

Single weakly-bound NaCs molecule in optical tweezers

Yichao Yu

Kenneth Wang, Lewis Picard

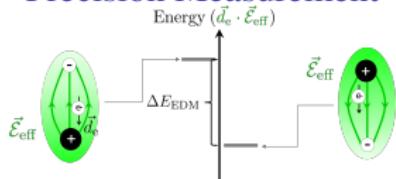
Jessie T. Zhang, William Cairncross

Ni Group/Harvard

June 5, 2020

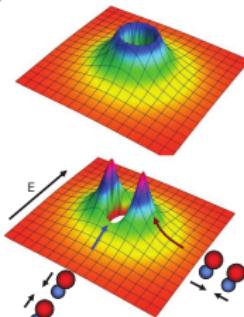
Molecules

Precision Measurement



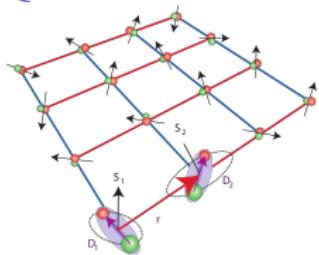
Science 343, p. 269-272 (2014)

Quantum Chemistry



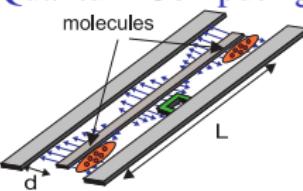
Nature 464, 1324 (2010)

Quantum Simulation



Nat. Phys. 2, 341 (2006)

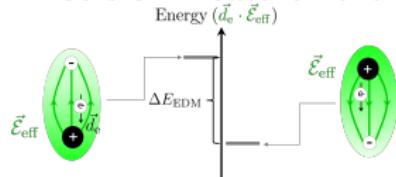
Quantum Computing



PRL. 97, 33003 (2006)

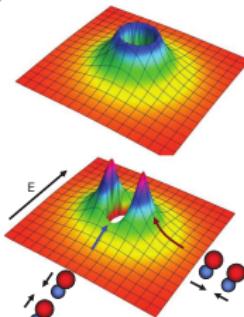
Molecules

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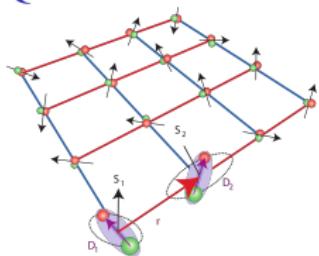
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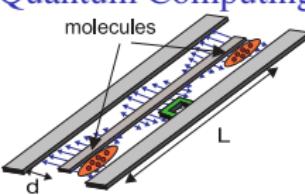
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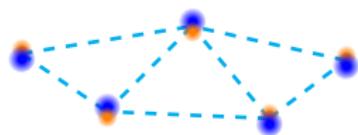
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Quantum Computing



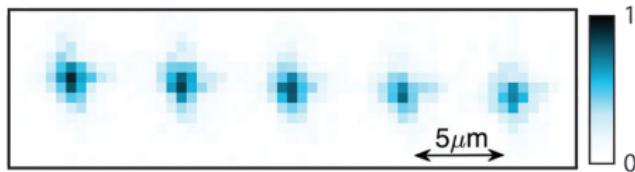
PRL. 97, 33003 (2006)

Optical tweezers



- Single site imaging
- Single site addressing
- Flexible geometry
- ...

Direct cooling



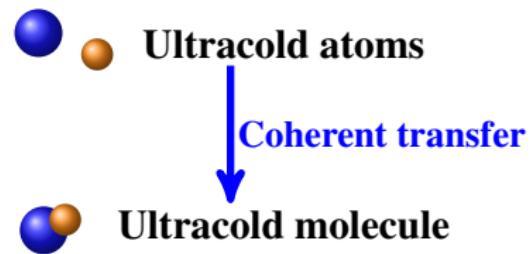
Science 365, p. 1156-1158 (2019)

Direct cooling



Science 365, p. 1156-1158 (2019)

