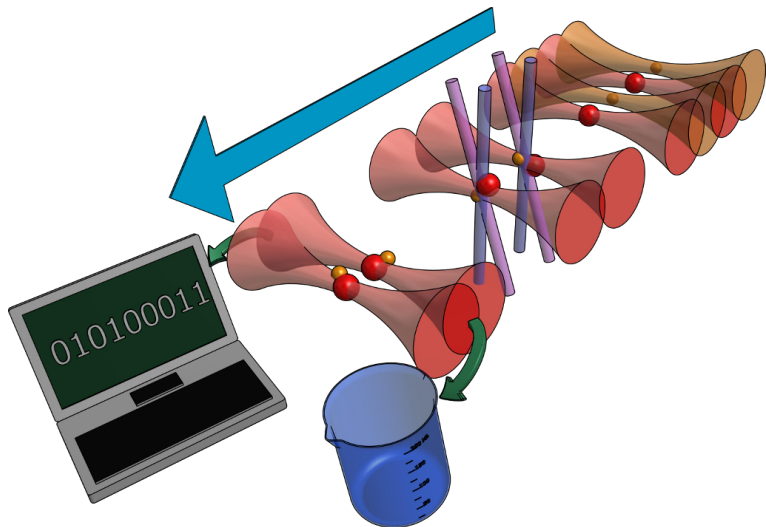
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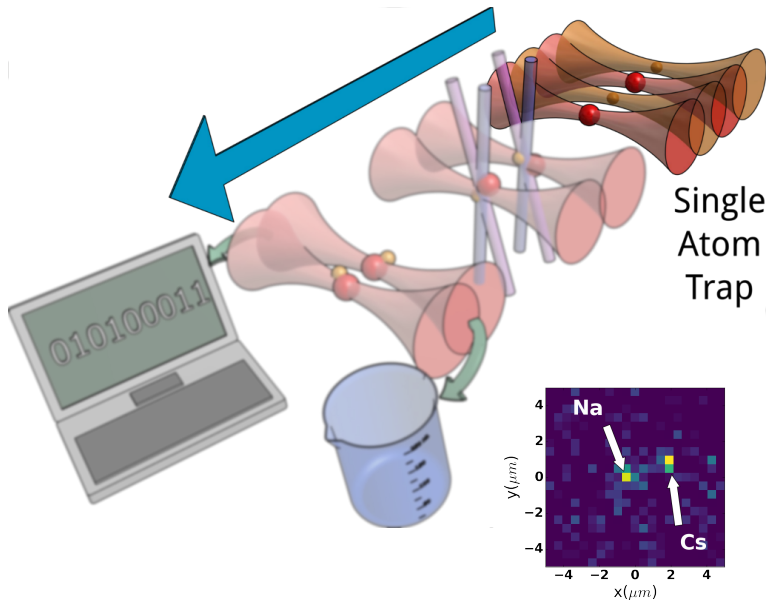
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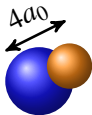
# Setup



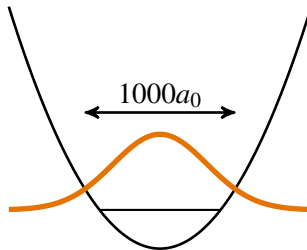
# Setup



## Wave function size mismatch



**Molecule**



**Atom**

### Goal of cooling

- Single initial state
- Shrink wavefunction size

# Raman sideband cooling of Sodium

# Raman sideband cooling of Sodium

## Difficulties

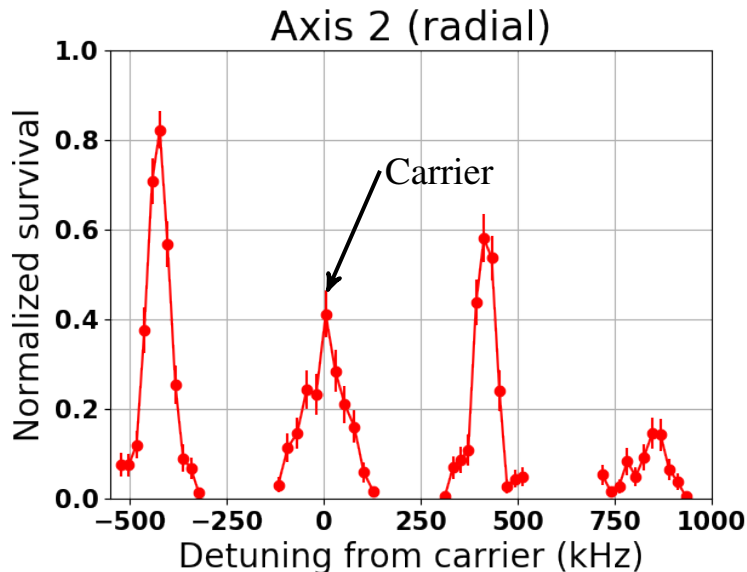
- High initial temperature ( $40\mu K$ )
- High recoil heating (High Lamb Dicke parameter)

