

# Single weakly-bound NaCs molecule in optical tweezers

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Kenneth Wang, Lewis Picard

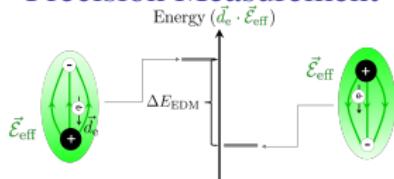
Jessie T. Zhang, William Cairncross

Ni Group/Harvard

June 5, 2020

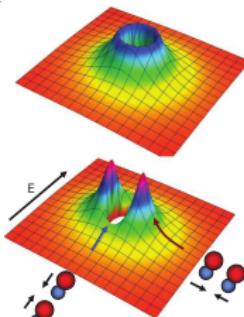
# Molecules

## Precision Measurement



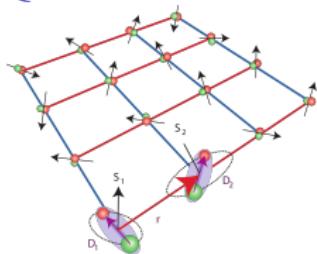
Science 343, p. 269-272 (2014)

## Quantum Chemistry



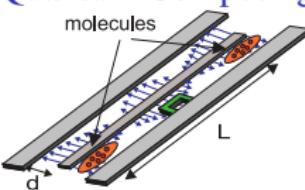
Nature 464, 1324 (2010)

## Quantum Simulation



Nat. Phys. 2, 341 (2006)

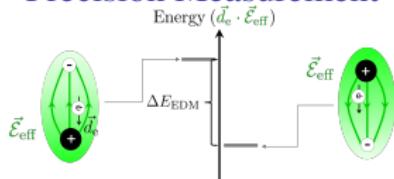
## Quantum Computing



Phys. Rev. Lett. 97, 33003 (2006)

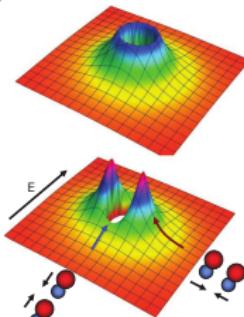
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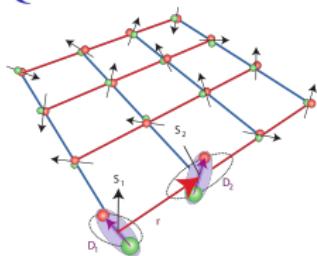
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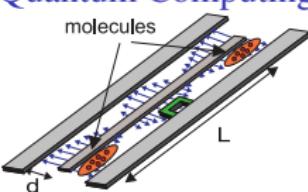
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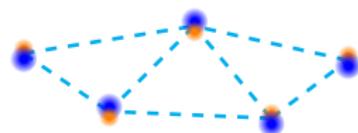
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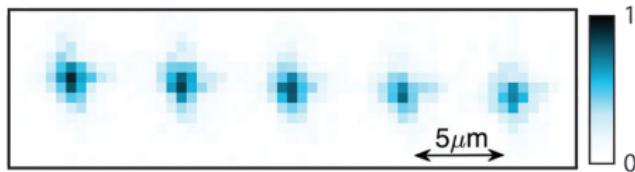
Phys. Rev. Lett. 97, 33003 (2006)

# Optical tweezers



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

## Direct cooling



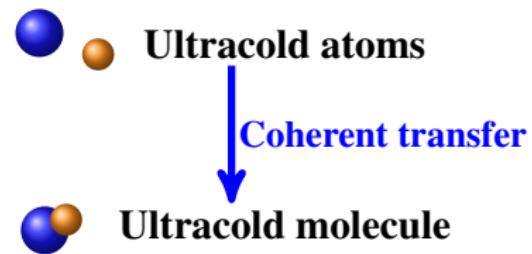
10.1126/science.aax1265

## Direct cooling



10.1126/science.aax1265

## Assembly

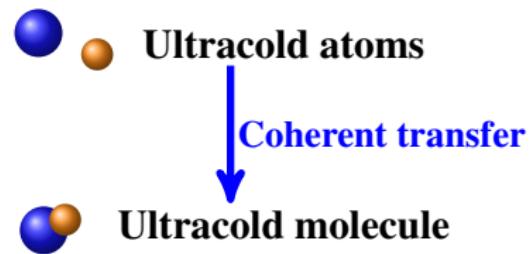


## Direct cooling



[10.1126/science.aax1265](https://doi.org/10.1126/science.aax1265)

