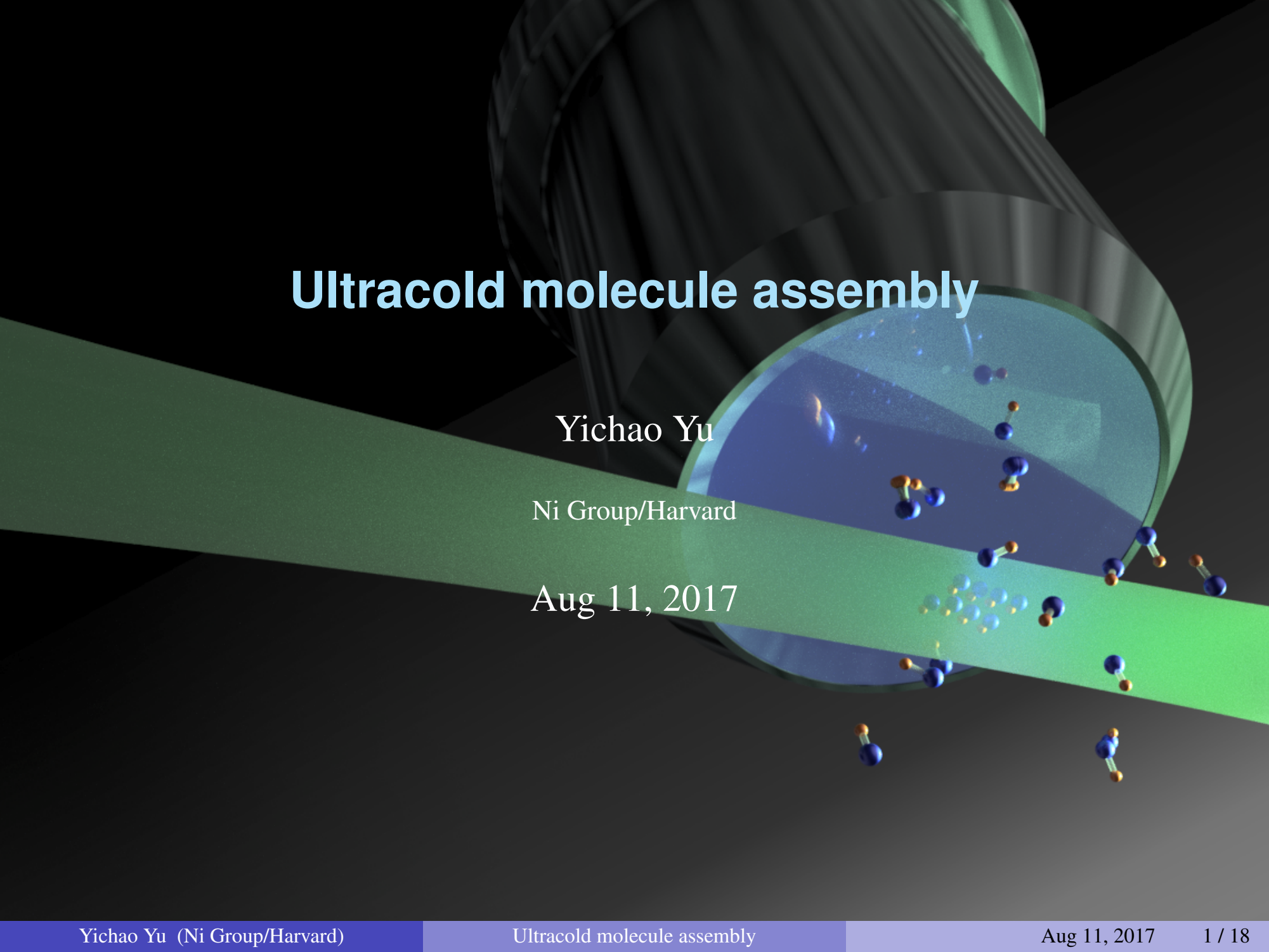


Ultracold molecule assembly

Yichao Yu

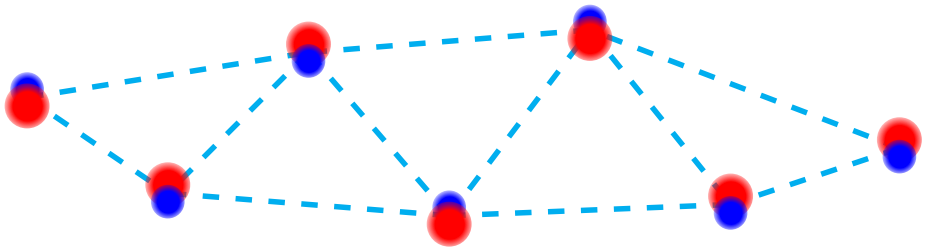
Ni Group/Harvard

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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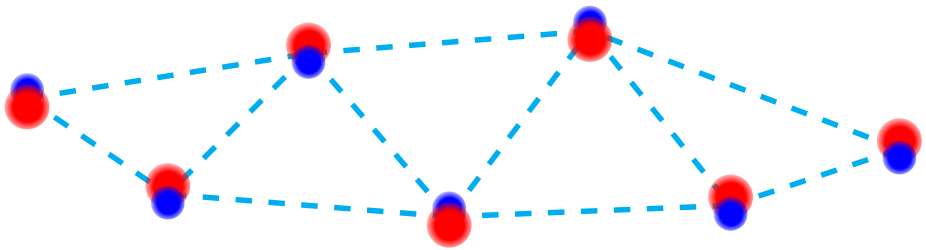

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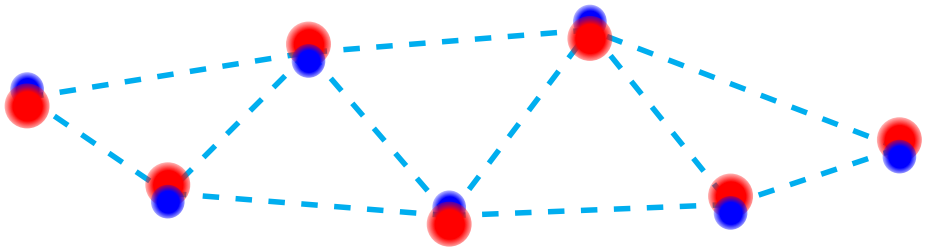

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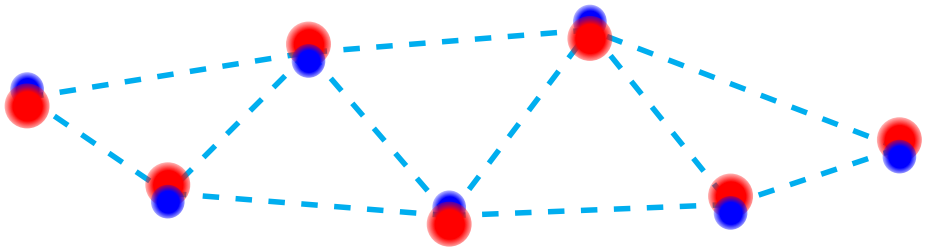

