

Ultracold molecule assembly

The background features a 3D visualization of an ultracold molecule assembly trap. A large, dark, cylindrical structure with a ribbed texture is shown in perspective. A bright green beam of light enters from the left and focuses into a blue, translucent, ellipsoidal region. Inside and around this region, numerous small molecular models are depicted, each consisting of blue and orange spheres connected by lines, representing atoms and bonds respectively. The overall scene is set against a dark, gradient background.

Yichao Yu

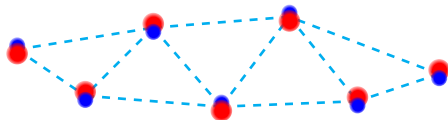
Ni Group/Harvard

Aug 11, 2017

Molecules in optical tweezer

Features

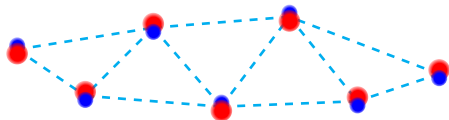
- Strong and tunable interaction
- Rich internal energy levels
- High filling fraction
- Single site detection and manipulation



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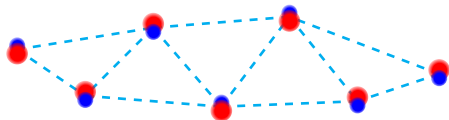
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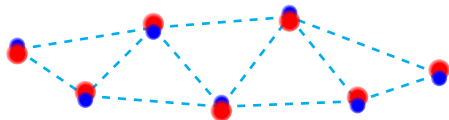
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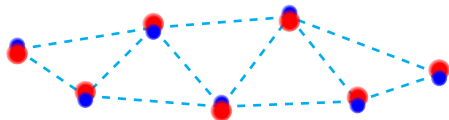
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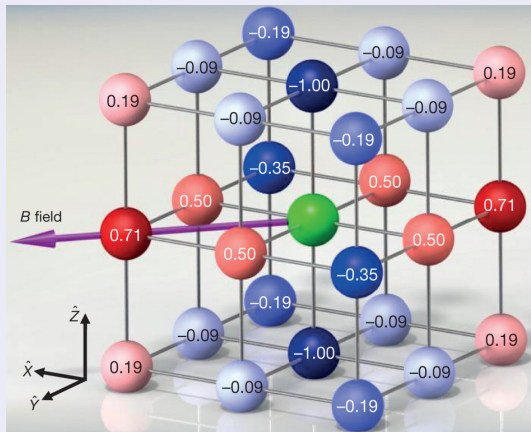
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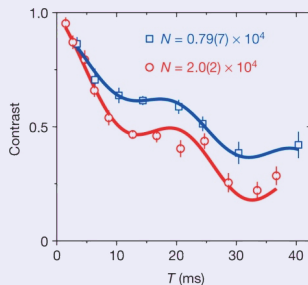
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Simulation of many-body system^[1]

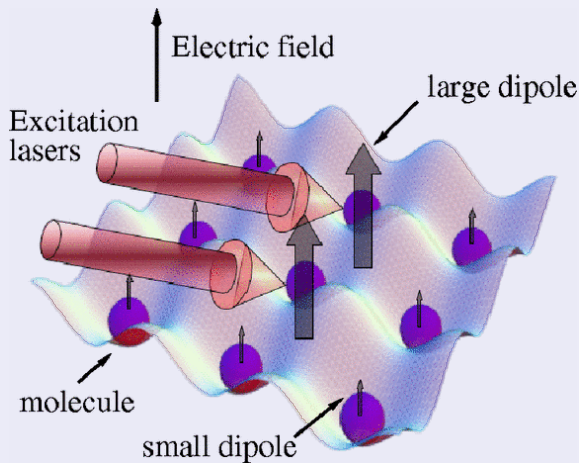


$$H \propto \sum_{ij} V_{ij} (S_i^+ S_j^- + S_i^- S_j^+)$$



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

Quantum computation^[2]