## Assembly



## Challenges

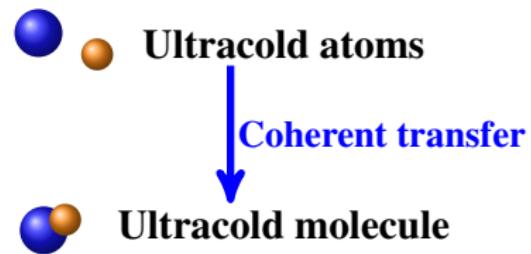
- Cooling
- Quantum control

## Direct cooling



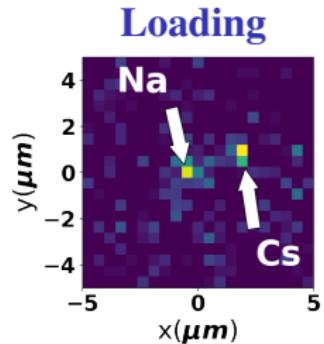
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## Assembly

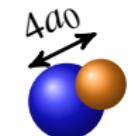
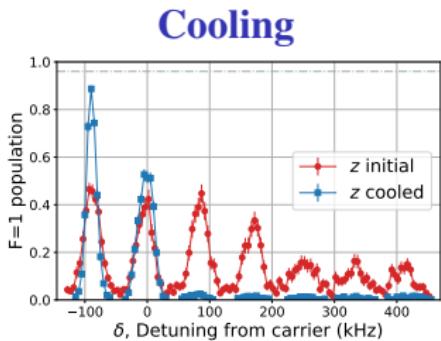
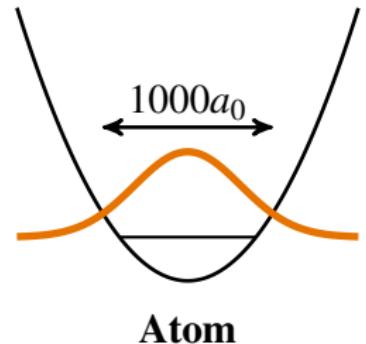
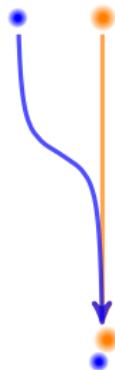


## Challenges

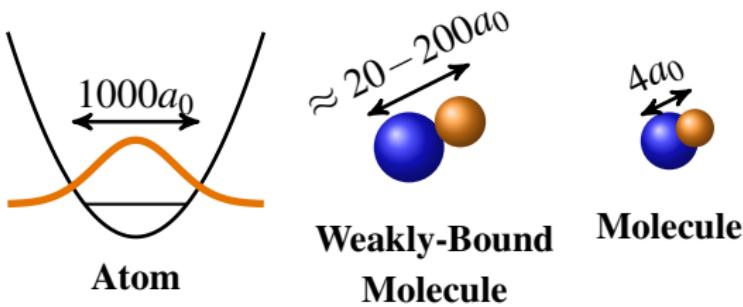
- Cooling
- Quantum control
- Creating molecules
- Maintain coherence

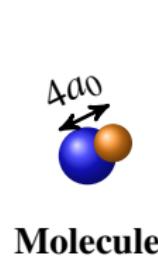
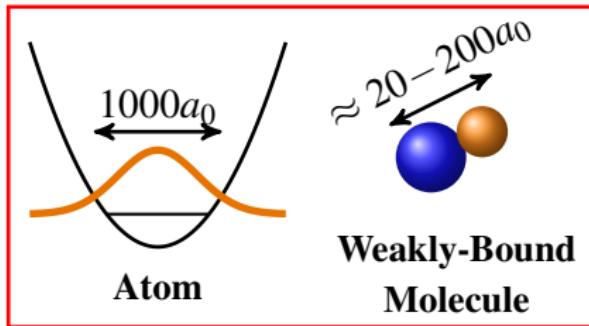