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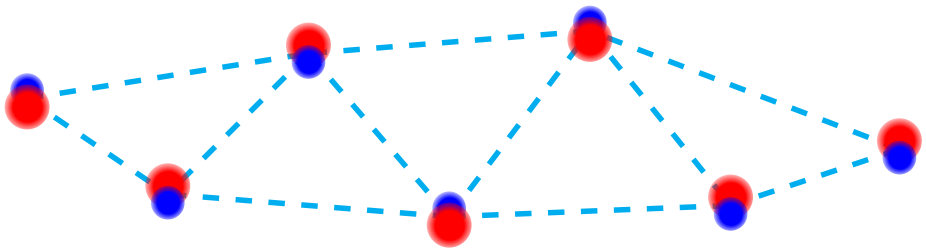
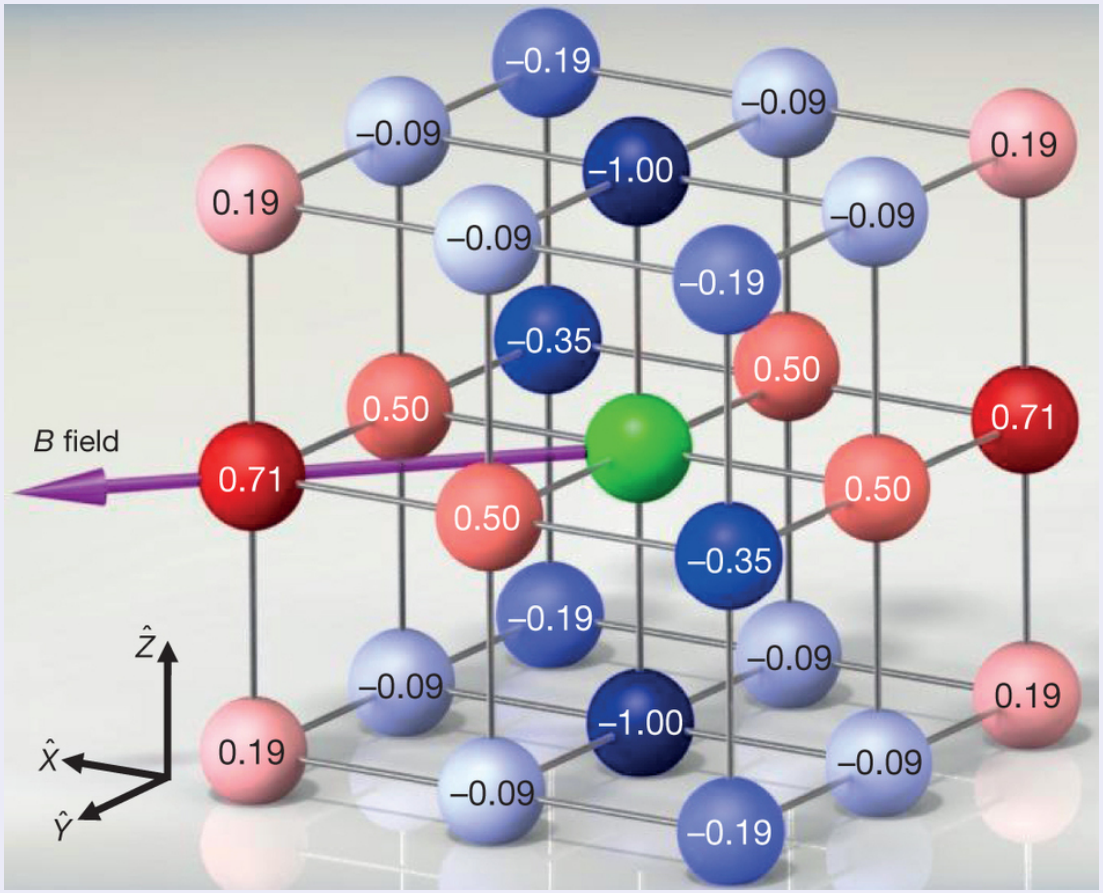
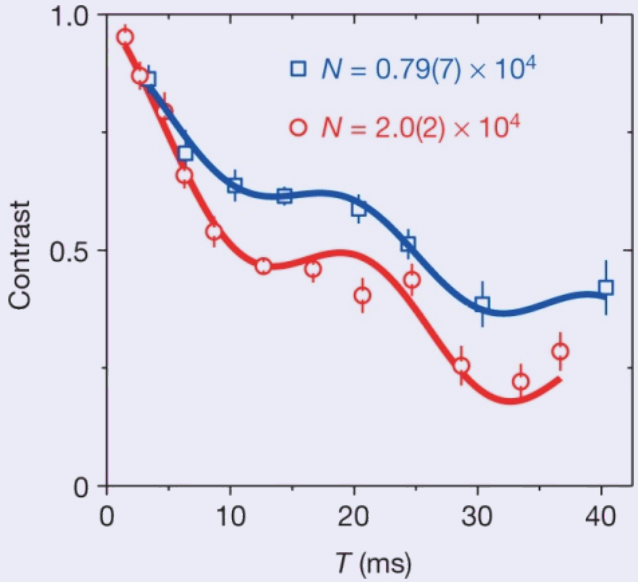


Applications

Simulation of many-body system[1]

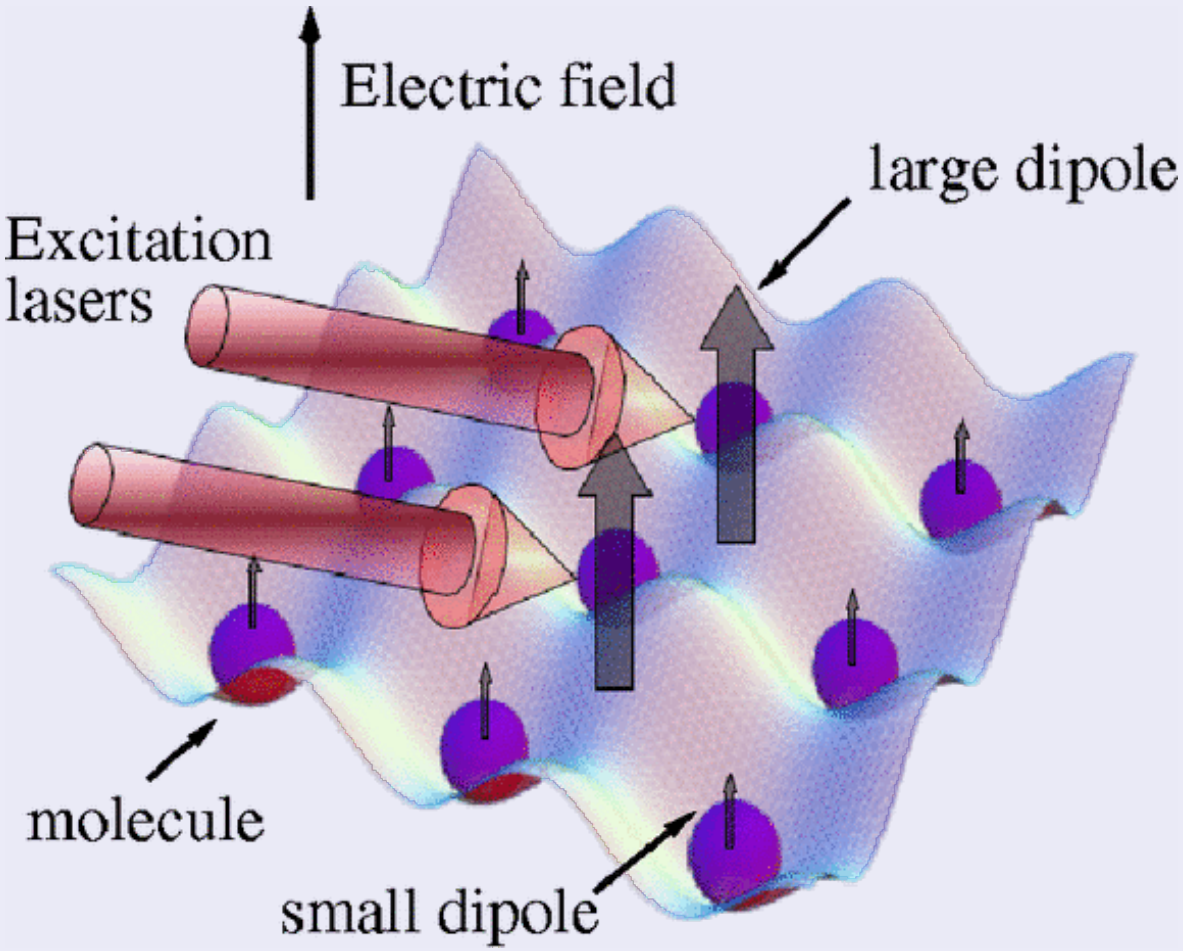




[1] B. Yan et al., "Observation of dipolar spin-exchange interactions with lattice-confined polar molecules.", Nature **501**, 521–5 (2013).

Applications

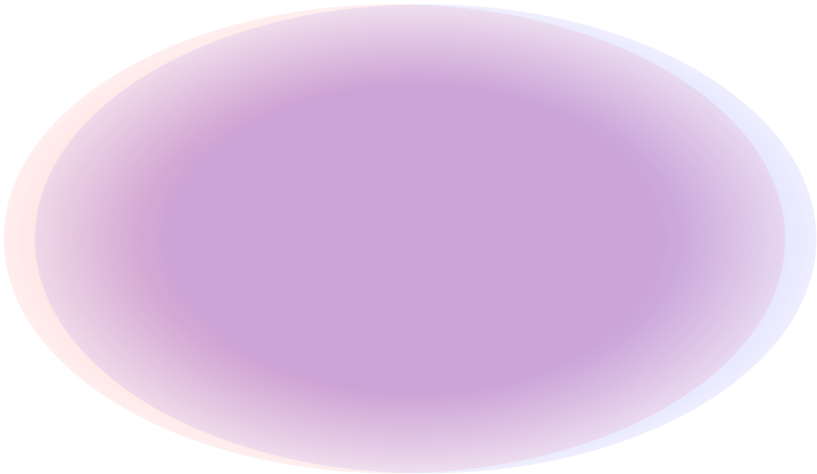
Quantum computation[2]



[2] S. F. Yelin et al., "Schemes for robust quantum computation with polar molecules", 4 (2006).