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

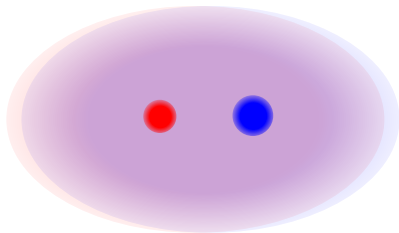
Making molecules from atoms

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



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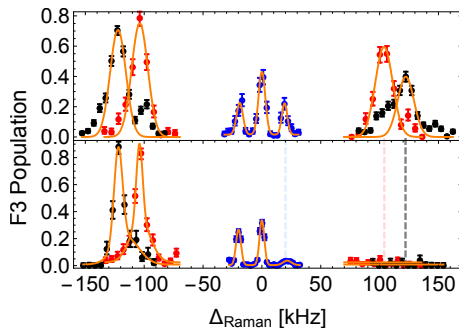
Atom loading and cooling

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

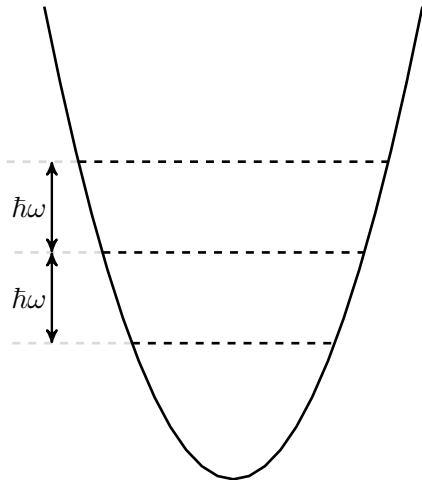


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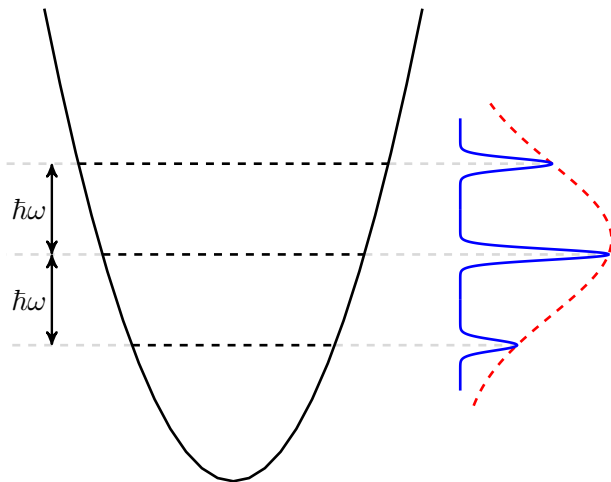
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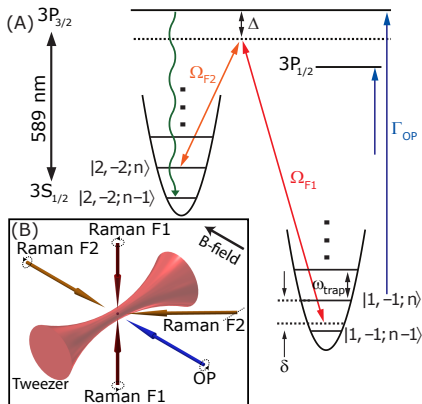
Raman sideband cooling



Raman sideband cooling

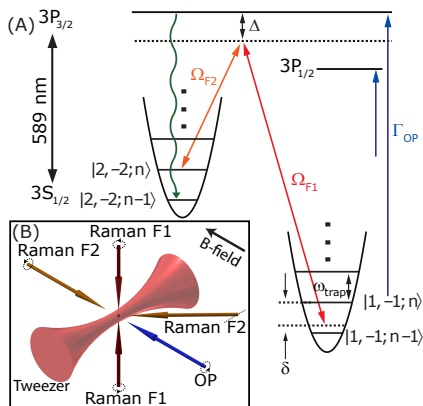


Raman sideband cooling



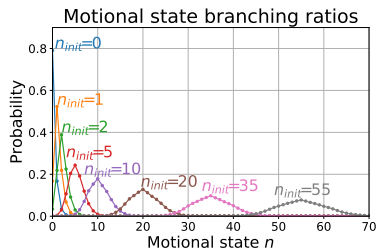
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift
- Trap anharmonicity
- Off resonance scattering from Raman beams
 $\approx 0.2 \sim 0.5\text{kHz}$