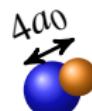
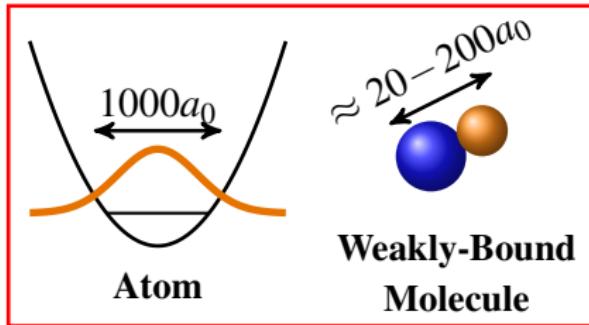
**Merging**



**Molecule**

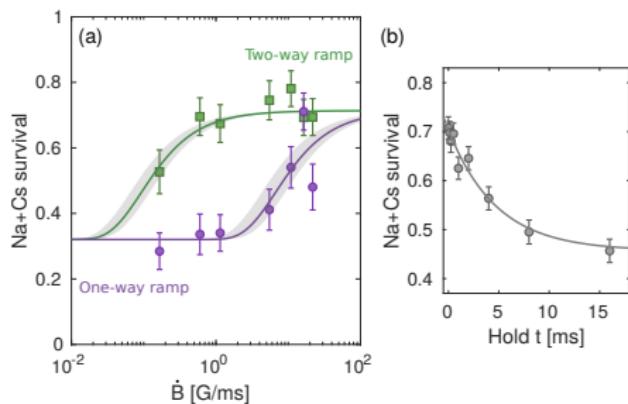




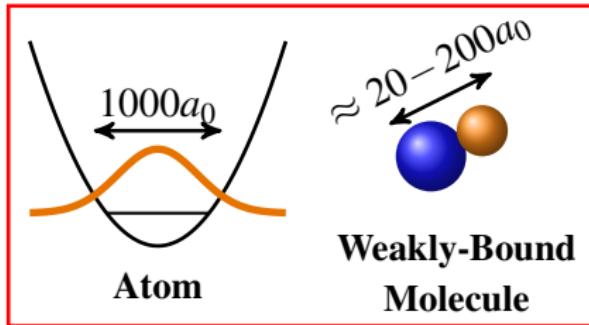


Molecule

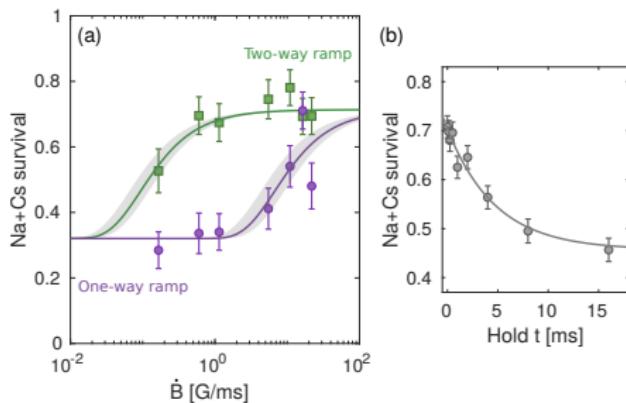
## Feshbach molecule



arXiv:2003.07850 (accepted by PRL)

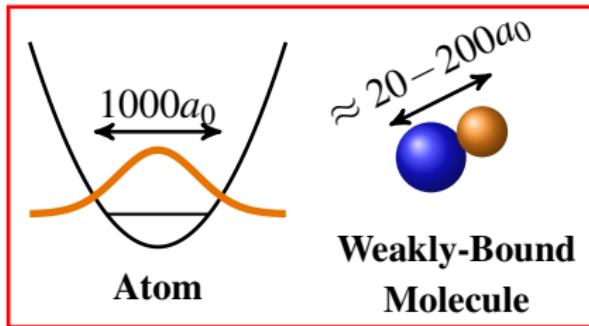


## Feshbach molecule

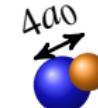


- Requires Feshbach resonance
- Usually large magnetic field

arXiv:2003.07850 (accepted by PRL)