Making molecules from atoms

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



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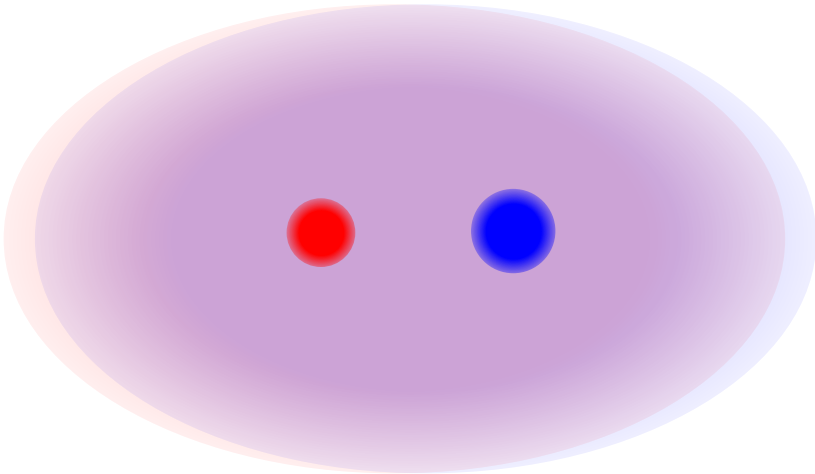

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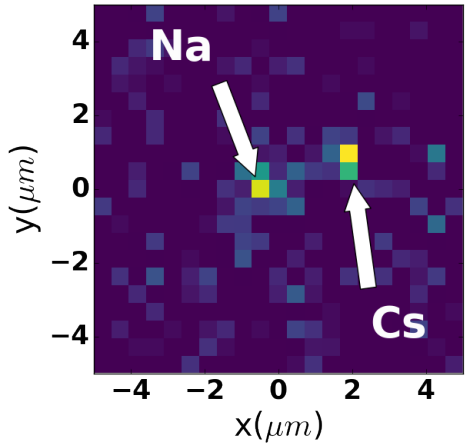
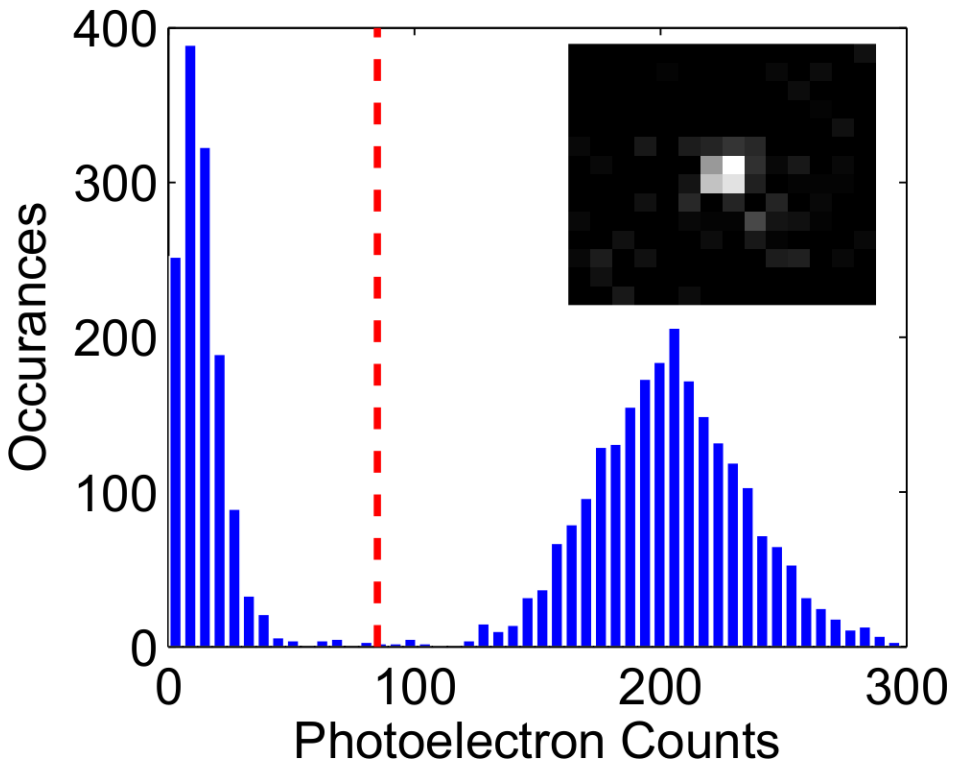


- Single atoms
- 85% cround state after Cesium Raman sideband cooling



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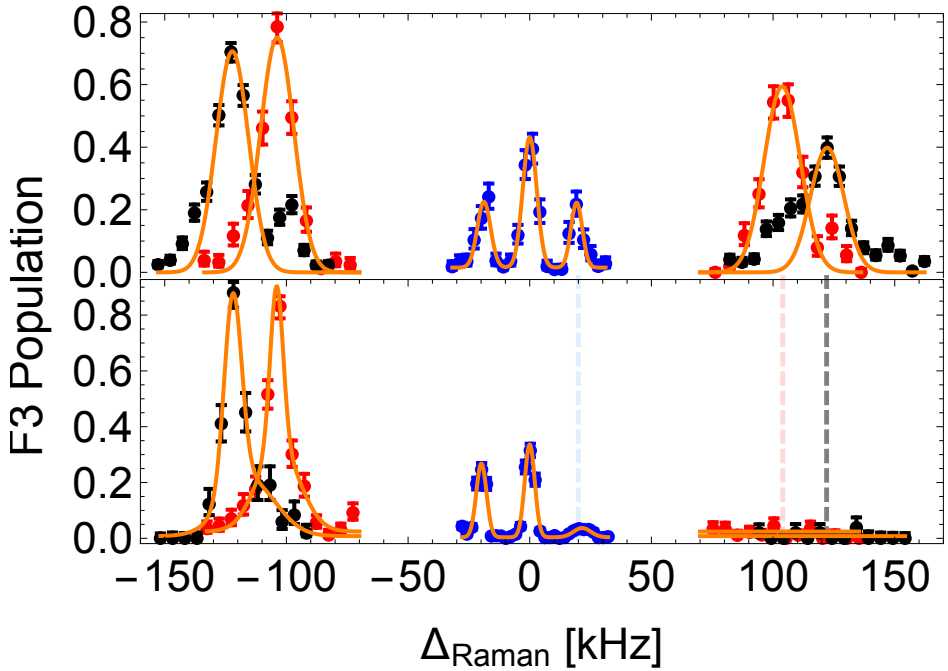
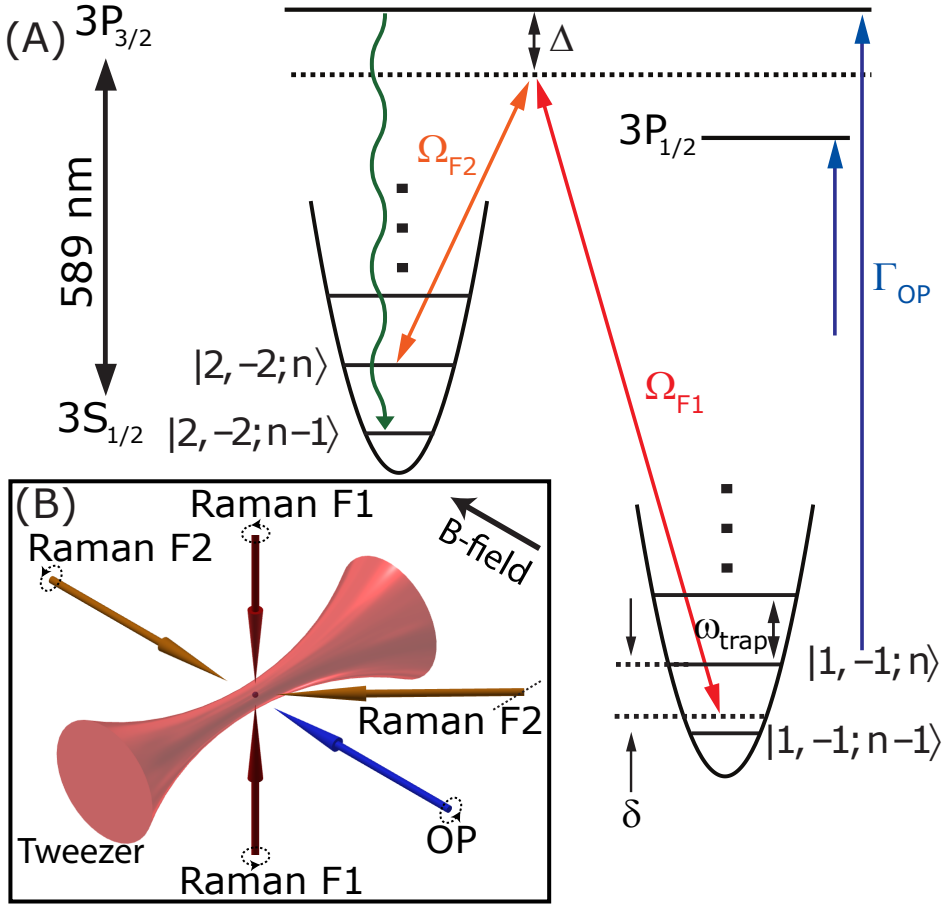