Assembly

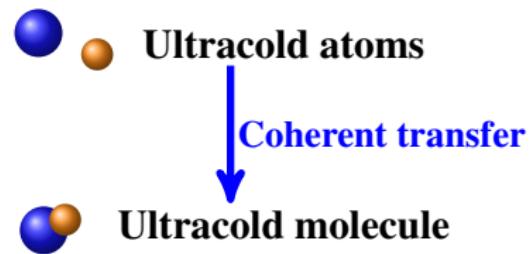


Direct cooling



Science 365, p. 1156-1158 (2019)

Assembly



Challenges

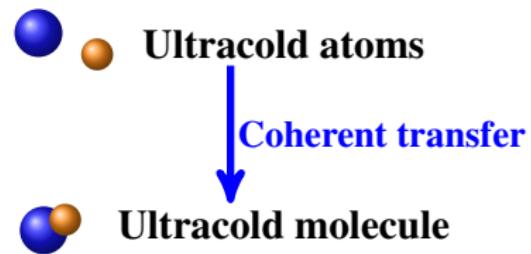
- Cooling
- Quantum control

Direct cooling



Science 365, p. 1156-1158 (2019)

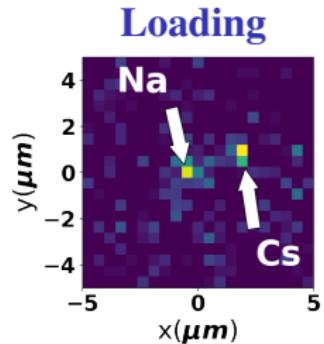
Assembly



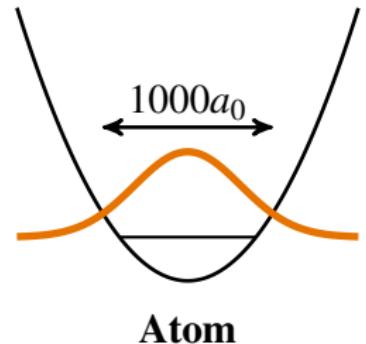
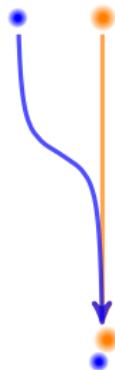
Challenges

- Cooling
- Quantum control

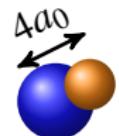
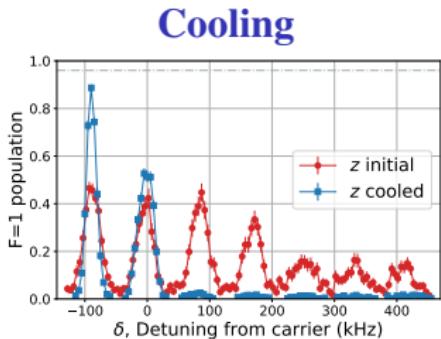
- Creating molecules
- Maintain coherence



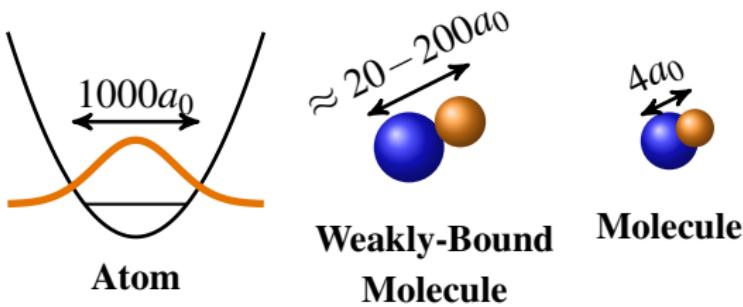
Merging

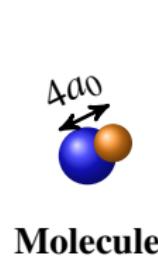
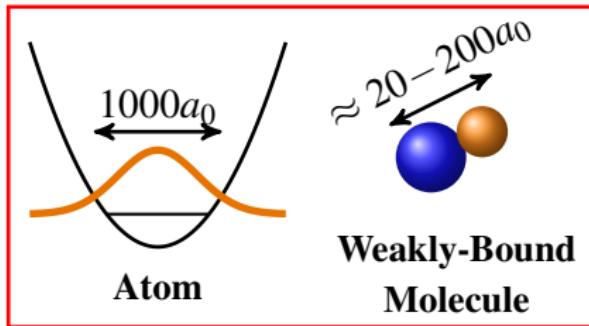