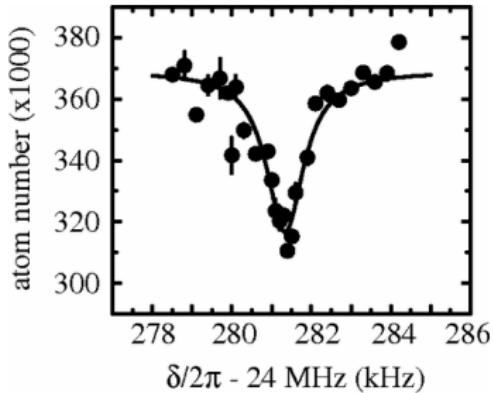
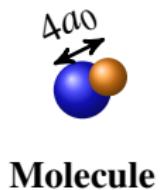
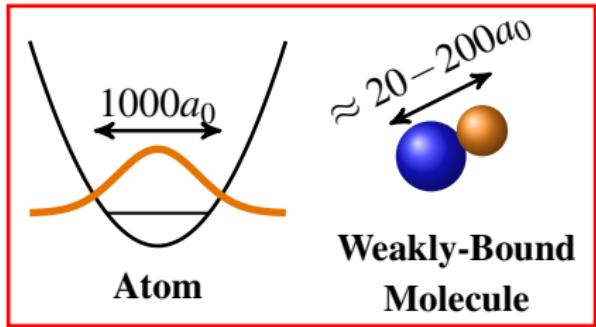
Weakly-Bound  
Molecule



Molecule

## Optical transfer

- More general
- Faster

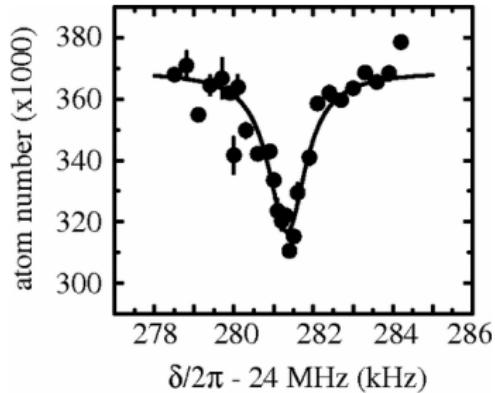
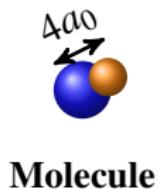
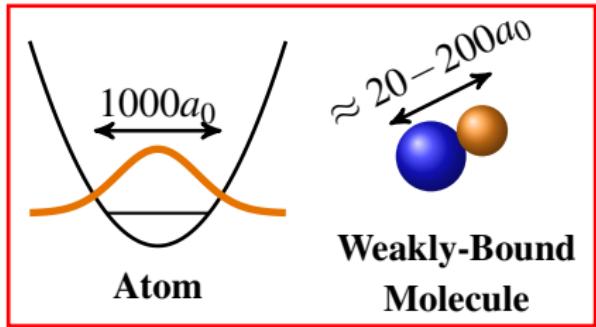


## Optical transfer

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## Previous results

- Rb<sub>2</sub> 10.1126/science.287.5455.1016  
Phys. Rev. Lett. 93, 073002
- Sr<sub>2</sub>



