

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

- Dipole moment
- Rich internal states
- ...

Optical tweezers

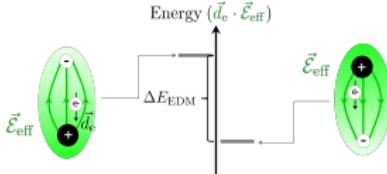
- Single site imaging
- Single site addressing
- Flexible geometry
- ...

Quantum Chemistry

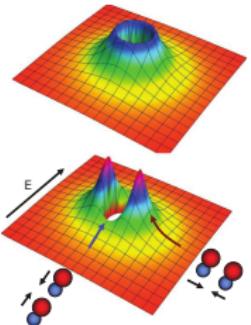
Molecules

- Dipole moment
- Rich internal states
- ...

Precision Measurement



Science 343, p. 269-272 (2014)

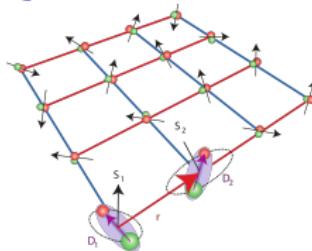


Nature 464, 1324 (2010)

Optical tweezers

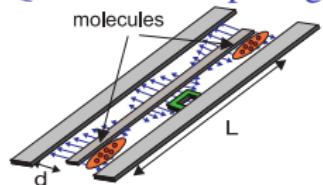
- Single site imaging
- Single site addressing
- Flexible geometry
- ...

Quantum Simulation



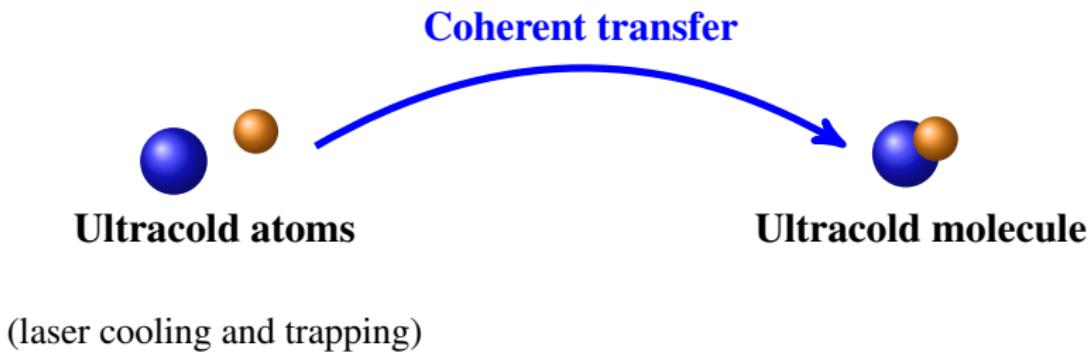
Nat. Phys. 2, 341 (2006)

Quantum Computing

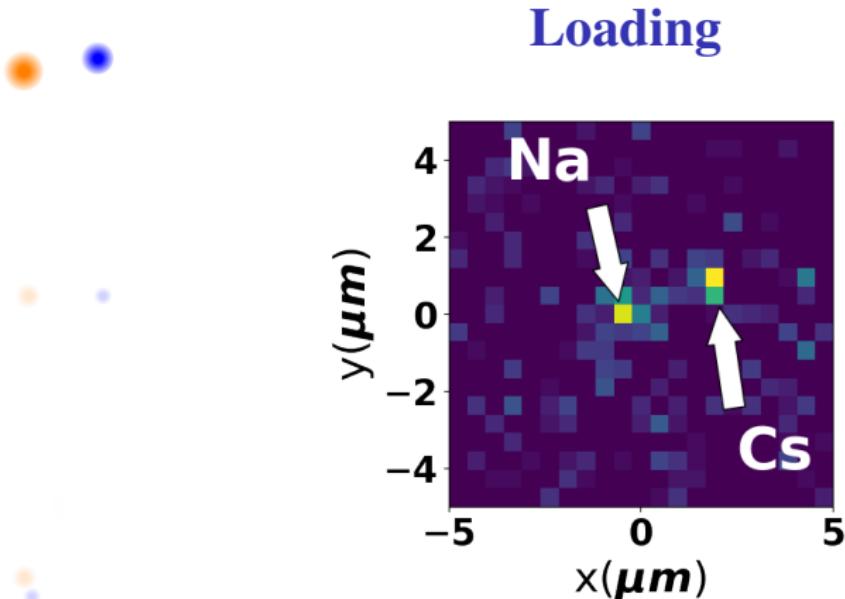


Phys. Rev. Lett. 97, 33003 (2006)