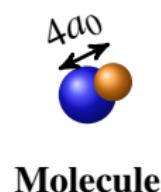
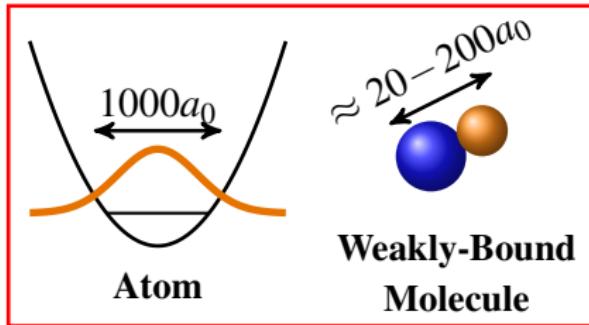
Atom



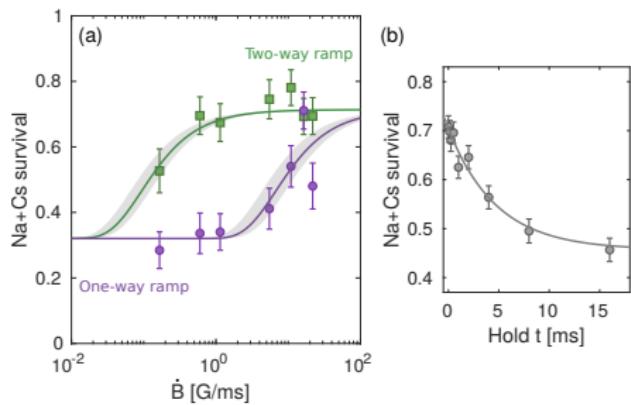
Molecule



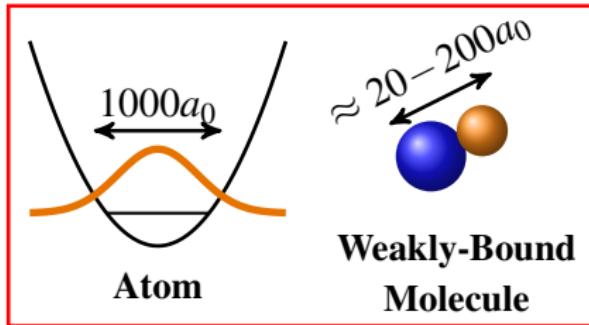




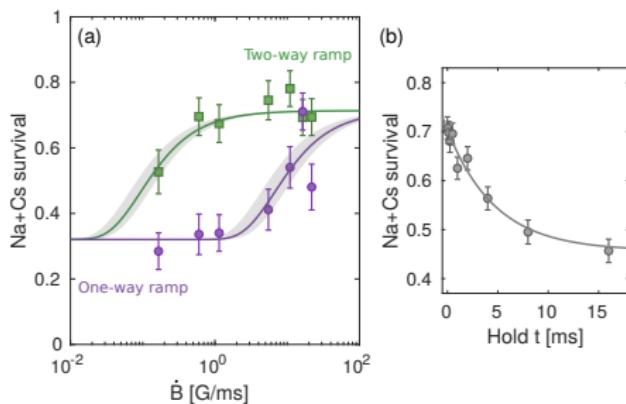
Feshbach molecule



arXiv:2003.07850 (accepted by PRL)

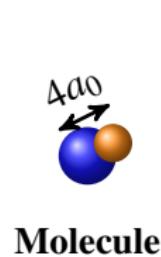
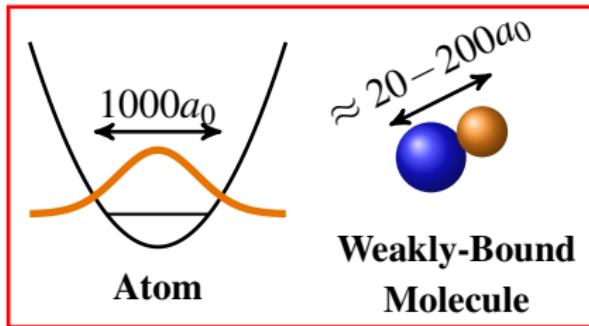