## Optical transfer

- More general
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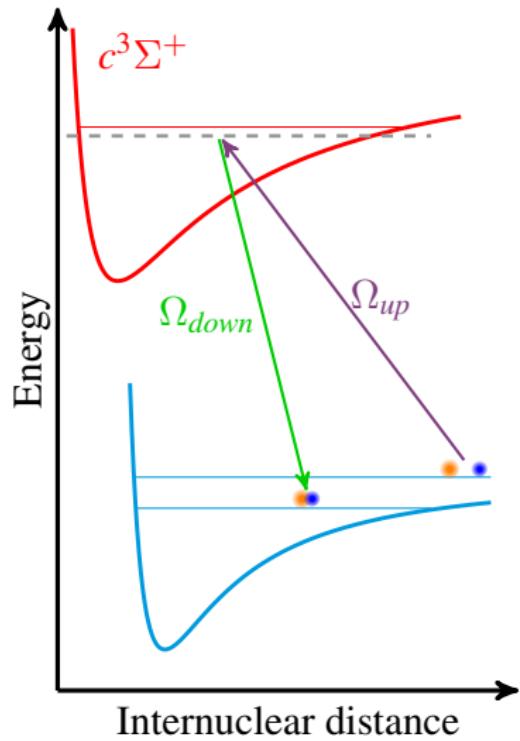
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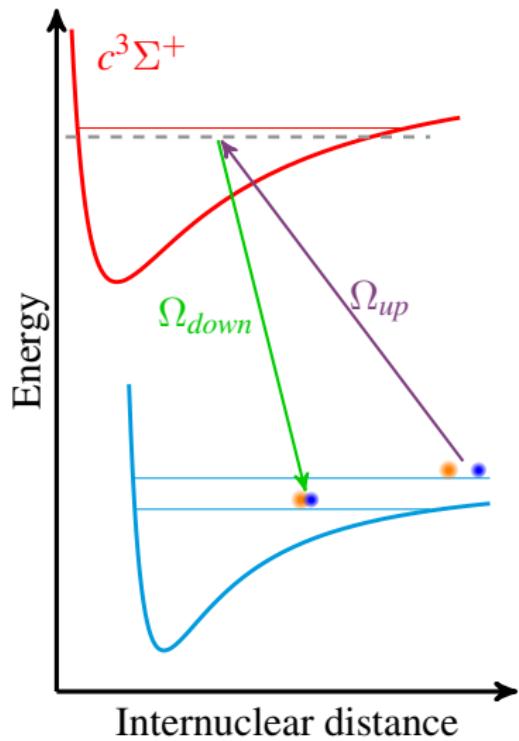
## Limitations

- Incoherent due to scattering
- Using narrow line optical transition

# Raman transfer



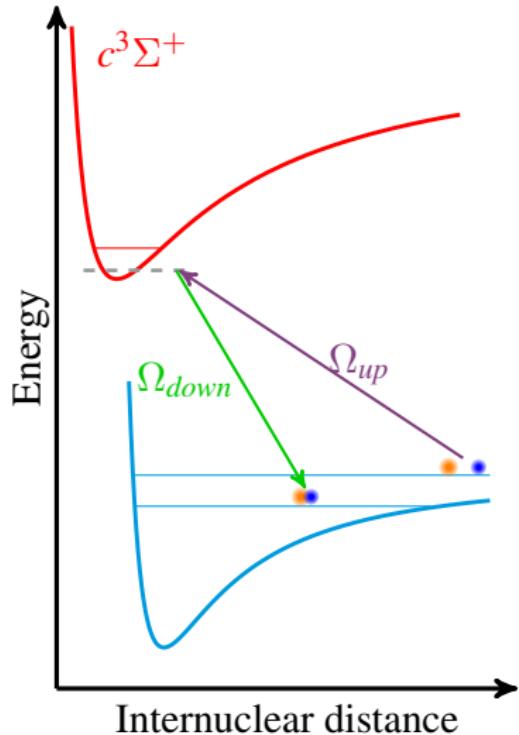
# Raman transfer



## Near threshold states

- Stronger coupling ( $\Omega_{up}$  and  $\Omega_{down}$ )
- Closely spaced
- Fast scattering