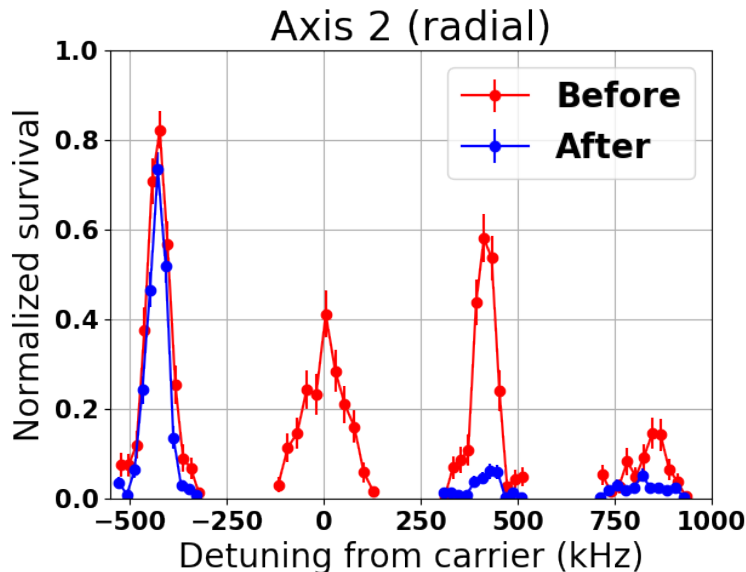
# Raman sideband cooling of Sodium

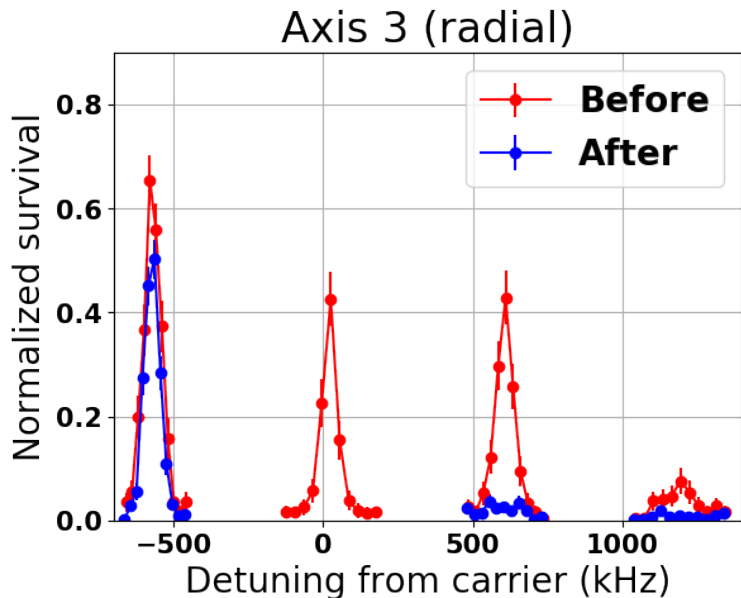
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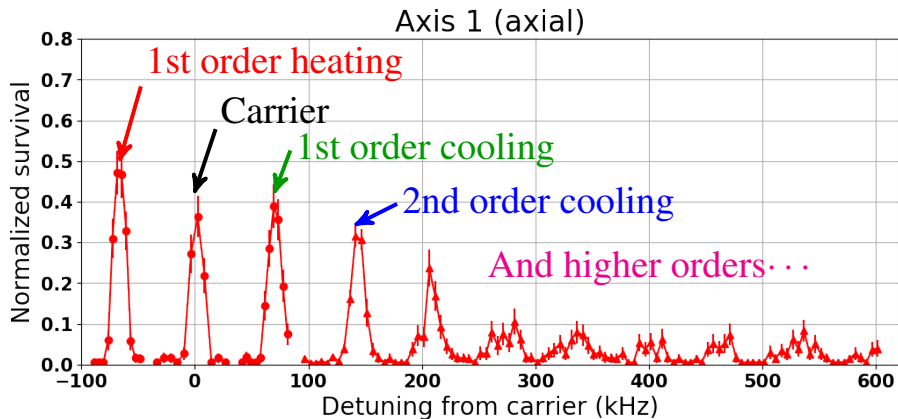