From atoms to molecules

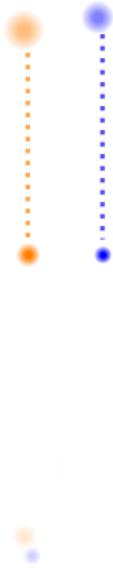


From atoms to molecules

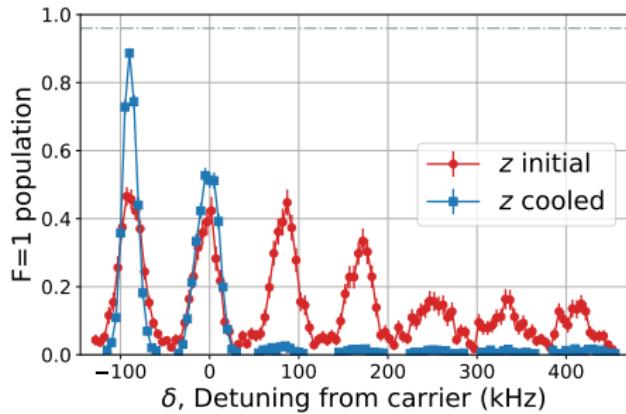


Loading probability per site: 60%
Post select on initial and final state.

From atoms to molecules



Cooling



Cs: 96% ground state¹

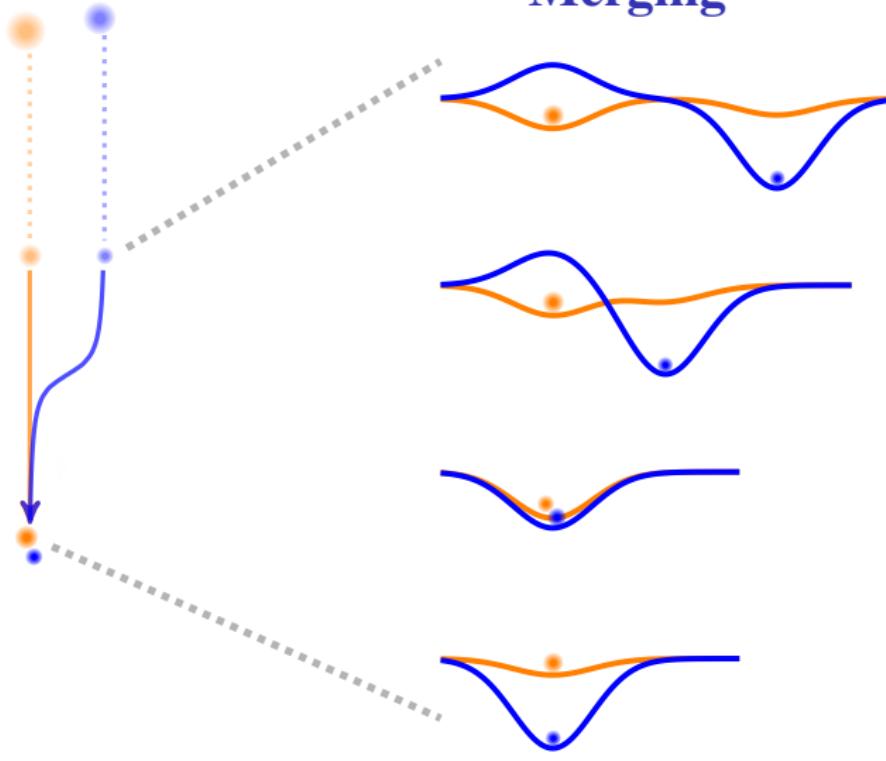
Na: 94% ground state²

¹Phys. Rev. X 9, 021039

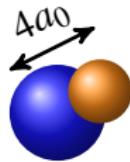
²Phys. Rev. A 97, 063423

From atoms to molecules

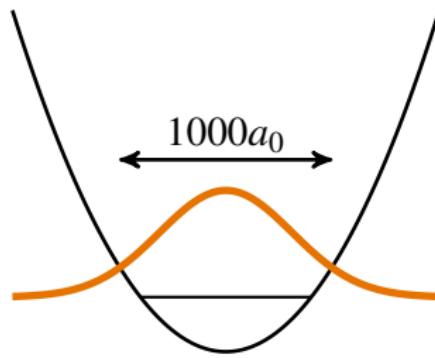