## Raman transfer



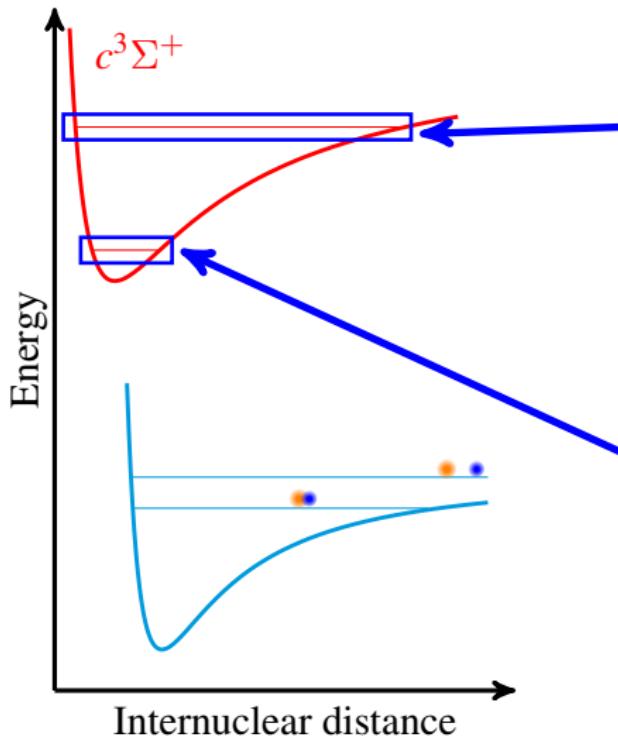
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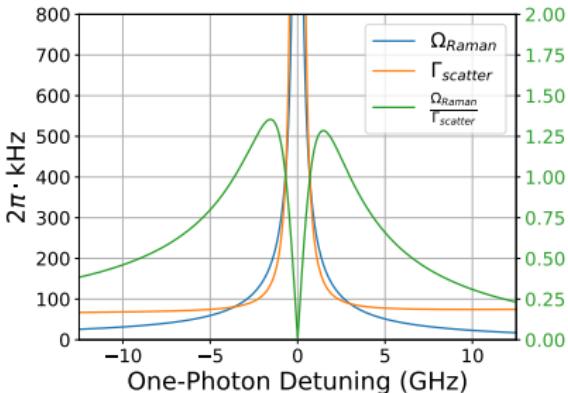
### Deeply bound states