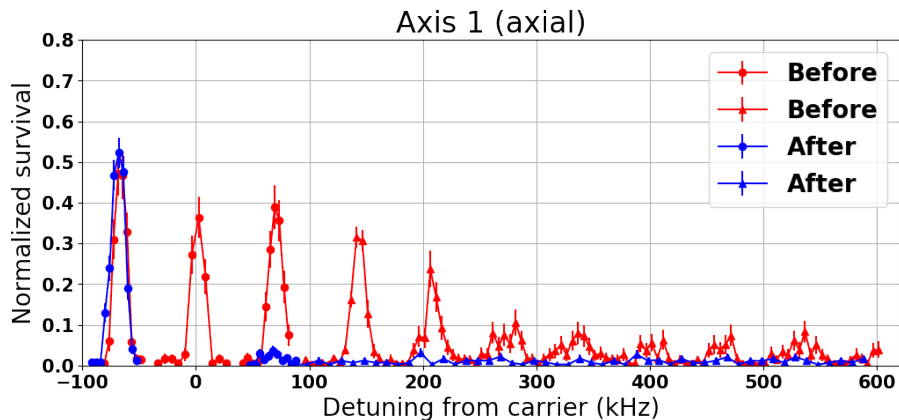




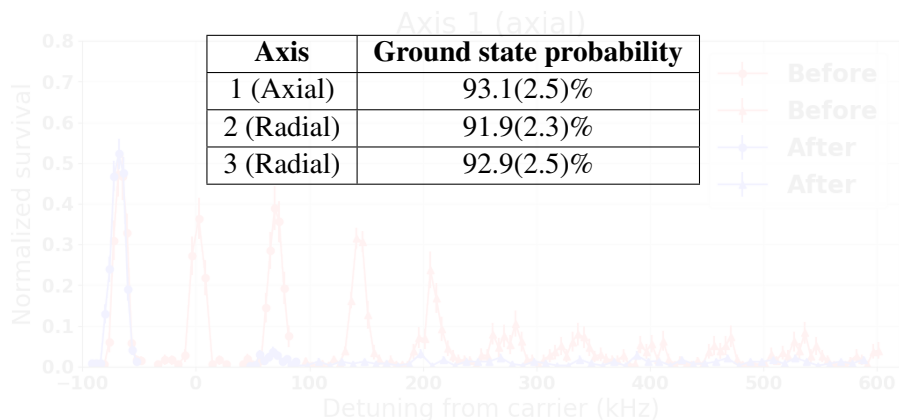
## Raman sidebands



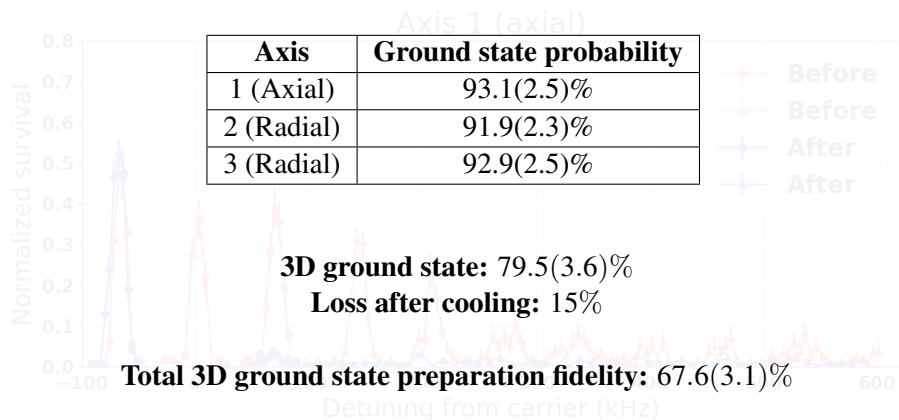
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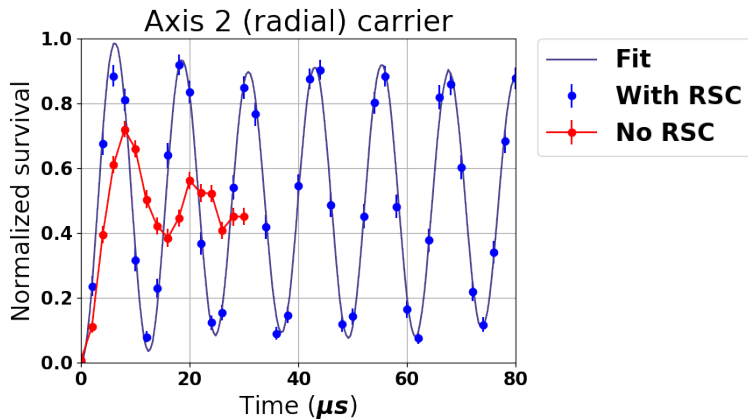
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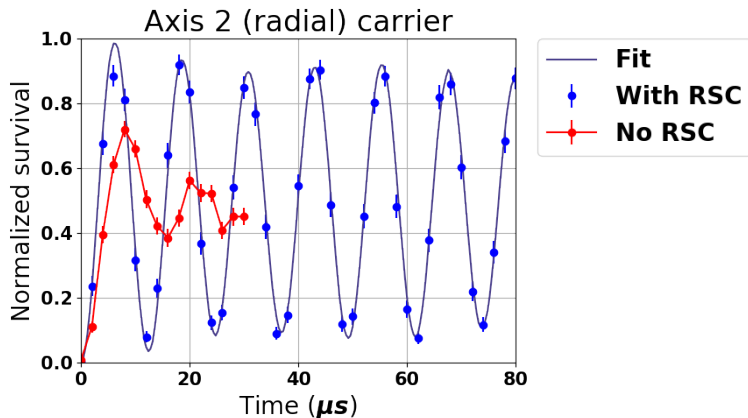


## Rabi flopping (radial)



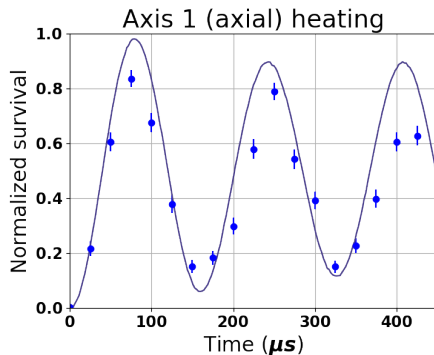
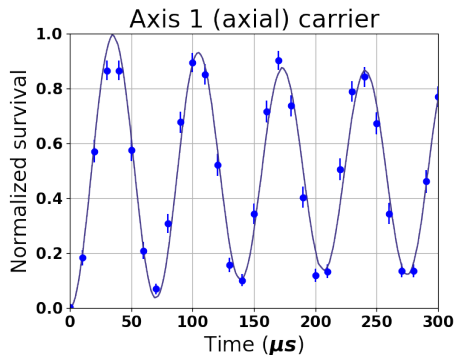


