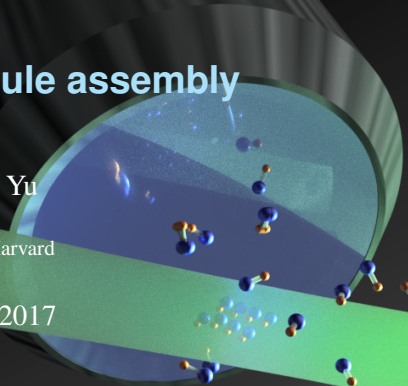


Ultracold molecule assembly

Yichao Yu

Ni Group/Harvard

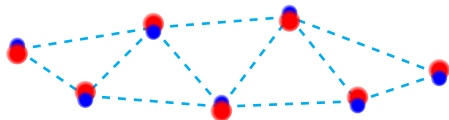
Aug 11, 2017



Molecules in optical tweezer

Features

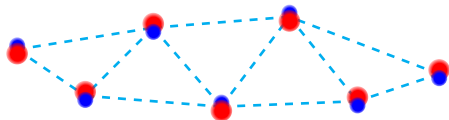
- Strong and tunable interaction
- Rich internal energy levels
- High filling fraction
- Single site detection and manipulation



Molecules in optical tweezer

Features

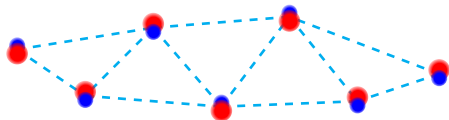
- Strong and tunable interaction
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Molecules in optical tweezer

Features

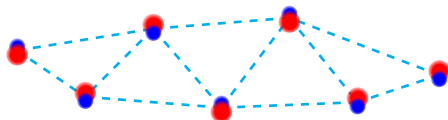
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Molecules in optical tweezer

Features

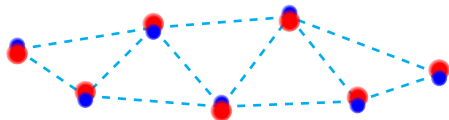
- Strong and tunable interaction
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- High filling fraction
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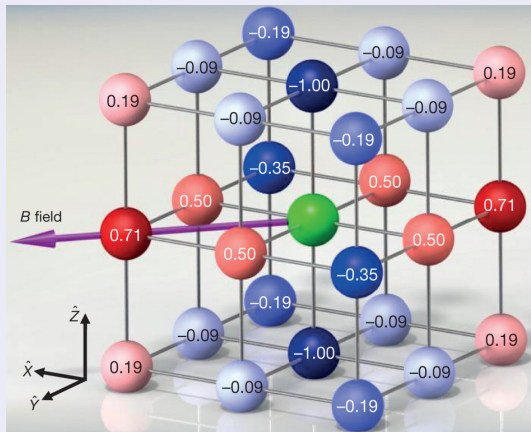
Molecules in optical tweezer

Features

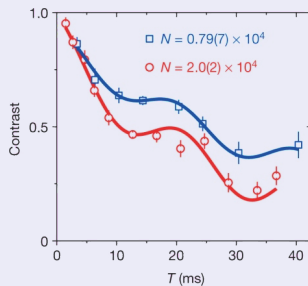
- Strong and tunable interaction
- Rich internal energy levels
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Simulation of many-body system^[1]

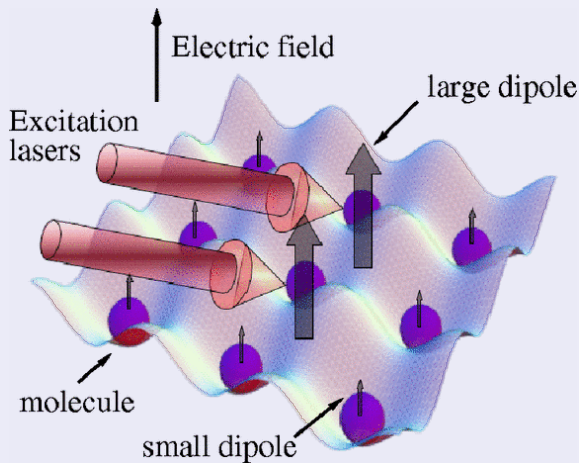


$$H \propto \sum_{ij} V_{ij} (S_i^+ S_j^- + S_i^- S_j^+)$$



[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).