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

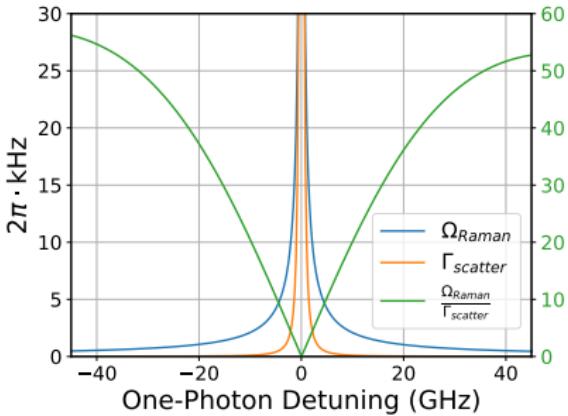
## Raman transfer



## Near threshold states



## Deeply bound states

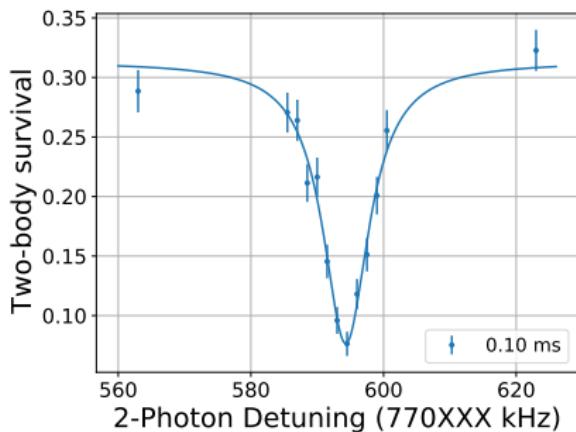


# Experiment

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

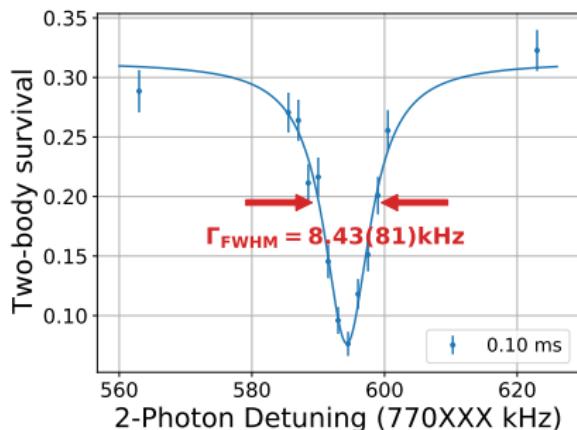
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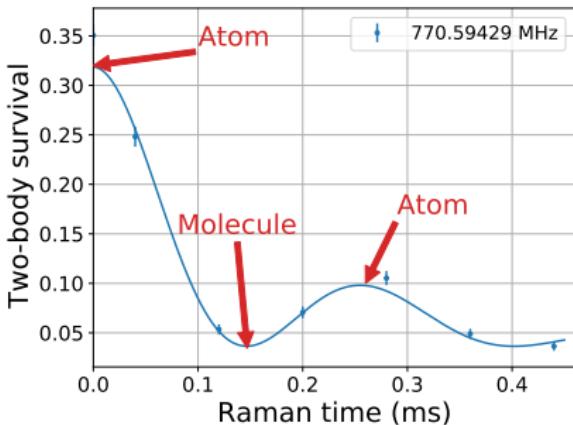
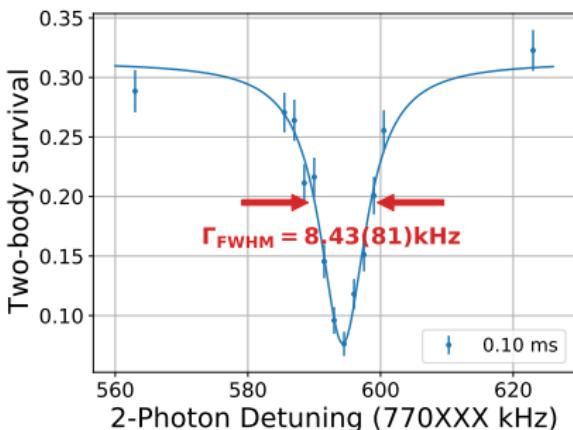
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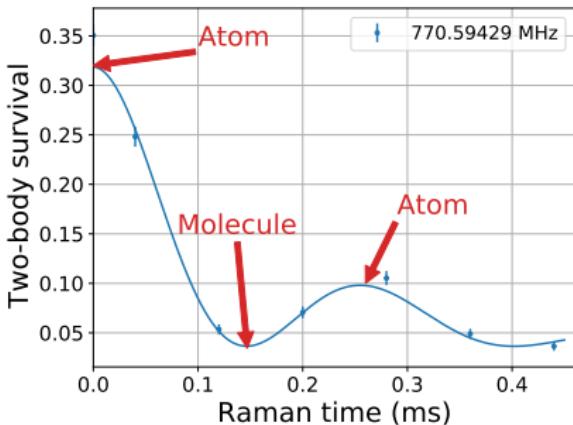
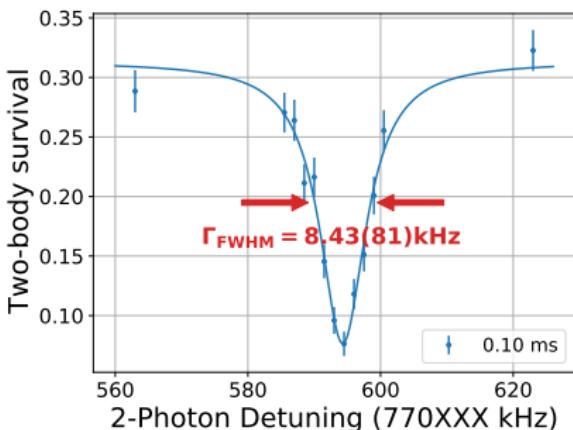
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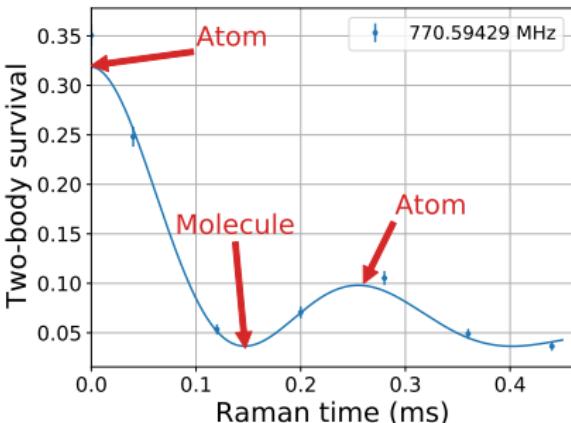
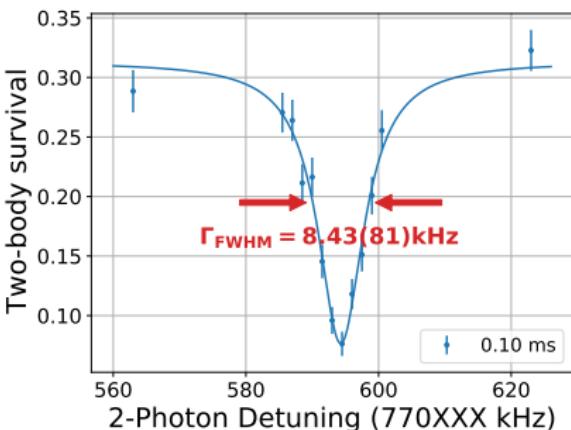
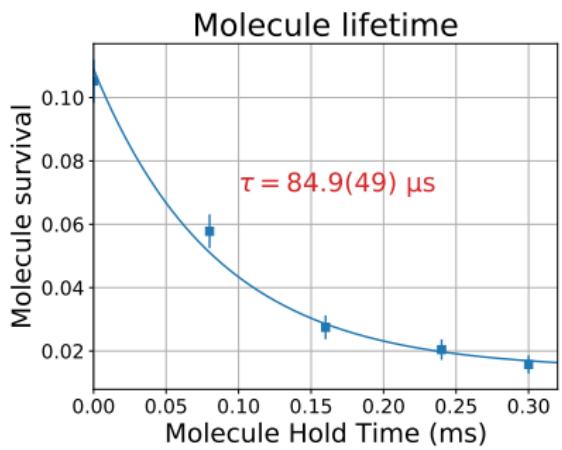
## Experiment