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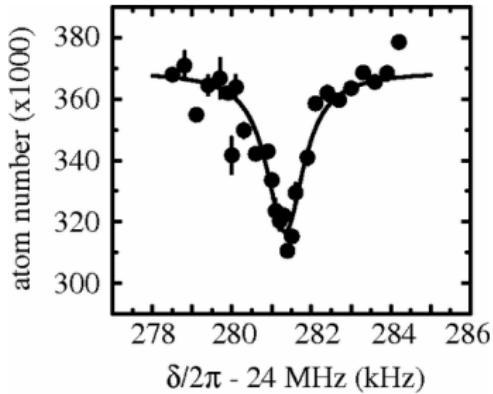
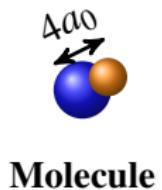
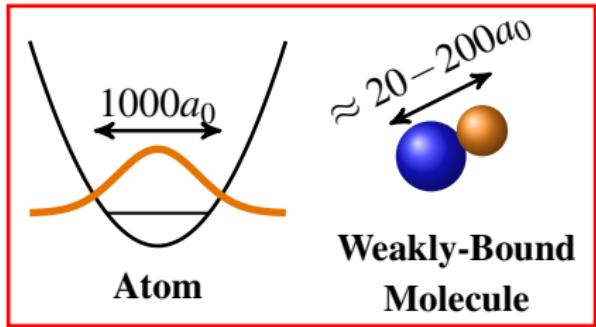
- Requires Feshbach resonance
- Usually large magnetic field

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Optical transfer

- More general
- Faster

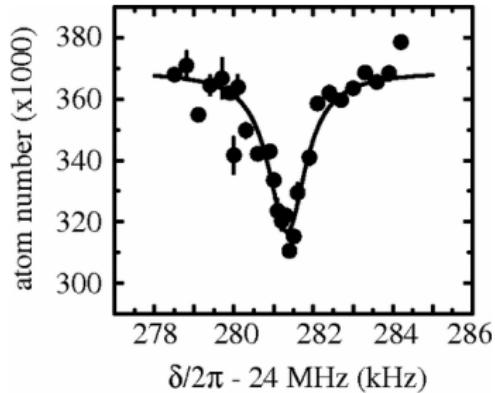
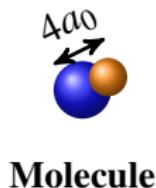
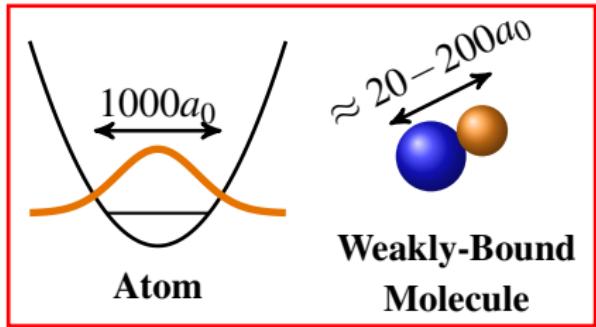


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Previous results

- Rb₂ Science 287, p. 1016-1019 (2000)
PRL. 93, 073002 (2004)
- Sr₂ PRL. 96, 203201 (2006)



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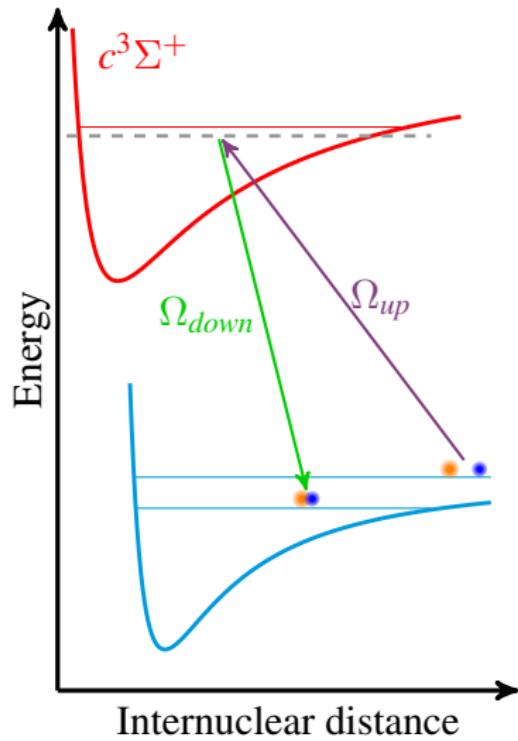
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Limitations