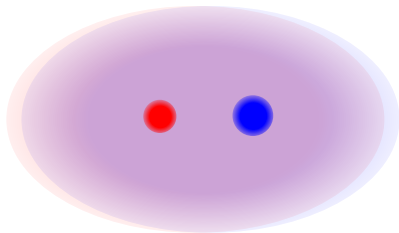
Making molecules from atoms

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



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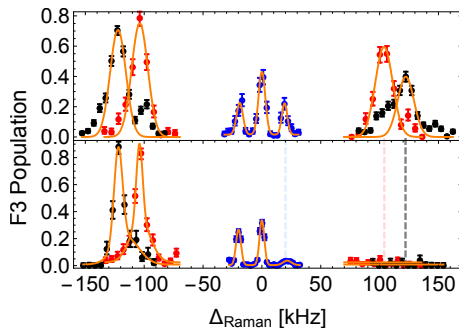
Atom loading and cooling

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

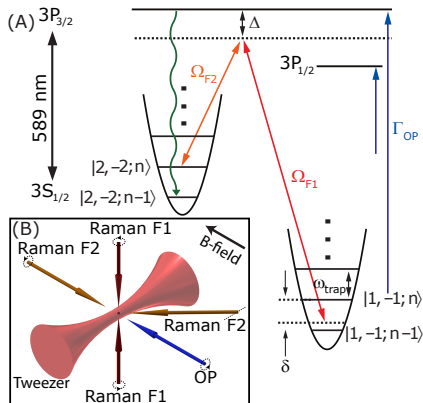


Atom loading and cooling

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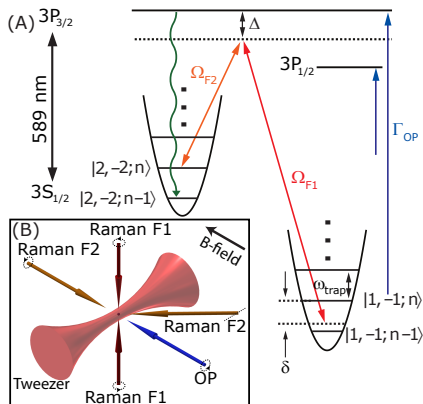


Raman sideband cooling



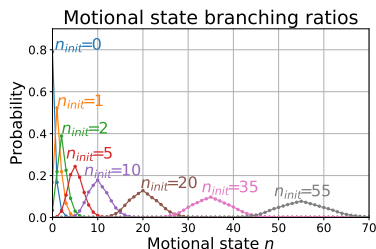
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
- Trap anharmonicity

Raman sideband cooling



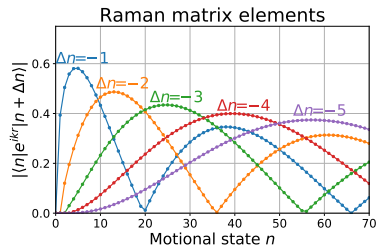
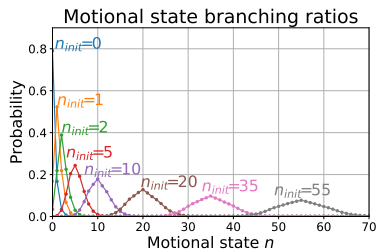
- High initial temperature ($70\mu K$)
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- Large light shift (scalar and tensor)
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Raman sideband cooling