Raman sideband cooling



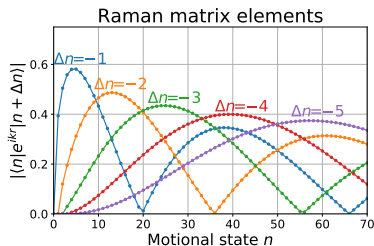
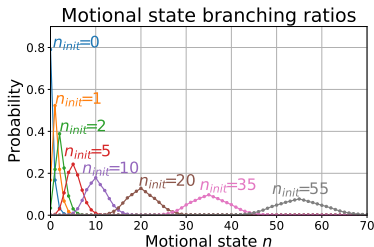
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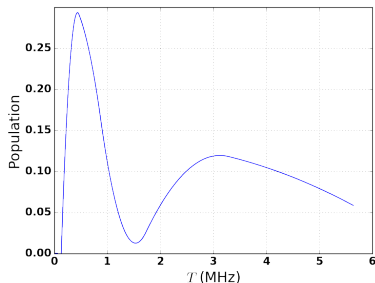
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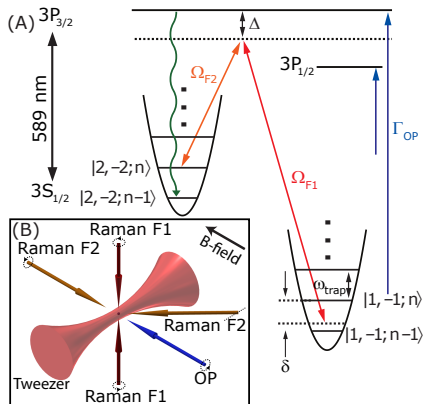
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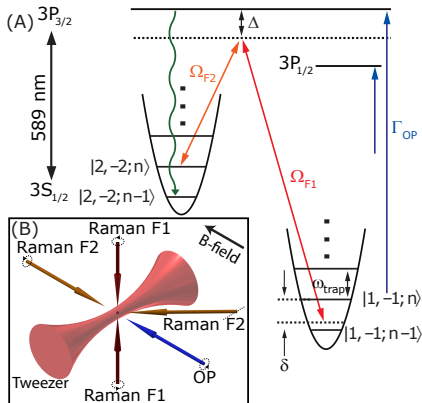
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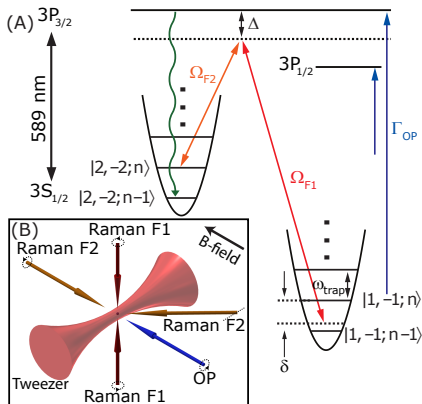
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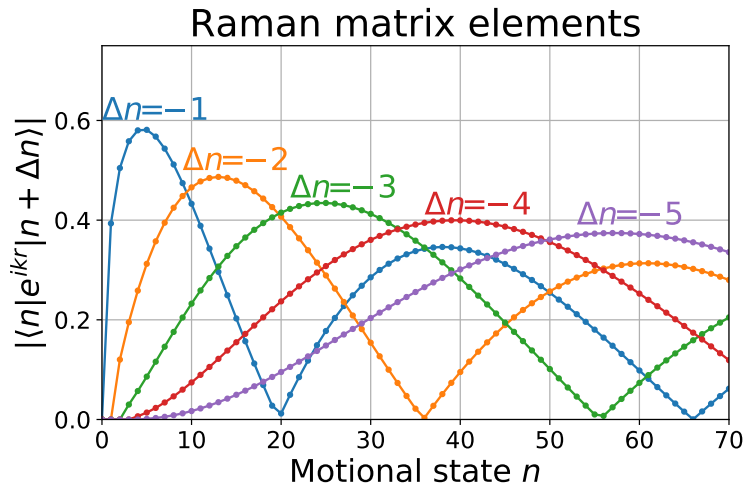