Raman sideband cooling



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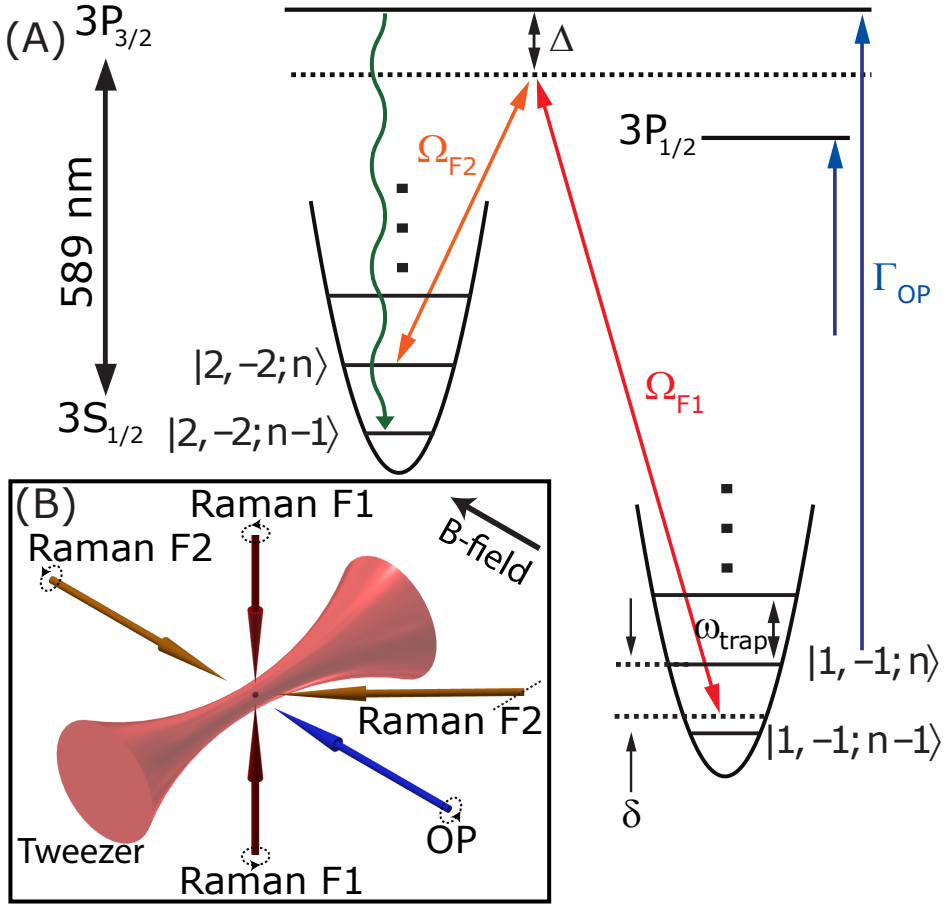

Difficulties

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

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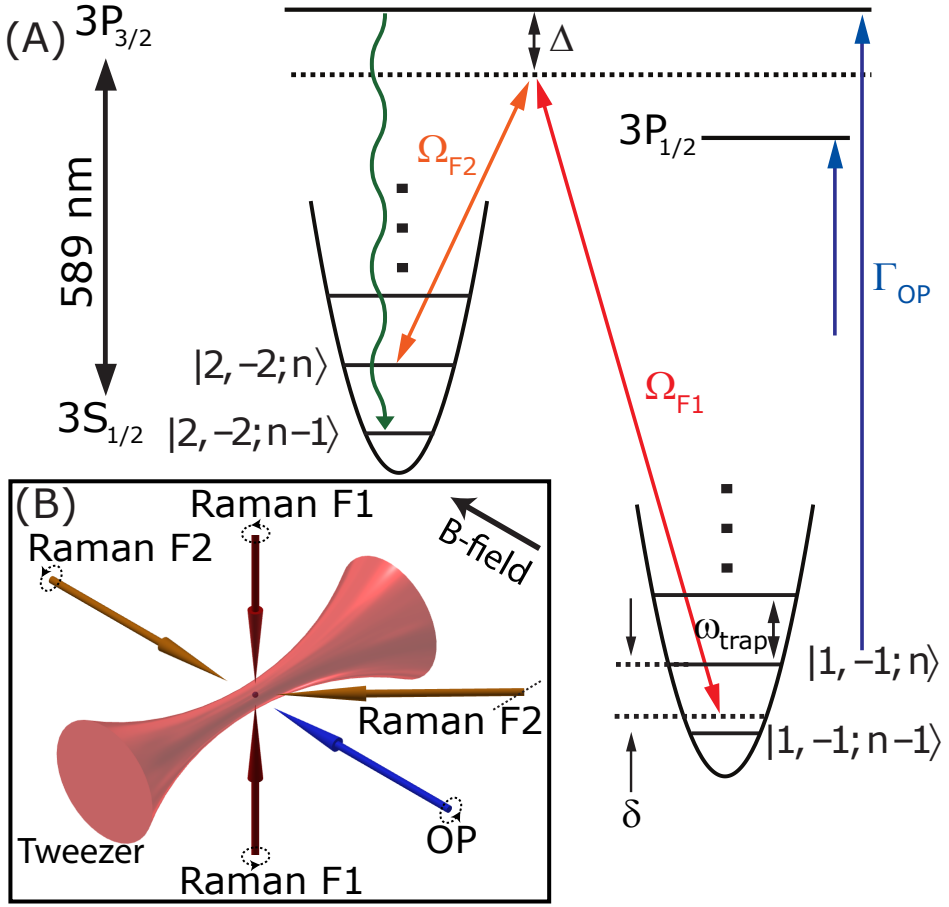

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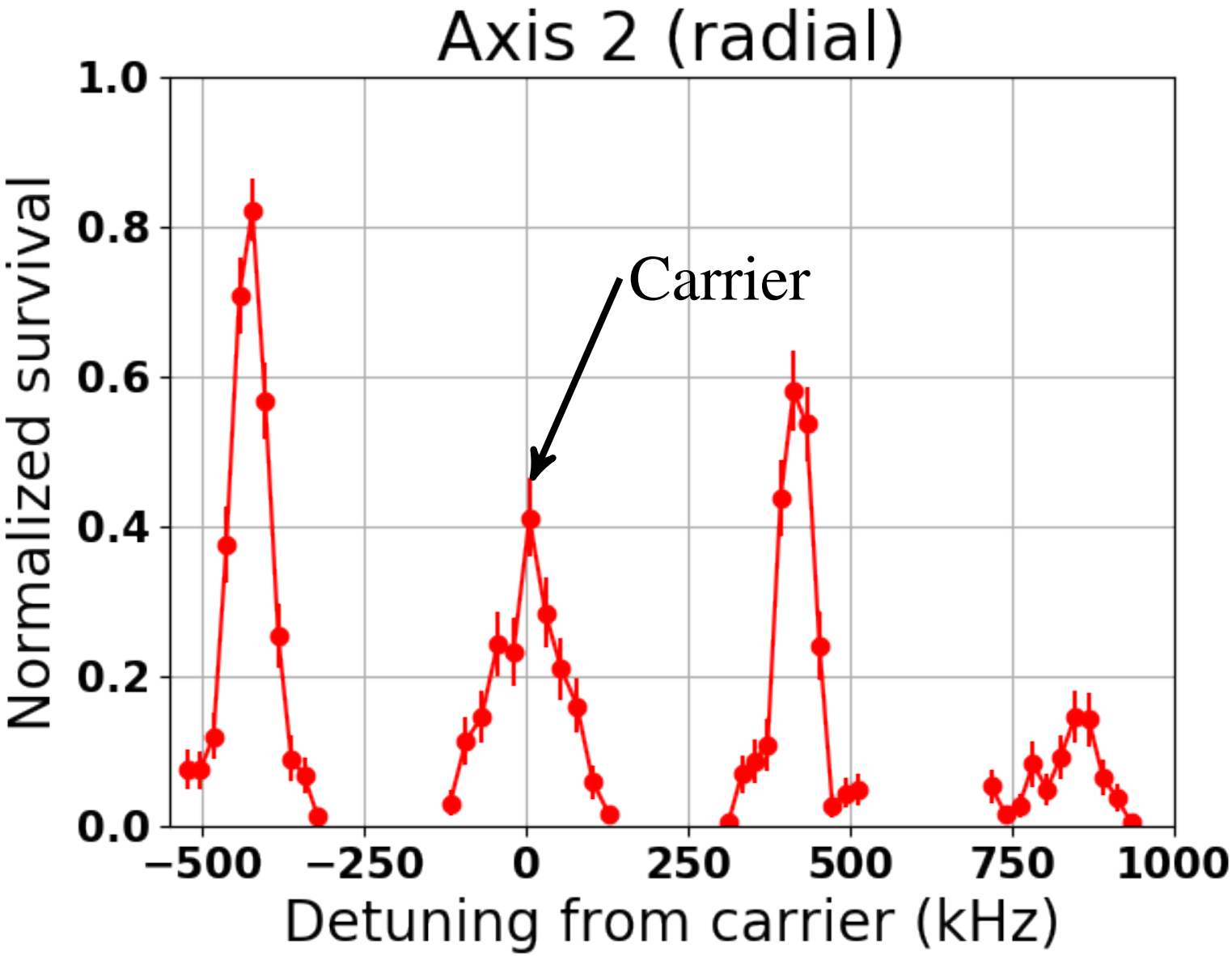