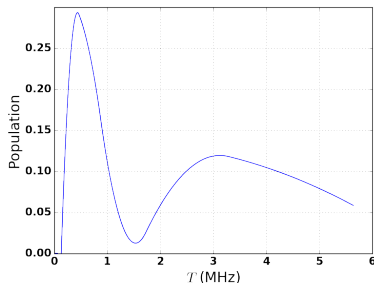
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
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Raman sideband cooling



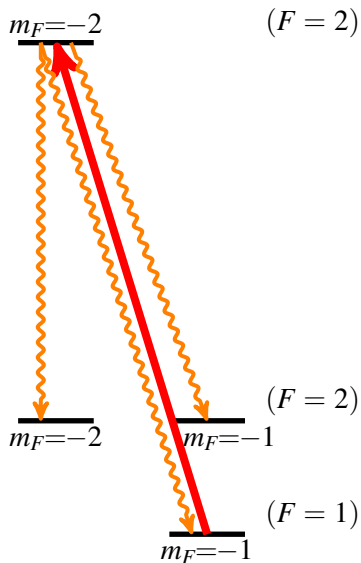
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
- Trap anharmonicity

Raman sideband cooling



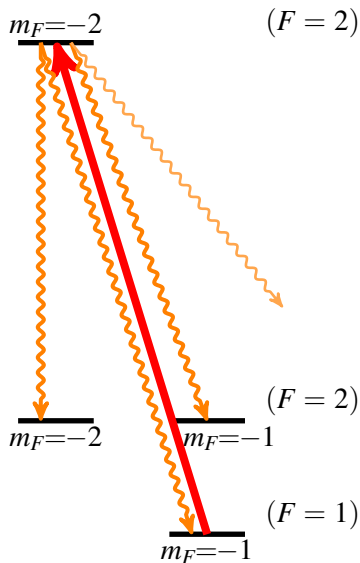
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
- Trap anharmonicity

Raman sideband cooling



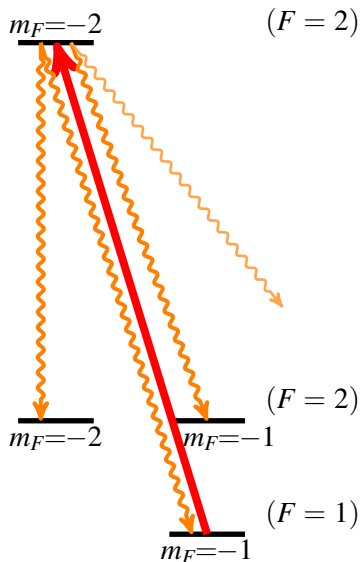
- High initial temperature ($70\mu K$)
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- Large light shift (scalar and tensor)
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Raman sideband cooling



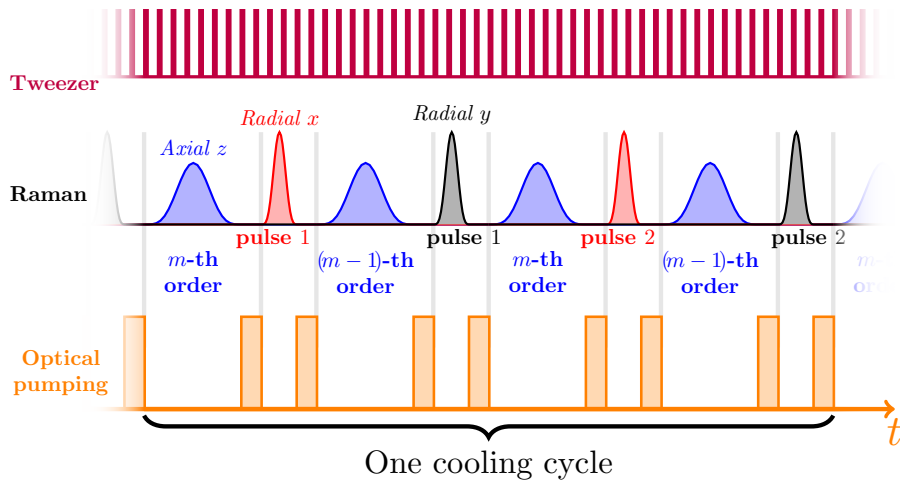
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
- Trap anharmonicity