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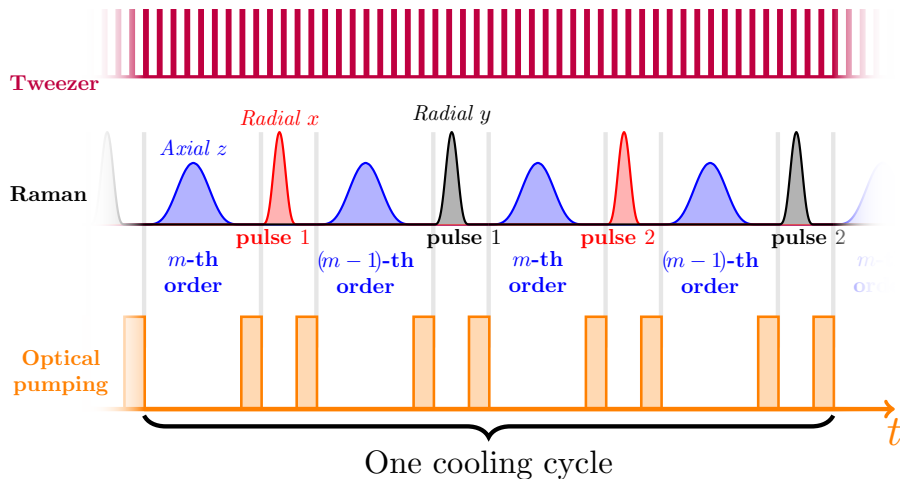
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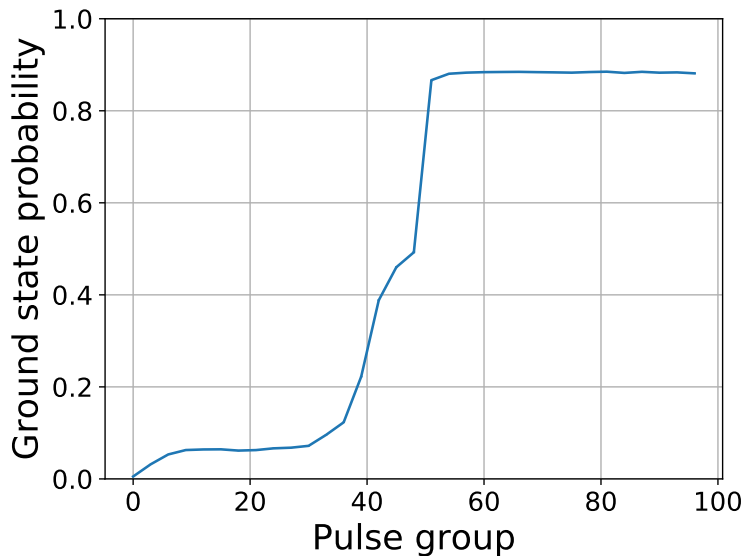
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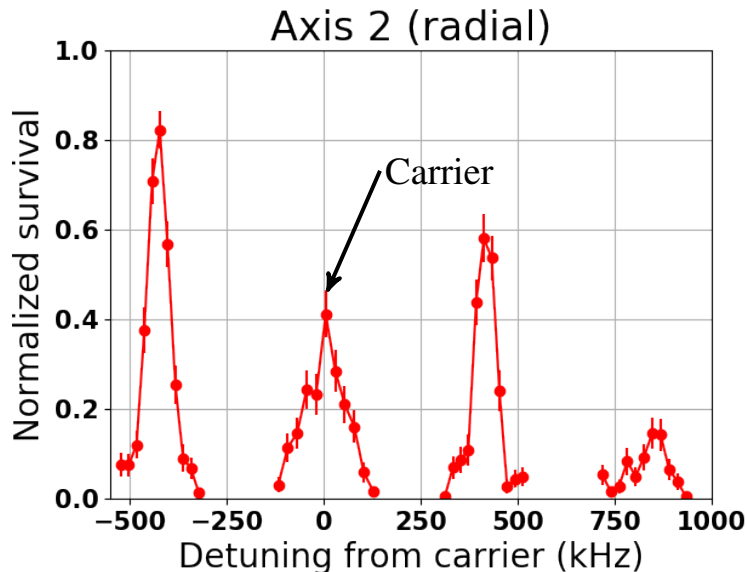