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



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## Conclusion and Outlook

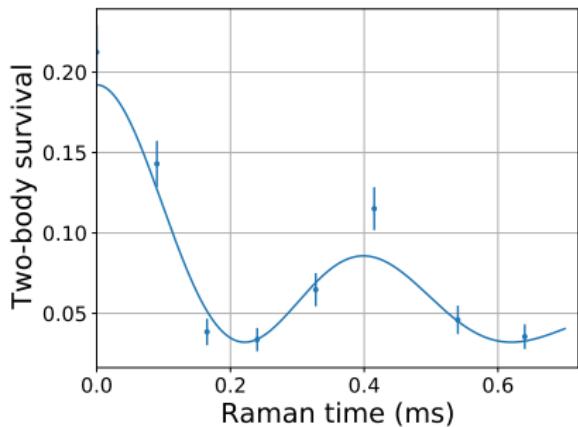
- Demonstrated formation of weakly-bound NaCs molecules while maintaining quantum control.
- Improve signal contrast.
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arXiv:2003.07850

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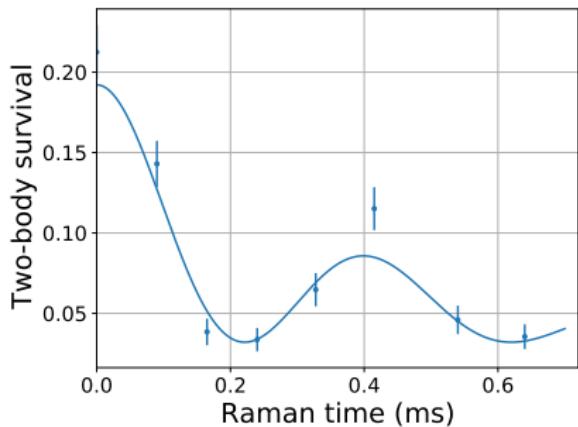
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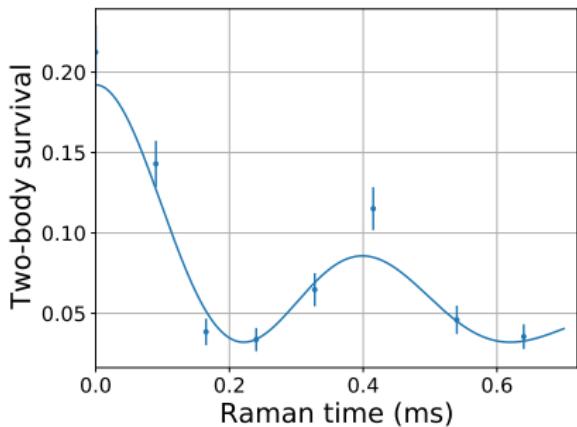
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**Poster Q01.00108**