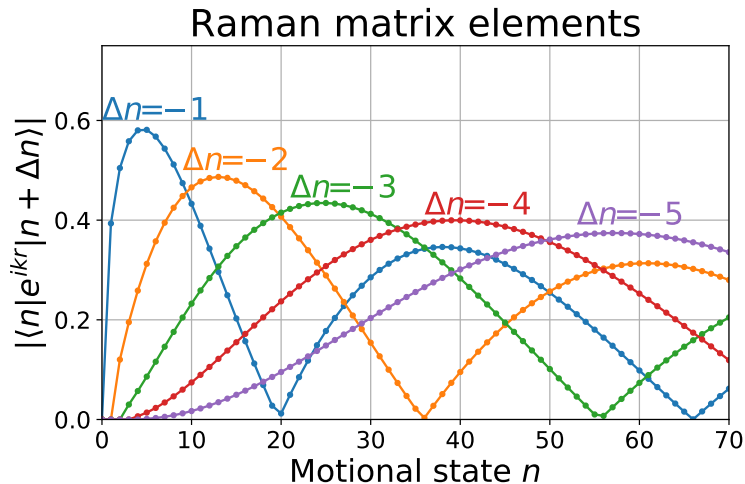
Raman sideband cooling



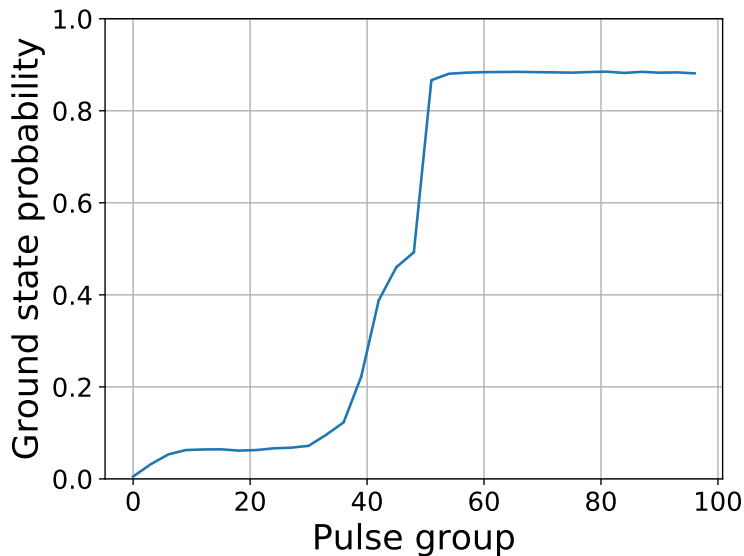
- High initial temperature ($70\mu K$)
- High Lamb Dicke parameter
- Large light shift (scalar and tensor)
- Trap anharmonicity