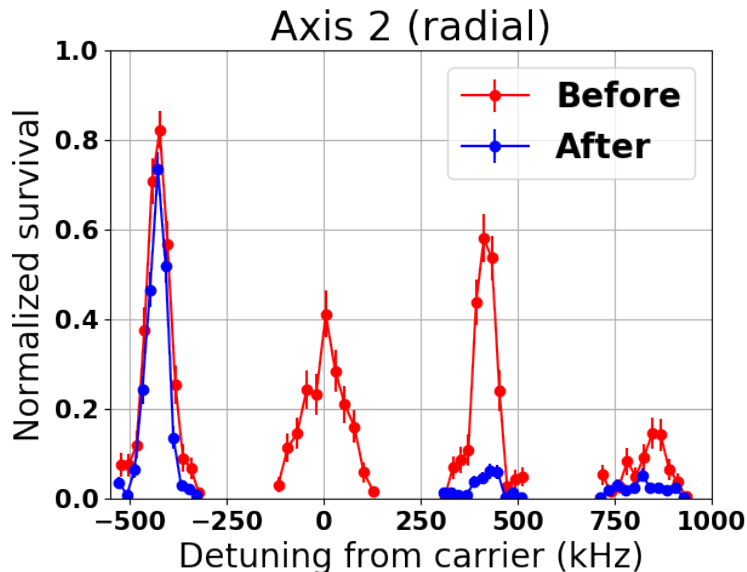
Sequence and simulation

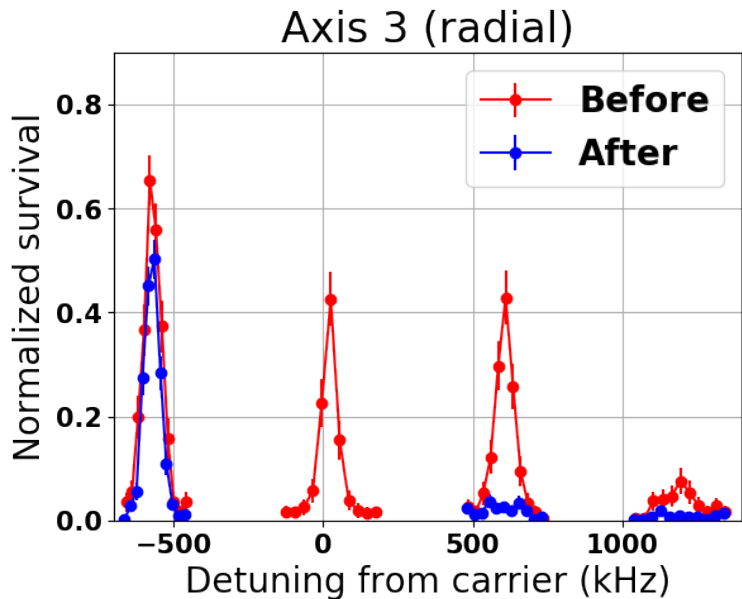


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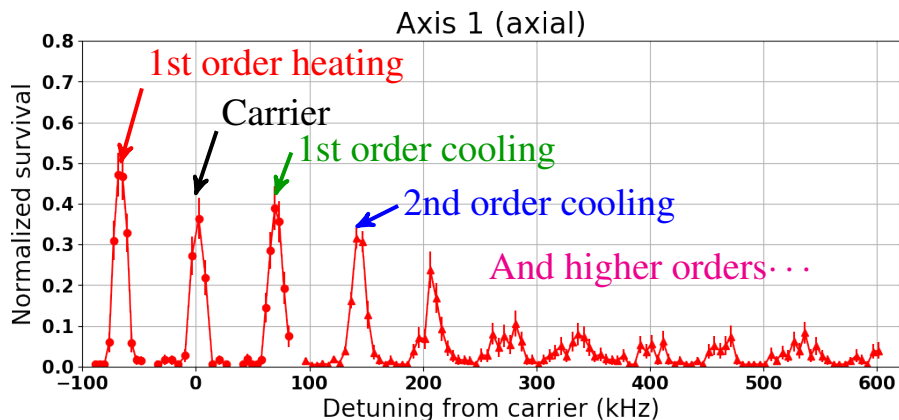