Merging



Wave function size mismatch

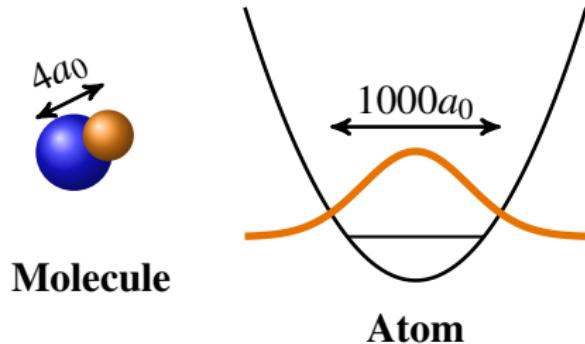


Molecule



Atom

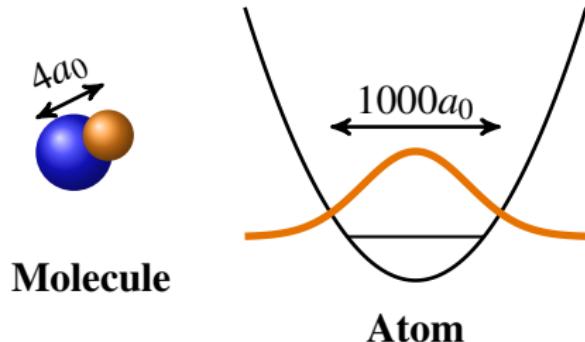
Wave function size mismatch



Feshbach molecule

- Requires Feshbach resonance
- Usually large magnetic field

Wave function size mismatch



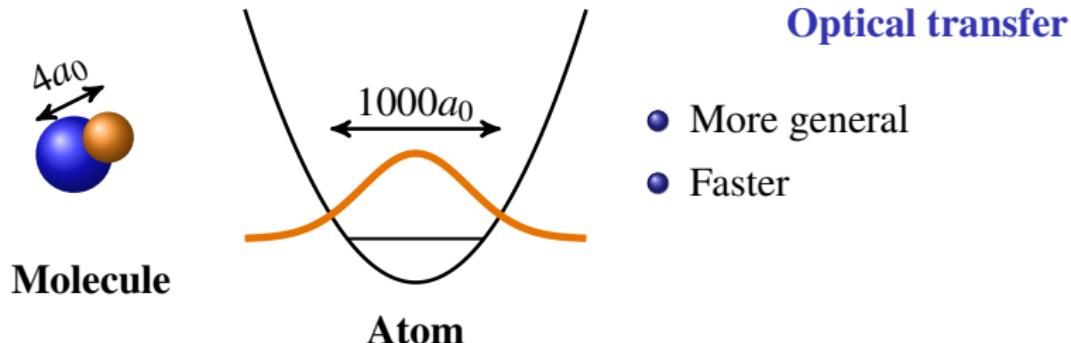
Feshbach molecule

- Requires Feshbach resonance
- Usually large magnetic field

Our implementation

arXiv:2003.07850 (accepted by PRL)