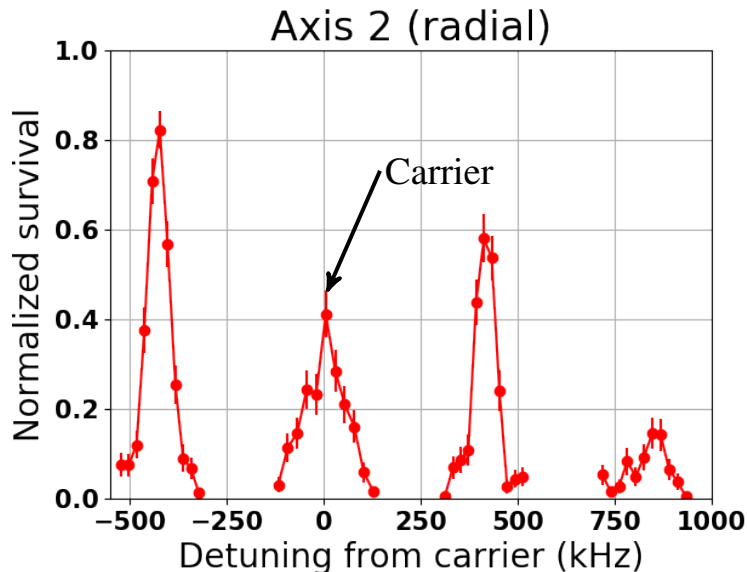
Sequence and simulation

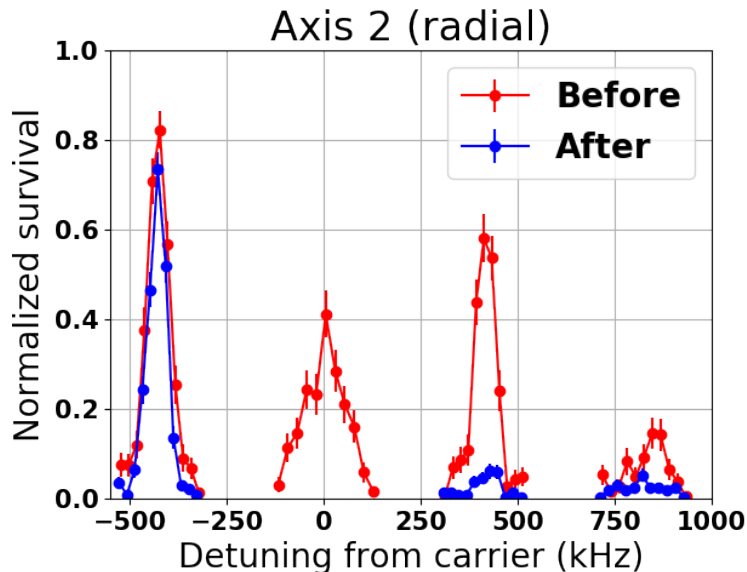


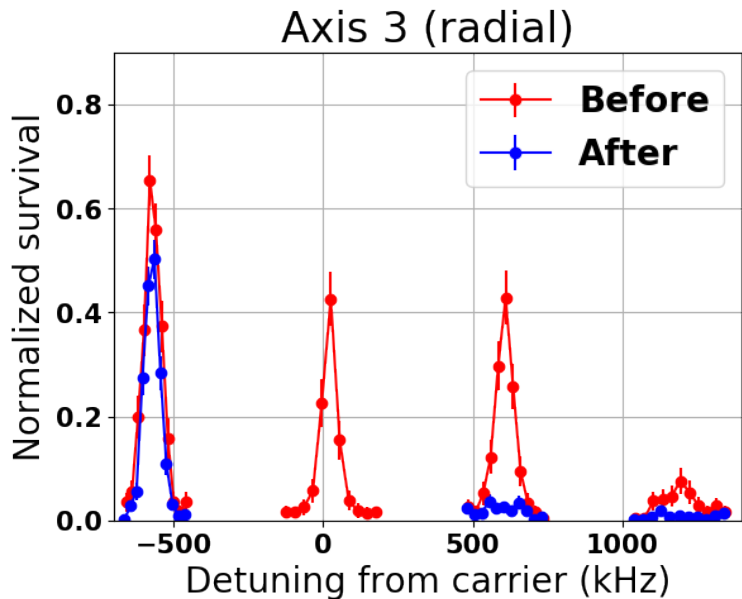


Sequence and simulation

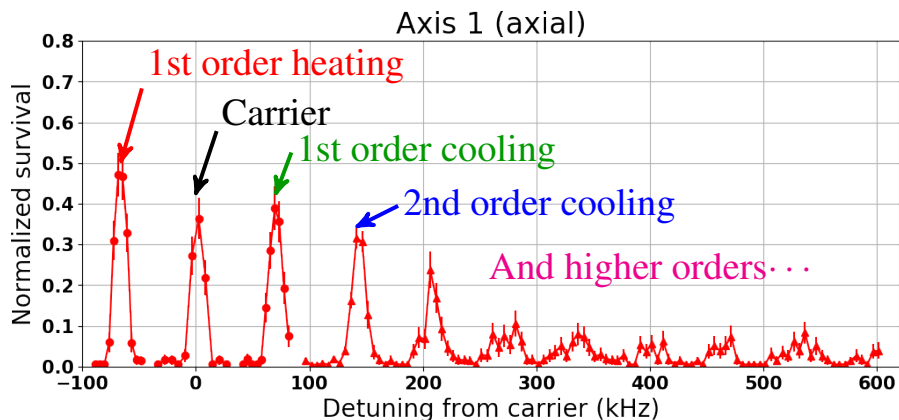