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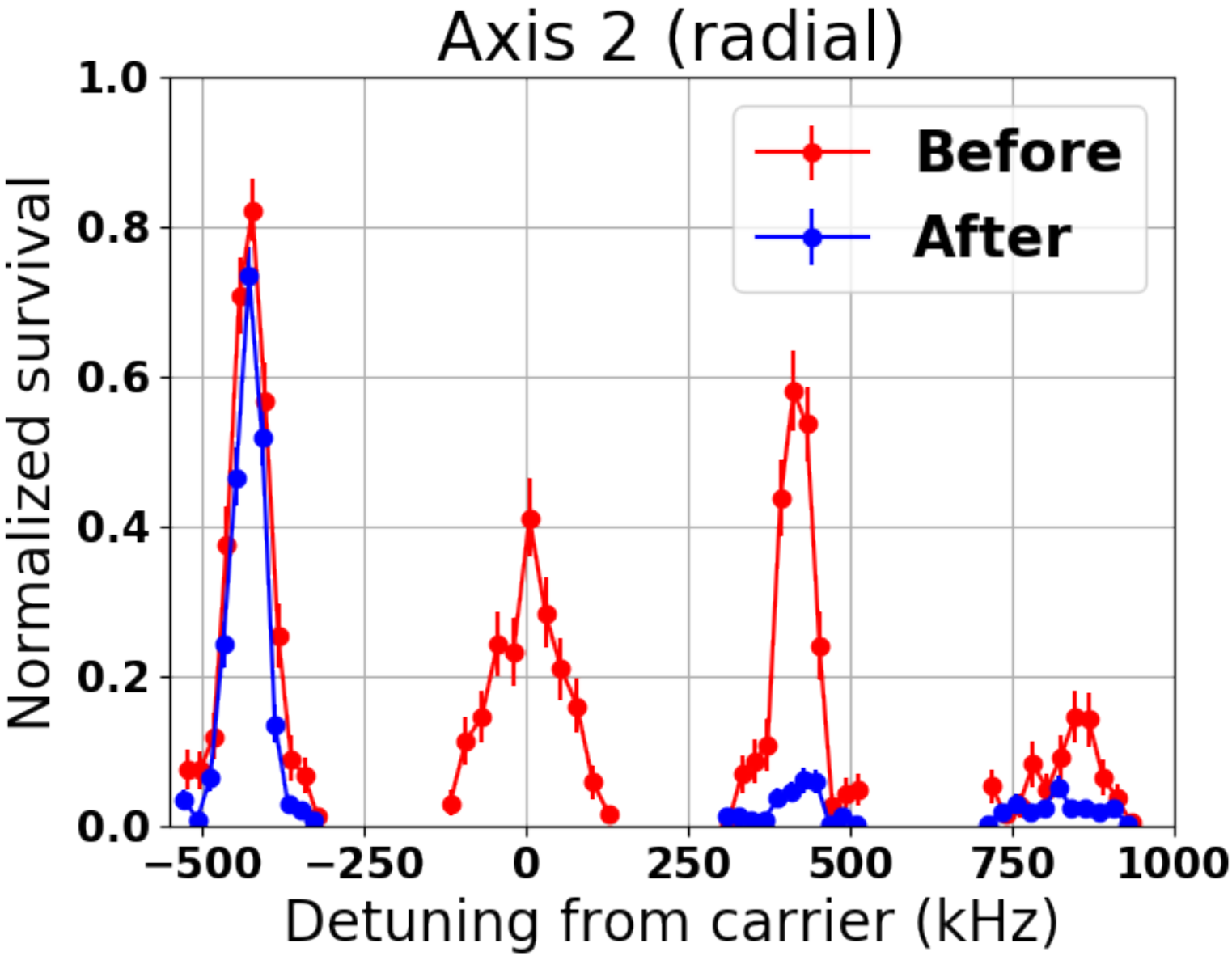

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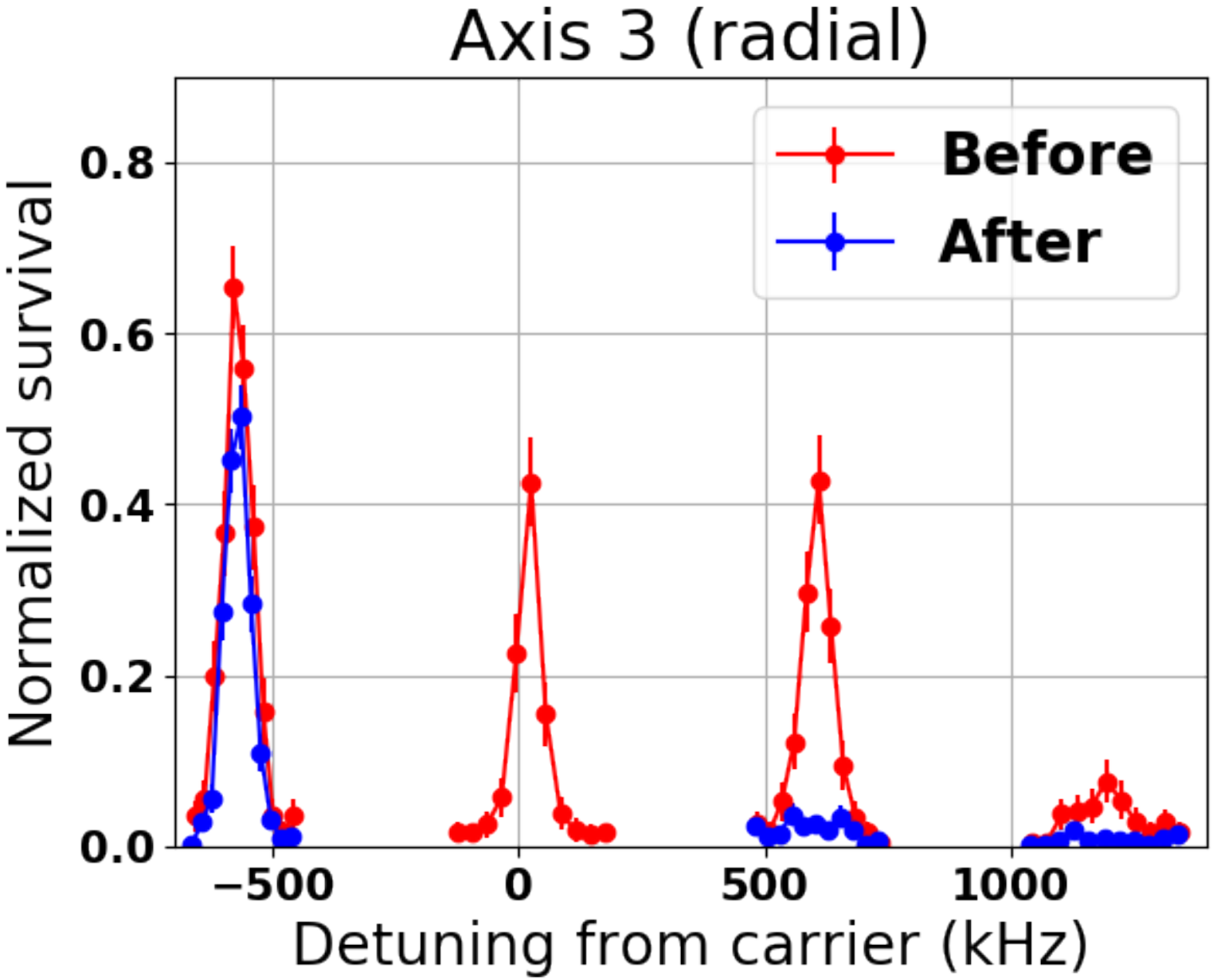