- Incoherent due to scattering
- Using narrow line optical transition

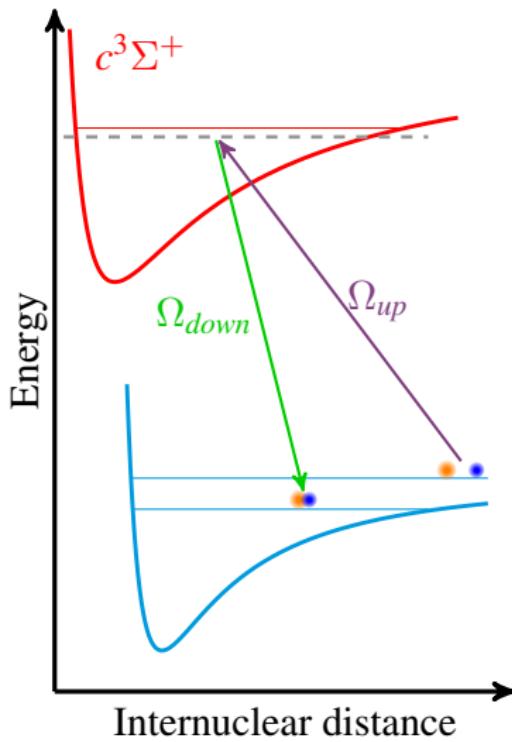
Raman transfer



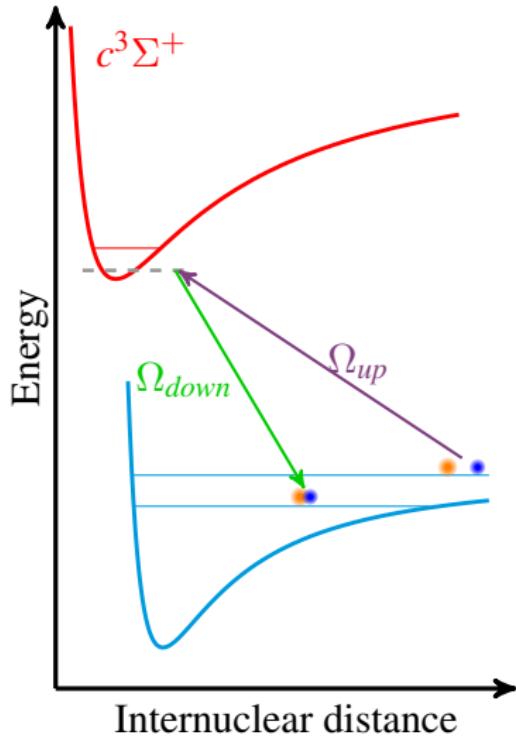
Raman transfer

Near threshold states

- Stronger coupling (Ω_{up} and Ω_{down})
- Closely spaced
- Fast scattering



Raman transfer



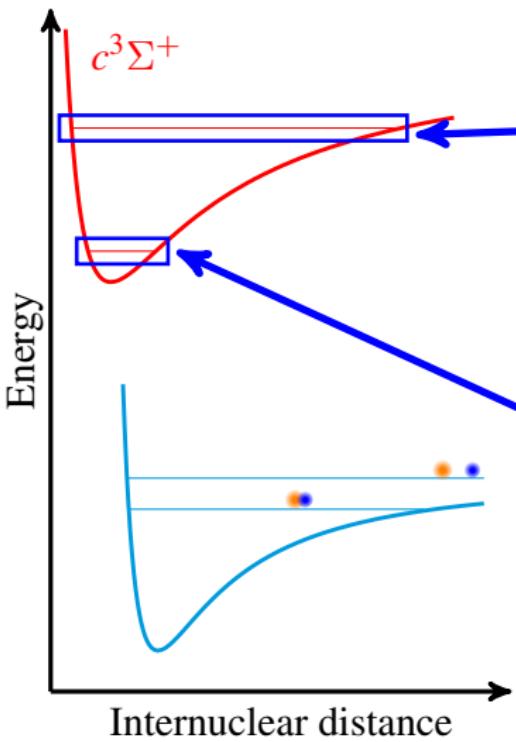
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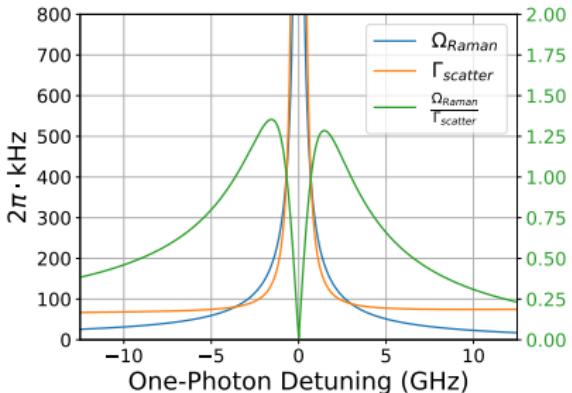
Deeply bound states