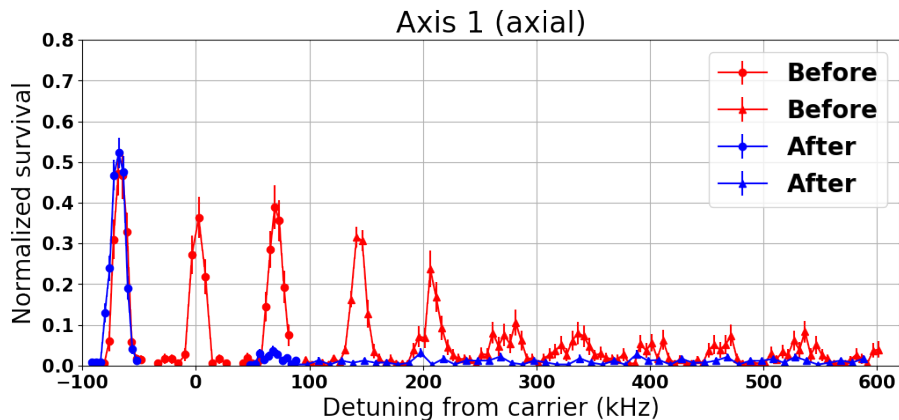




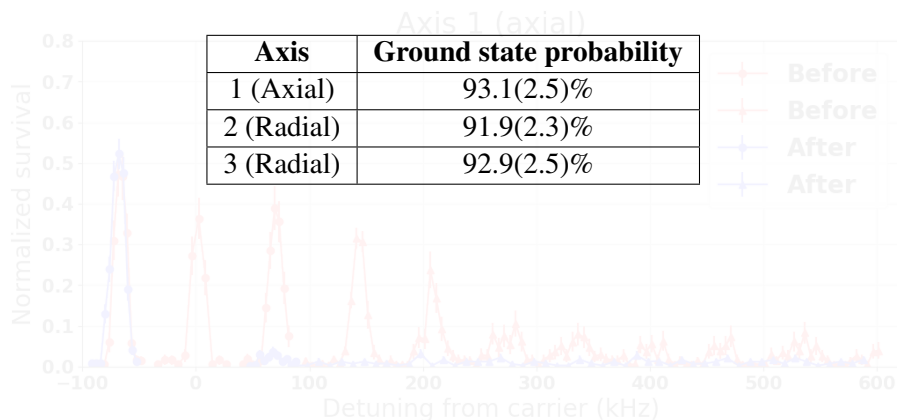
Raman sidebands



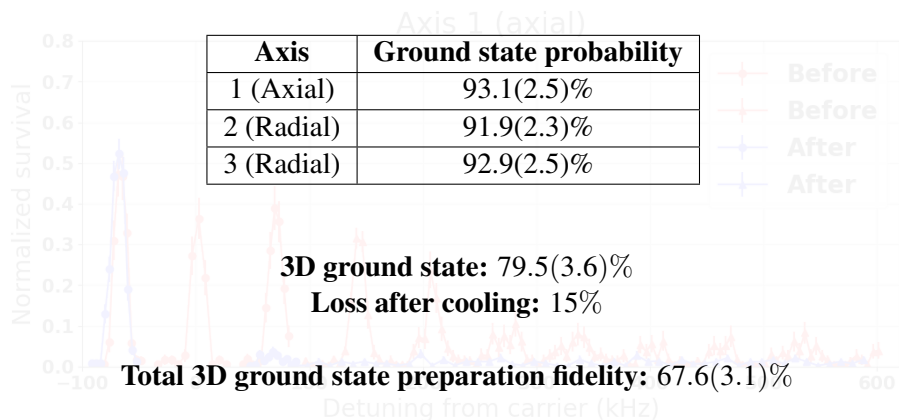
Raman sidebands



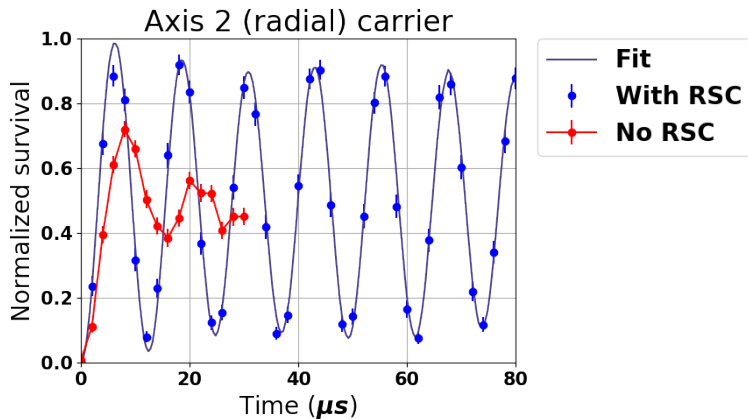
Raman sidebands



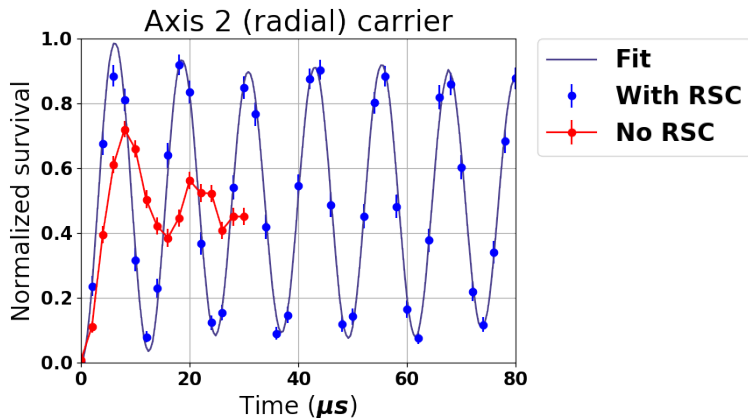
Raman sidebands



Rabi flopping (radial)

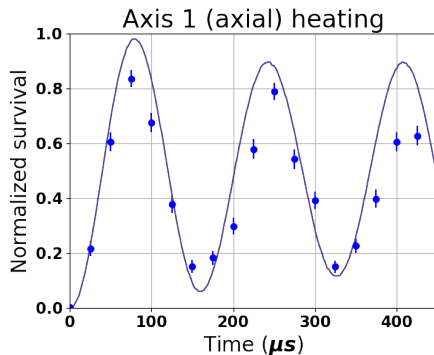
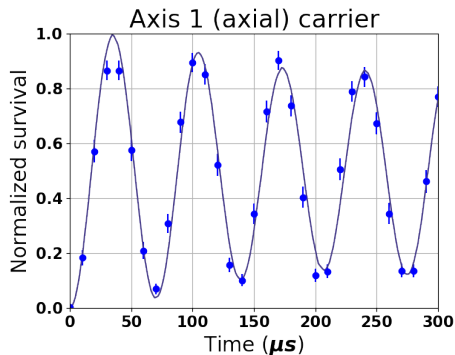


Rabi flopping (radial)



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

Rabi flopping (axial)



Merge