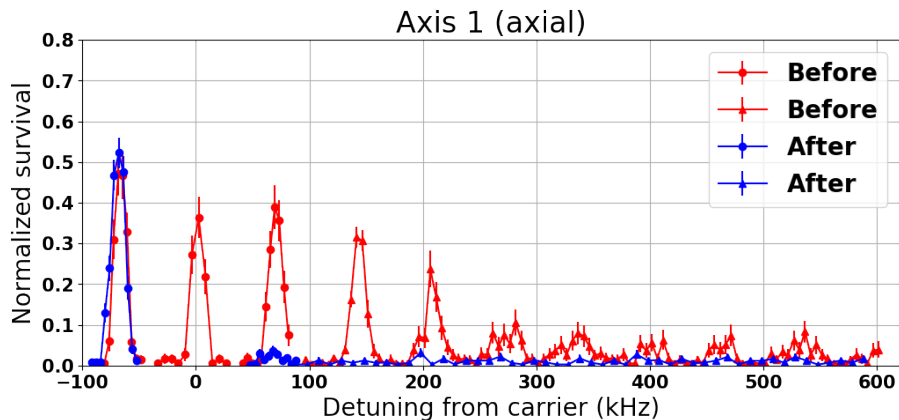




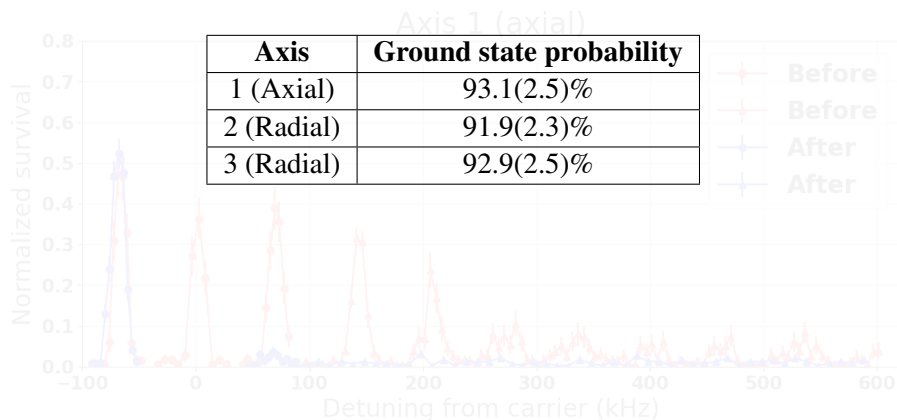
Raman sidebands



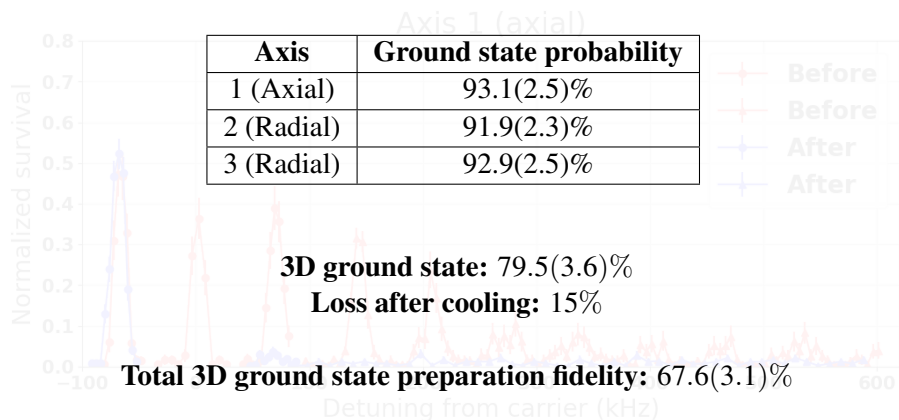
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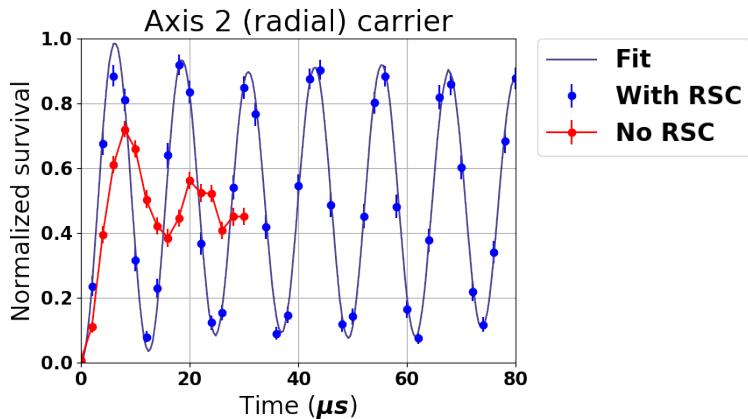
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