Poster Q01.00108

Wave function size mismatch



Optical transfer

- More general
- Faster

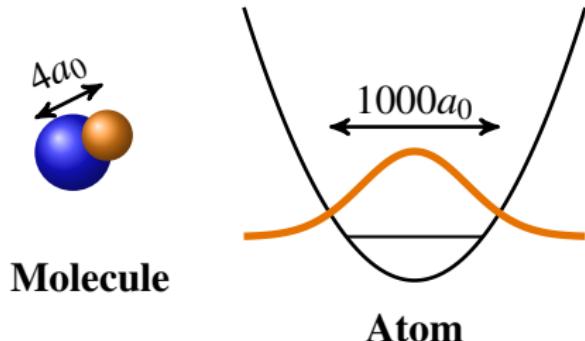
Feshbach molecule

- Requires Feshbach resonance
- Usually large magnetic field

Our implementation

arXiv:2003.07850 (accepted by PRL)
Poster Q01.00108

Wave function size mismatch



Molecule

Atom

Feshbach molecule

- Requires Feshbach resonance
- Usually large magnetic field

Optical transfer

- More general
- Faster

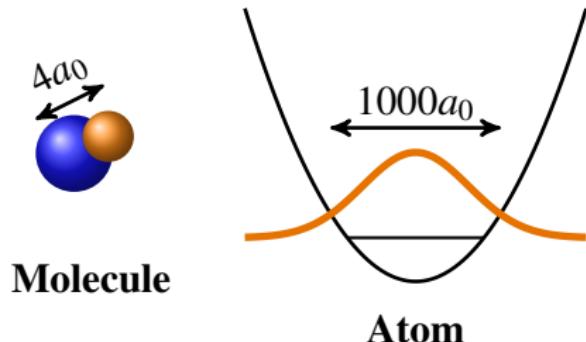