- Weaker coupling
- Sparsely spaced
- Allow larger detuning
- Slower scattering

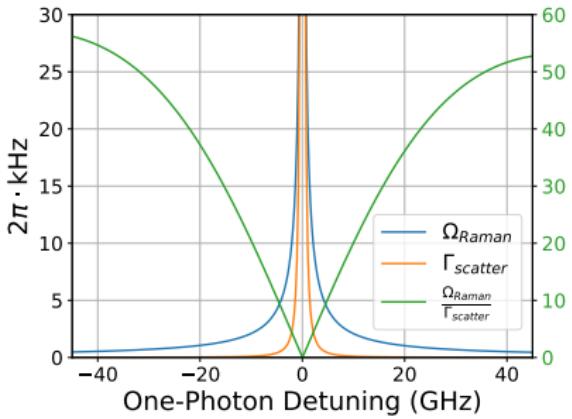
Raman transfer



Near threshold states



Deeply bound states

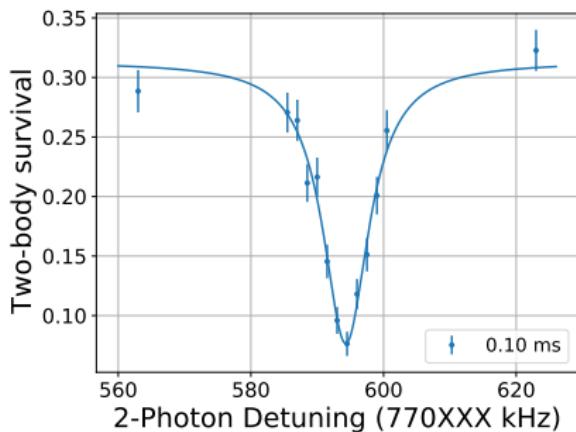


Experiment

- $c^3\Sigma^+$ $\nu = 0$ excited state.
- Ground binding energy
predirected $\approx 771\text{MHz}$
by Jeremy Hutson.