## Rabi flopping (radial)



Good agreement in ground state probability between spectrum and Rabi flopping data.

# Rabi flopping (axial)



## Conclusion

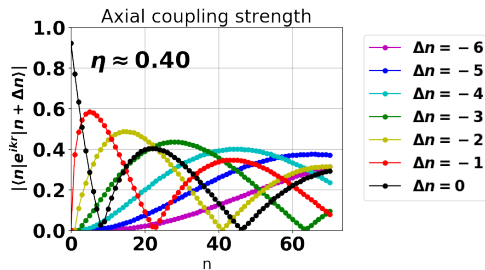
67.6(3.1)% ground state preparation fidelity (79.5(3.6)% without loss)

## Improvements

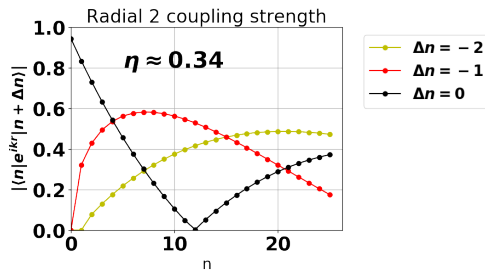
- Reduce off-resonance scattering from Raman beams
- Reduce magnetic field fluctuation
- Reduce loss during cooling



# Axial matrix element



# Radial 2 matrix element



# Radial 3 matrix element