Previous results

- Rb + Rb
Phys. Rev. Lett. 93, 073002 (2004)
- Sr + Sr

Our implementation

arXiv:2003.07850 (accepted by PRL)
Poster Q01.00108

Wave function size mismatch



Feshbach molecule

- Requires Feshbach resonance
- Usually large magnetic field

Our implementation

arXiv:2003.07850 (accepted by PRL)
Poster Q01.00108

Optical transfer

- More general
- Faster

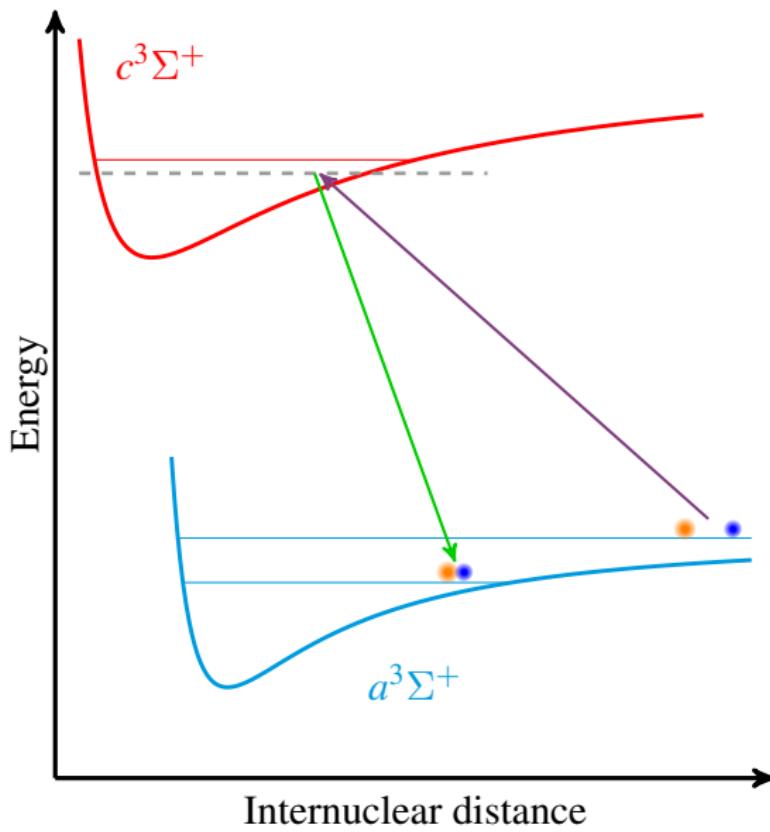
Previous results

- Rb + Rb
Phys. Rev. Lett. 93, 073002 (2004)