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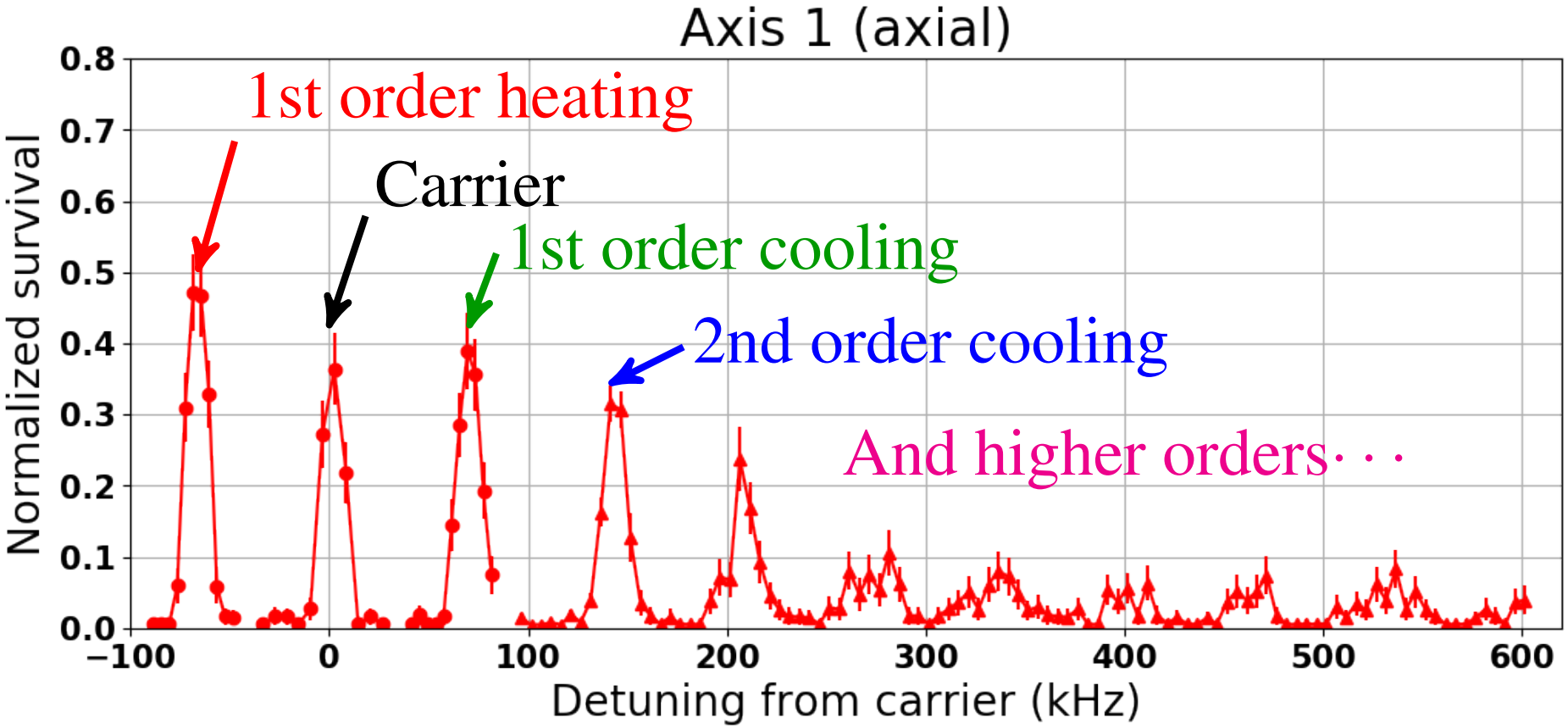

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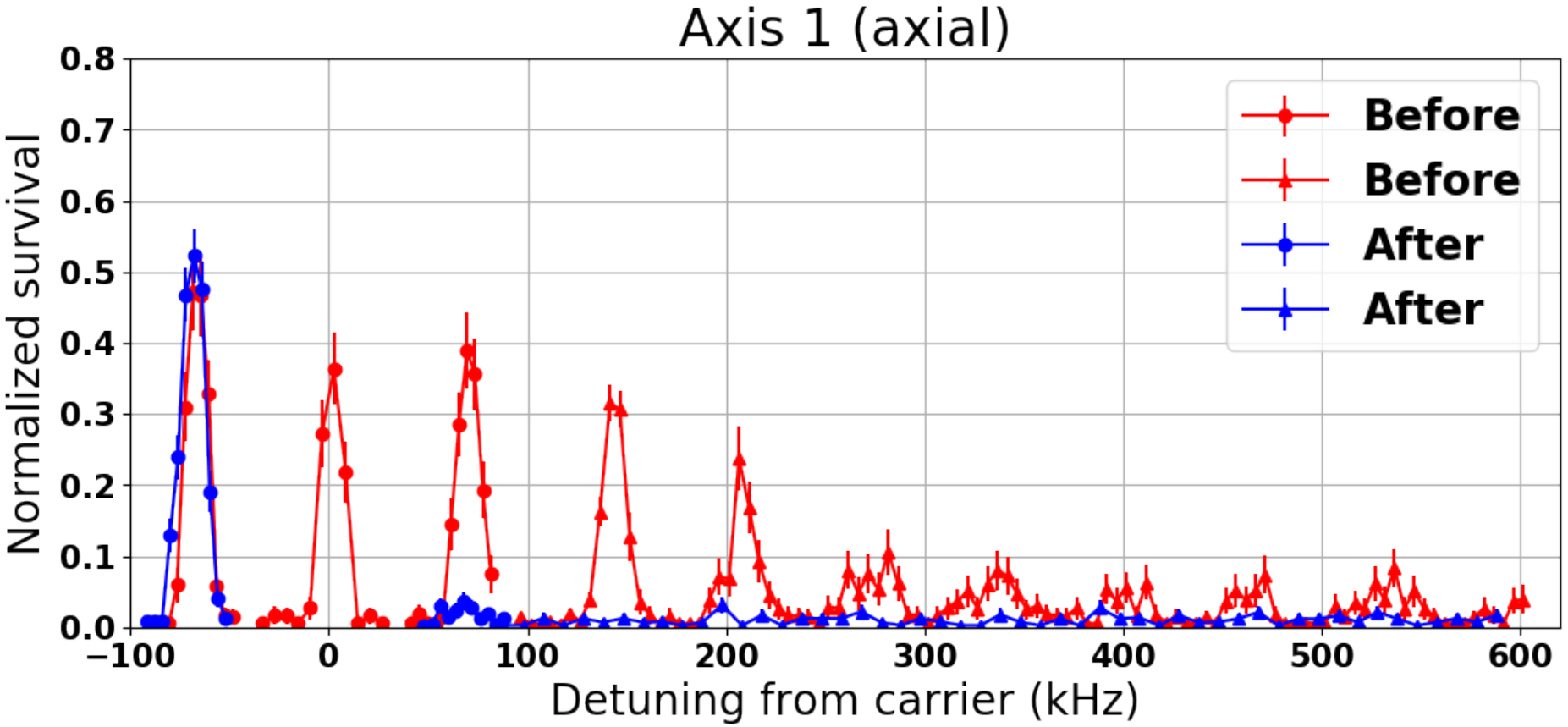
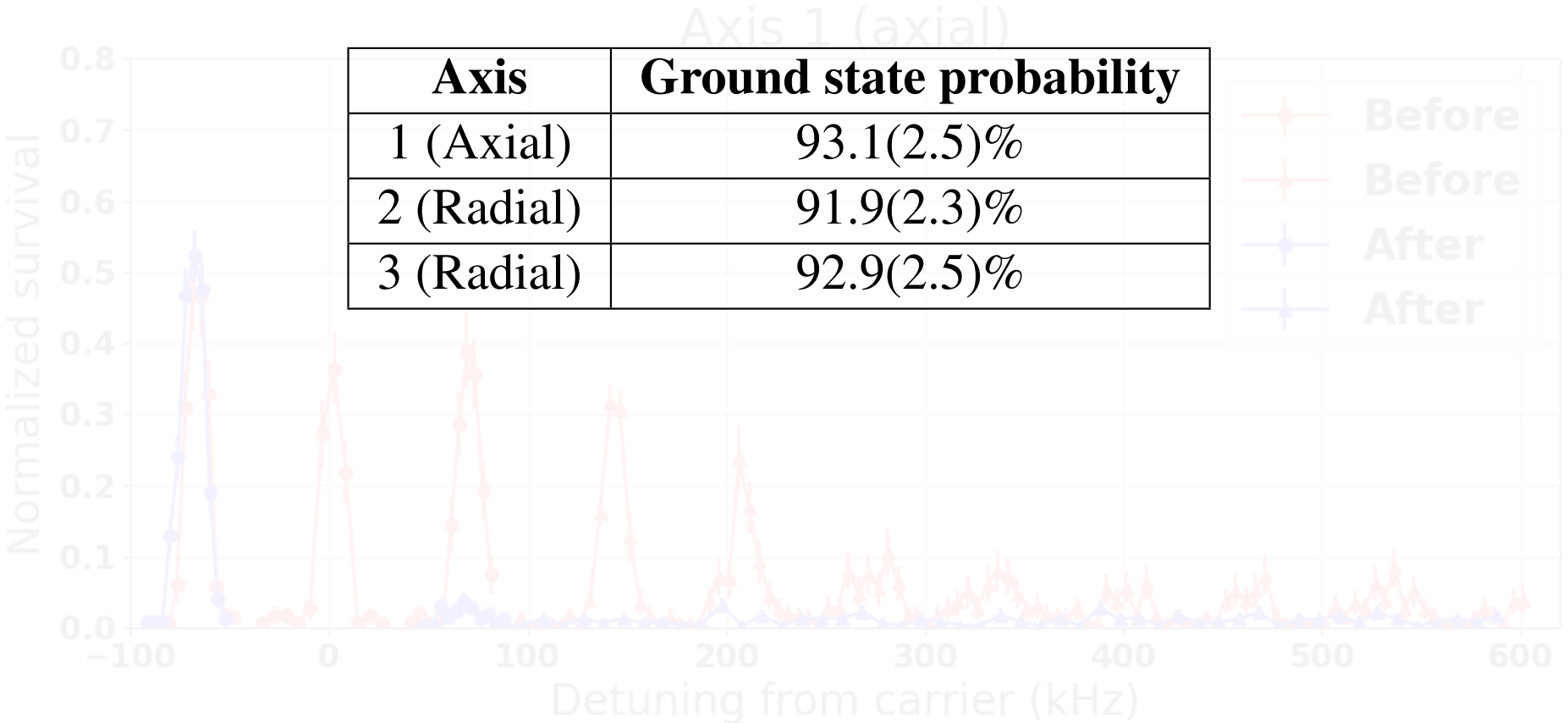