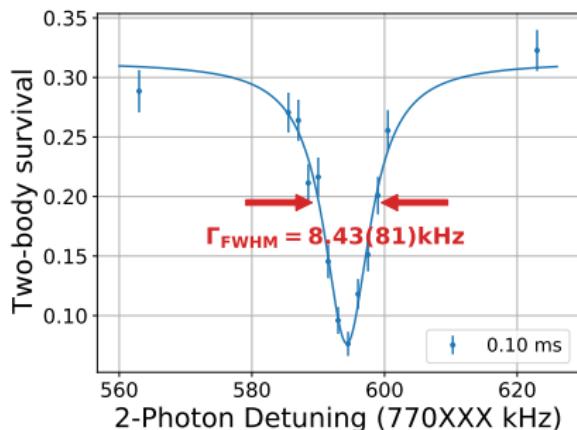
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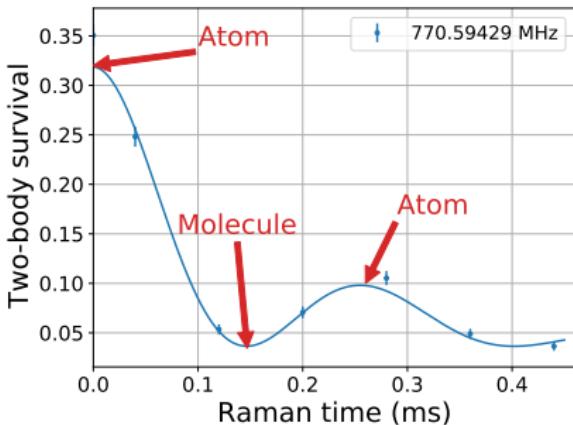
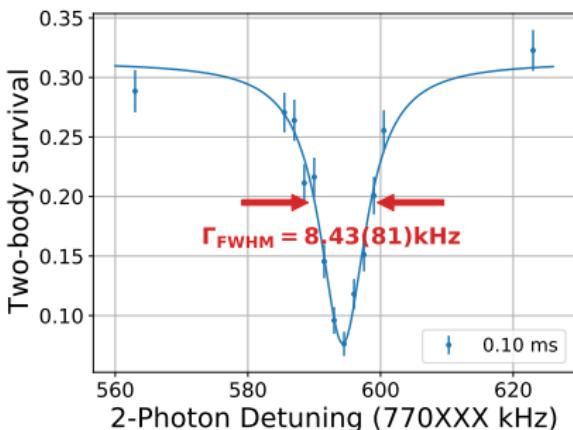
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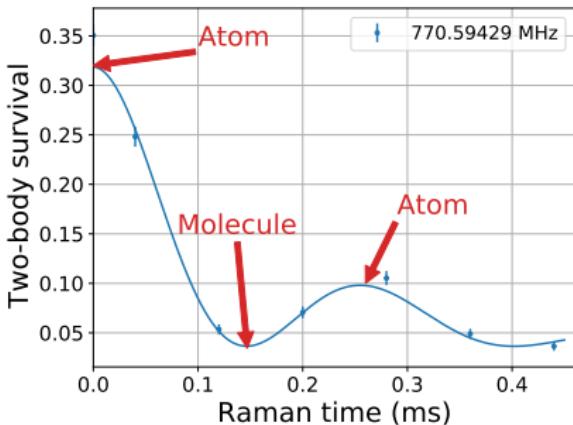
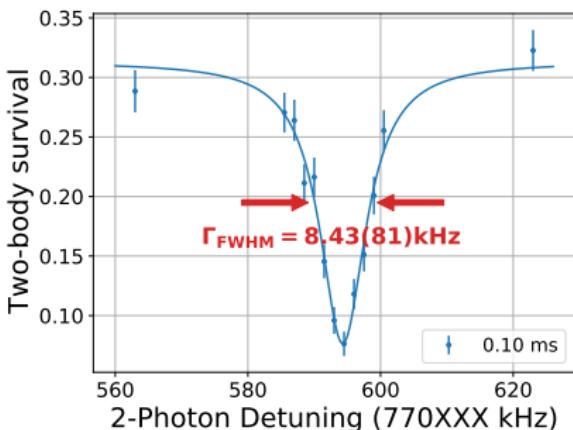
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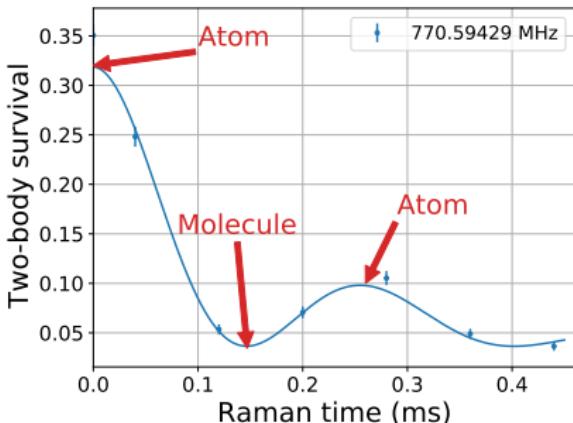
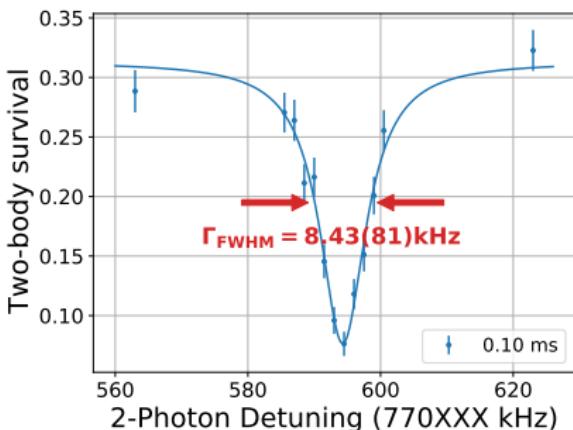
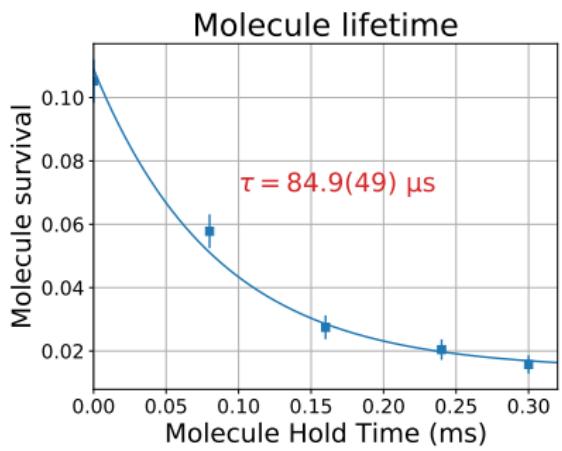
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- Transferred 50% of initial atom to molecule.
- > 50% of molecule in motional ground state.