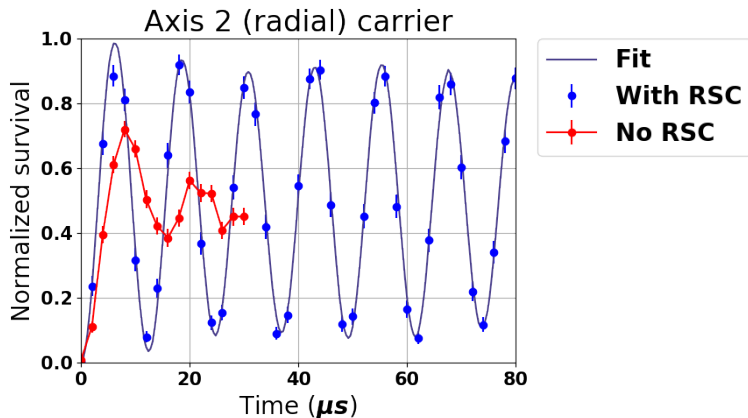
Raman sidebands



Rabi flopping (radial)

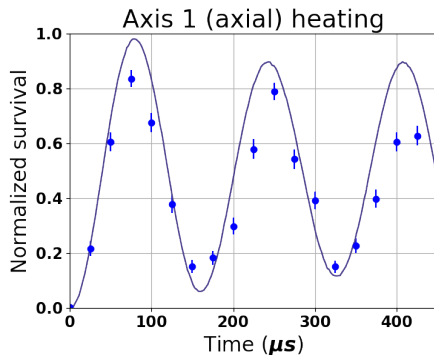
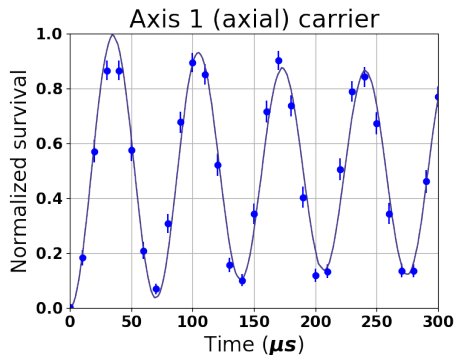


Rabi flopping (radial)



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

Rabi flopping (axial)



Merge