Raman sidebands

Axis	Ground state probability
1 (Axial)	93.1(2.5)%
2 (Radial)	91.9(2.3)%
3 (Radial)	92.9(2.5)%



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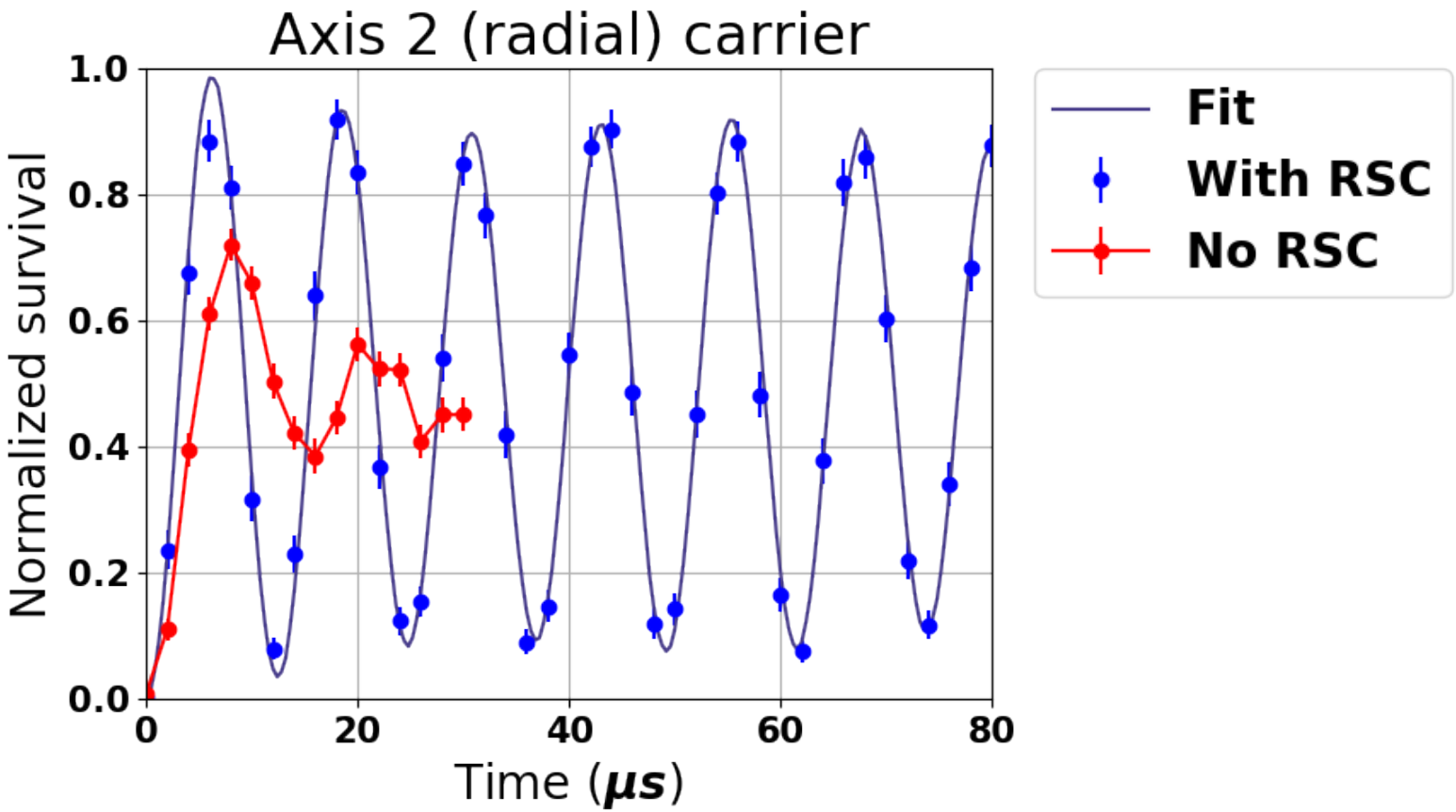
1 (Axial)	93.1(2.5)%
2 (Radial)	91.9(2.3)%
3 (Radial)	92.9(2.5)%

3D ground state: 79.5(3.6)%
Loss after cooling: 15%

Total 3D ground state preparation fidelity: 67.6(3.1)%

Rabi flopping (radial)



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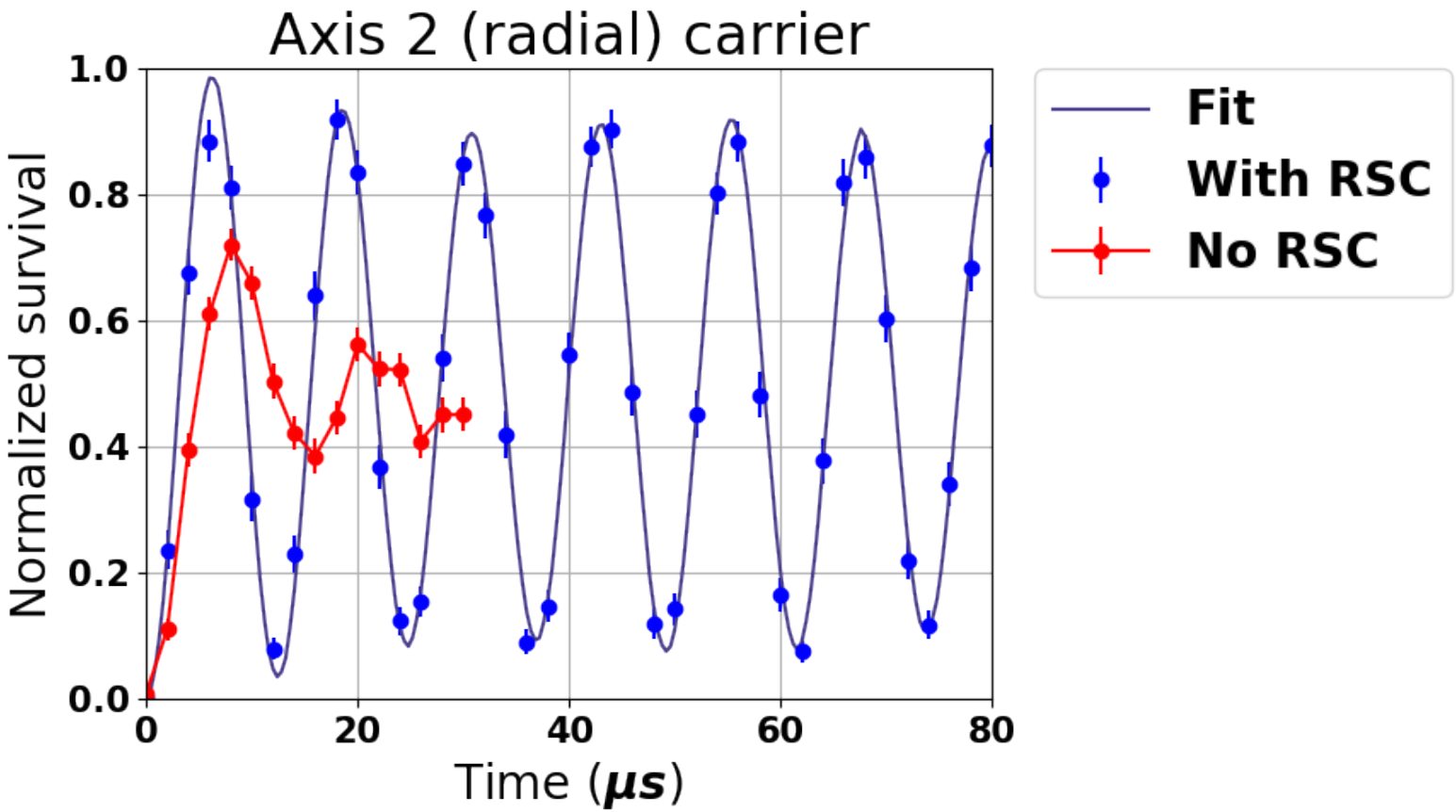
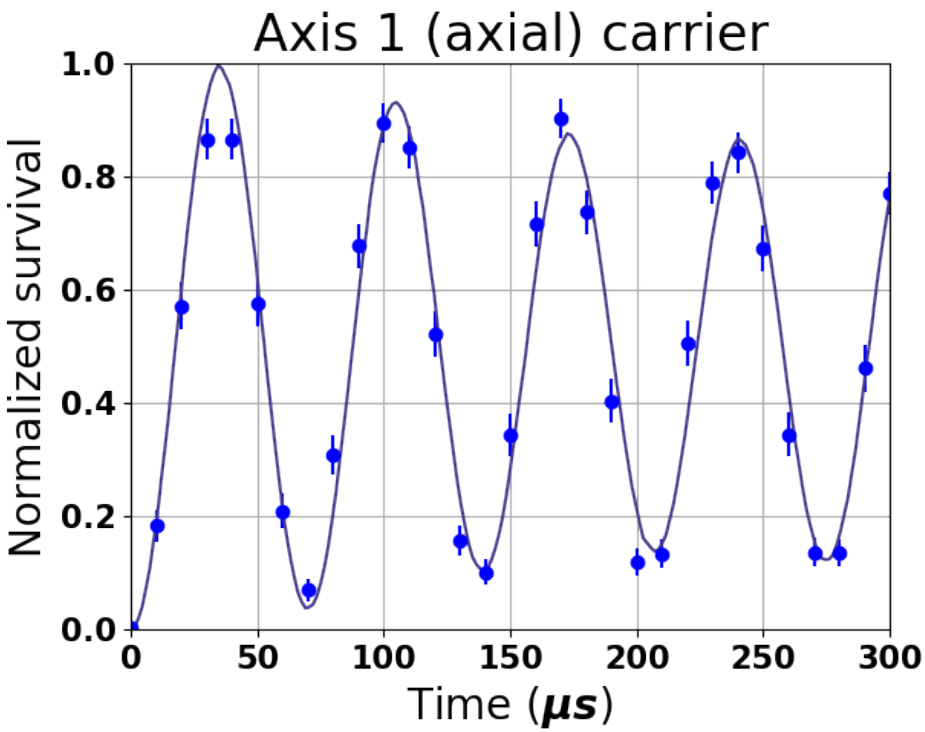
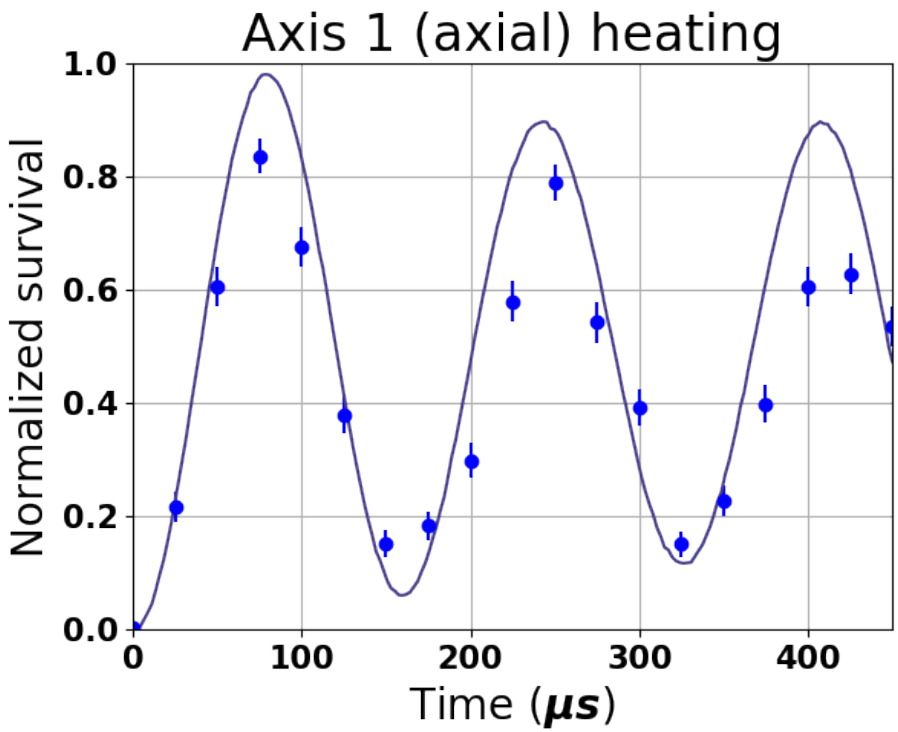