- Sr + Sr

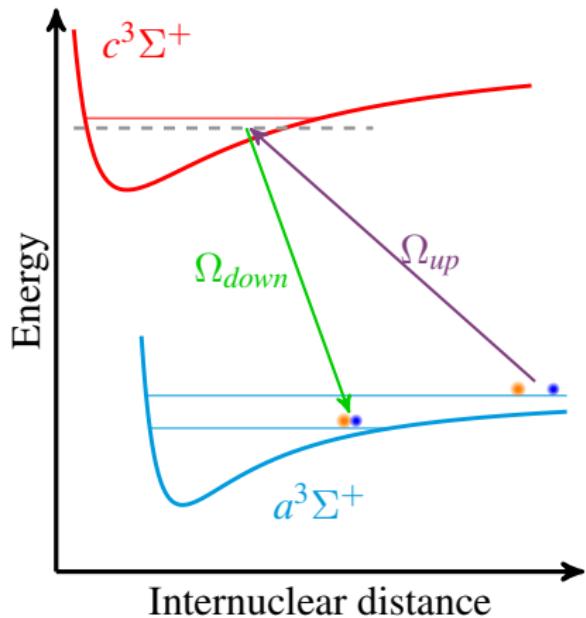
Limitations

- Incoherent due to scattering
- Using narrow line optical transition

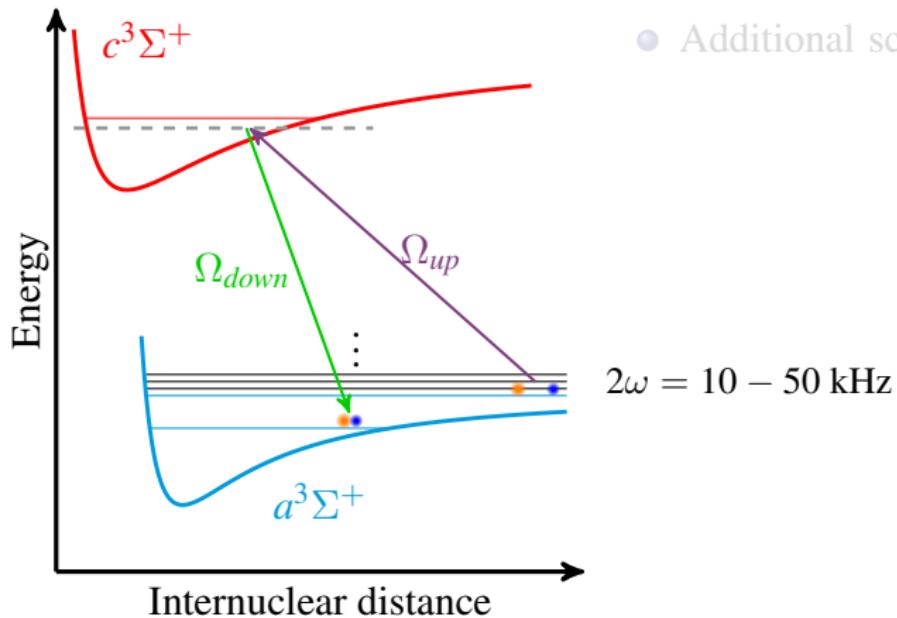
Raman transfer



Raman transfer

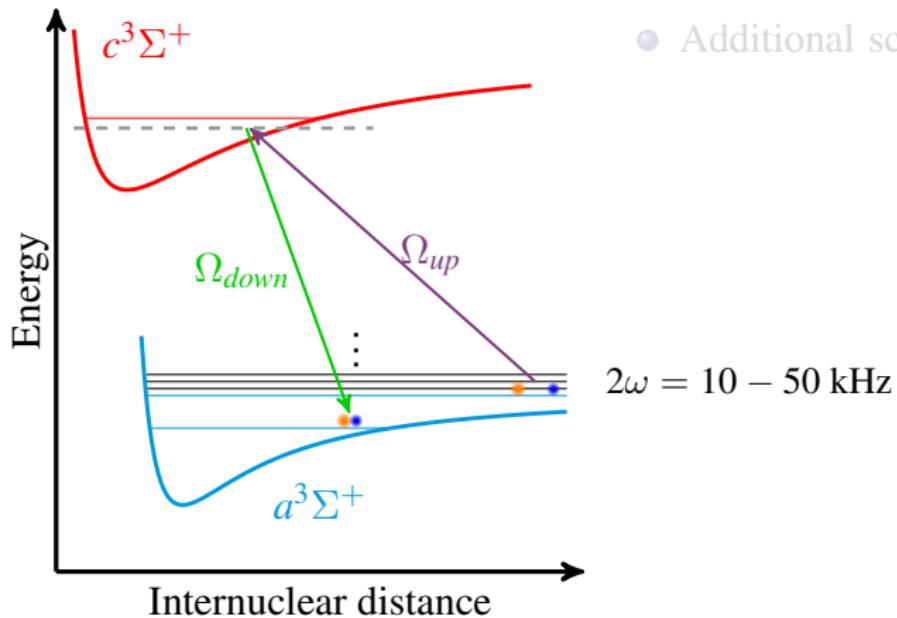


Raman transfer



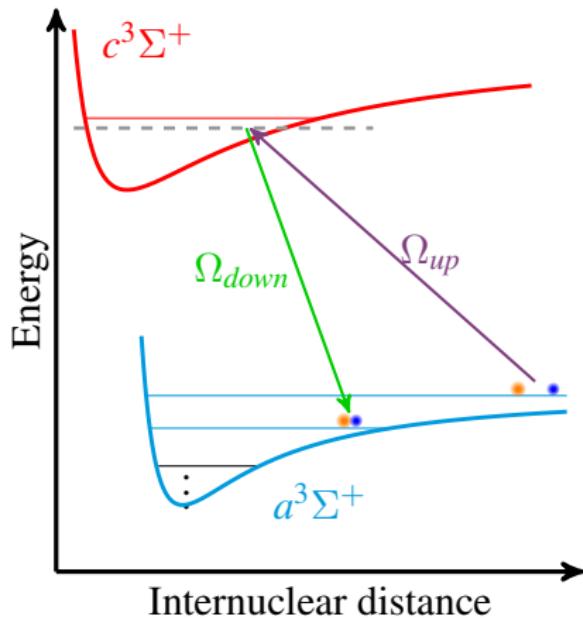
- No faster than $20 - 100 \mu\text{s}$
- Additional scattering.

Raman transfer



- No faster than $20 - 100 \mu\text{s}$
- Additional scattering.