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Conclusion and Outlook

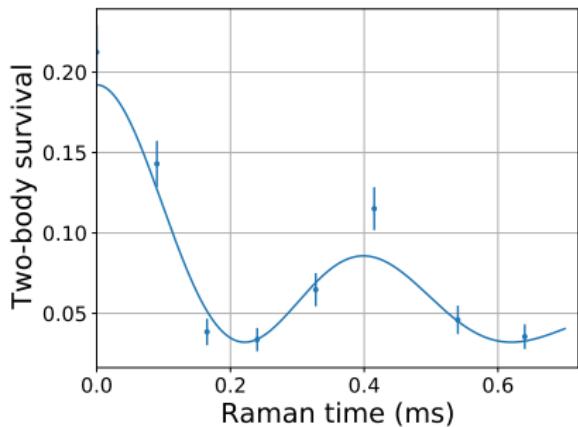
- Demonstrated formation of weakly-bound NaCs molecules while maintaining quantum control.
- Improve signal contrast.
- Feshbach molecule.

arXiv:2003.07850

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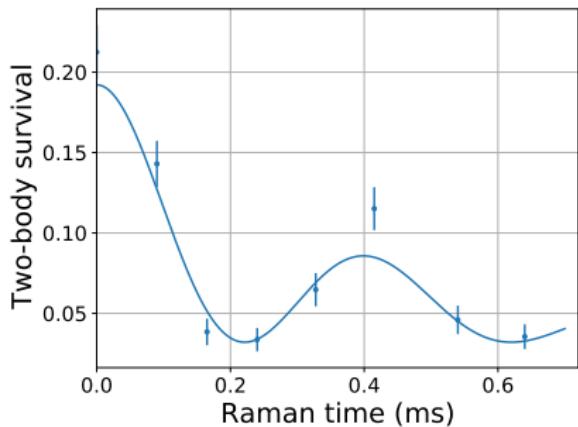
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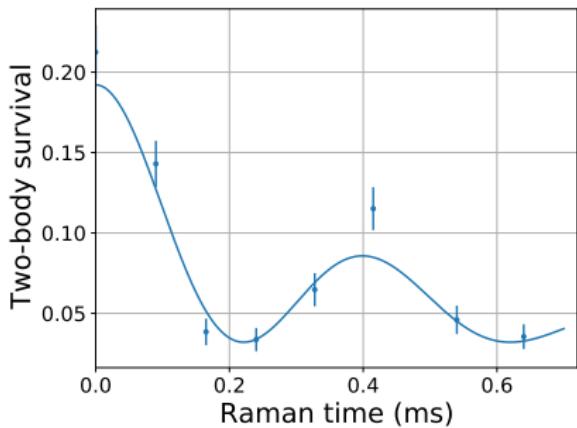
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Poster Q01.00108