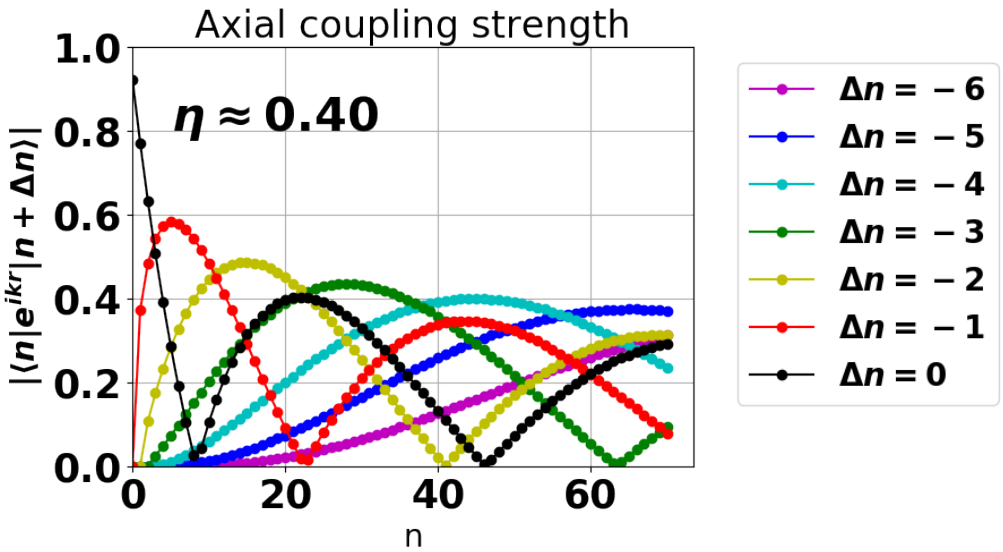
Good agreement in ground state probability between spectrum and Rabi flopping data.

Rabi flopping (axial)

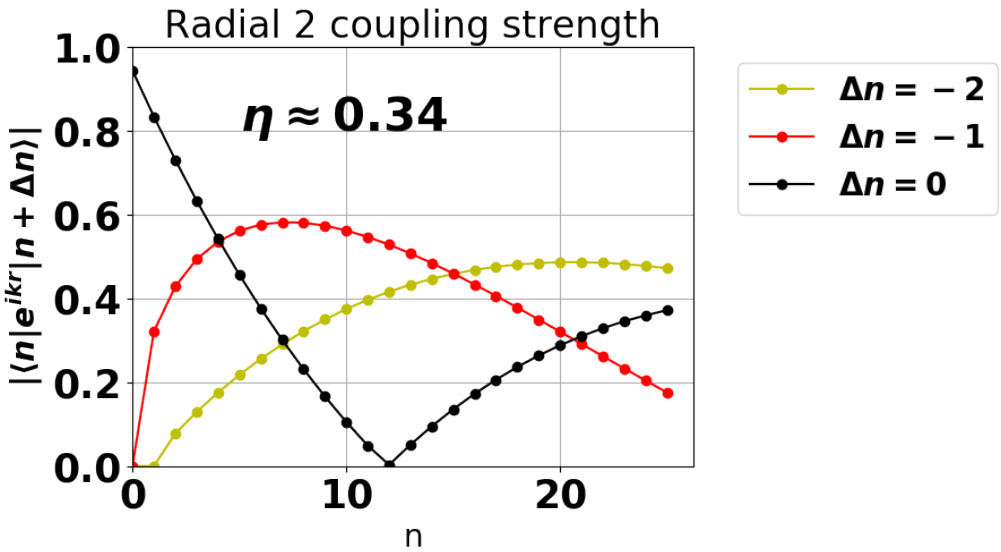




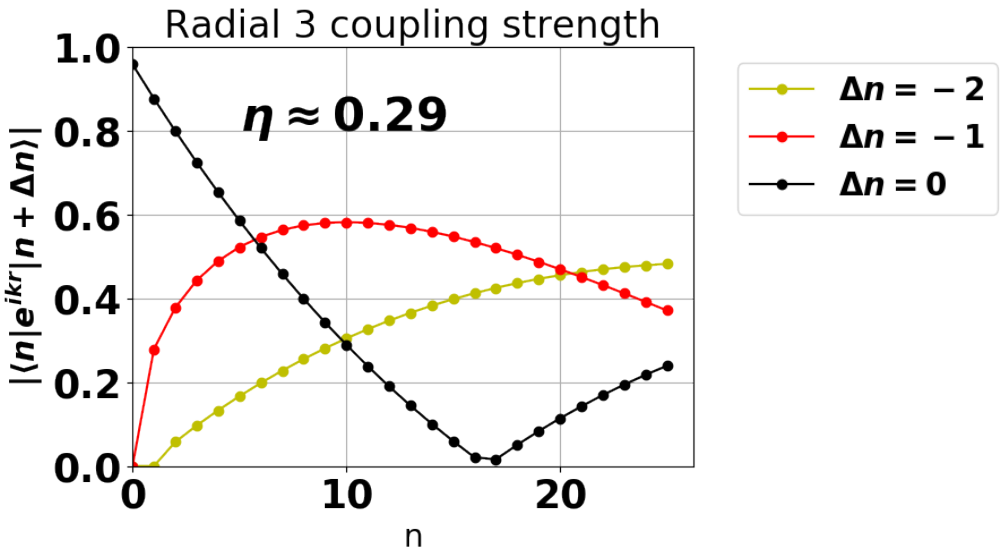
Axial matrix element



Radial 2 matrix element



Radial 3 matrix element



Next step