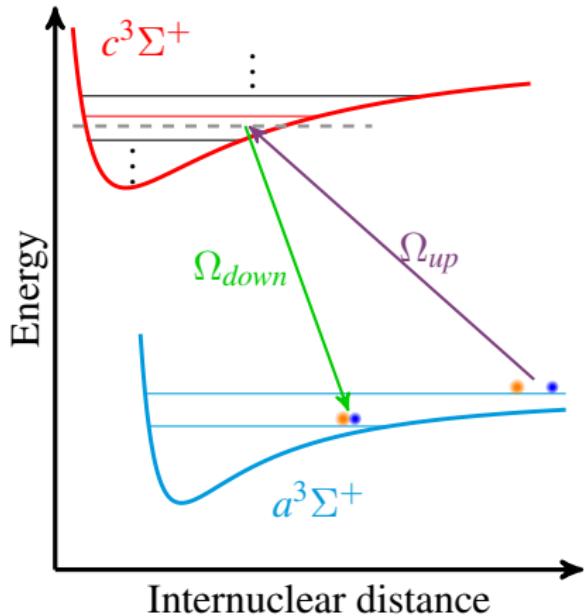
Raman transfer



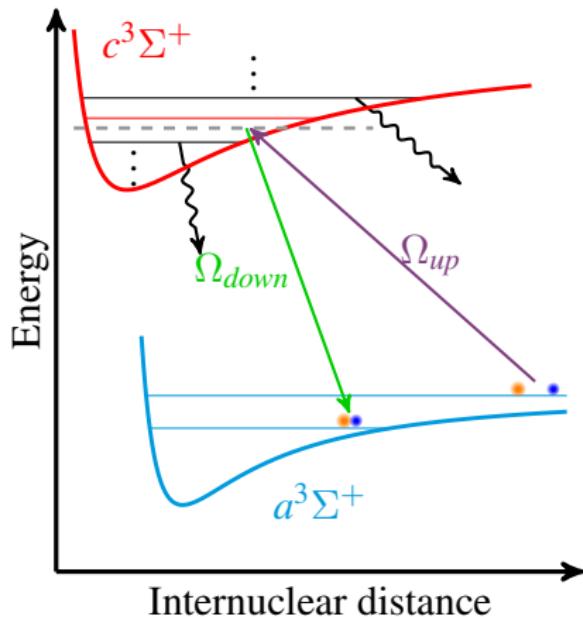
- No faster than $20 - 100 \mu s$
- Additional scattering.

Raman transfer

- No faster than $20 - 100 \mu s$
- Additional scattering.

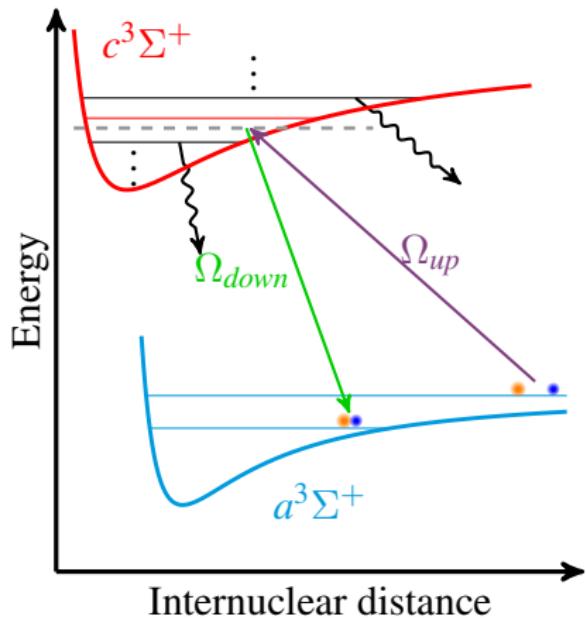


Raman transfer



- No faster than $20 - 100 \mu s$
- Additional scattering.

Raman transfer

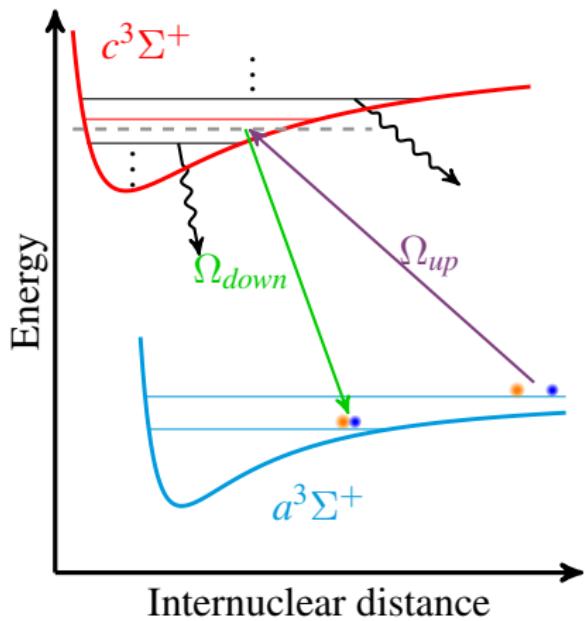


- No faster than $20 - 100 \mu s$
- Additional scattering.

Near threshold states

- Closely spaced
- Stronger coupling (Ω_{up})
- Easier to find

Raman transfer



- No faster than $20 - 100 \mu s$
- Additional scattering.

Near threshold states

- Closely spaced
- Stronger coupling (Ω_{up})
- Easier to find

Deeply states

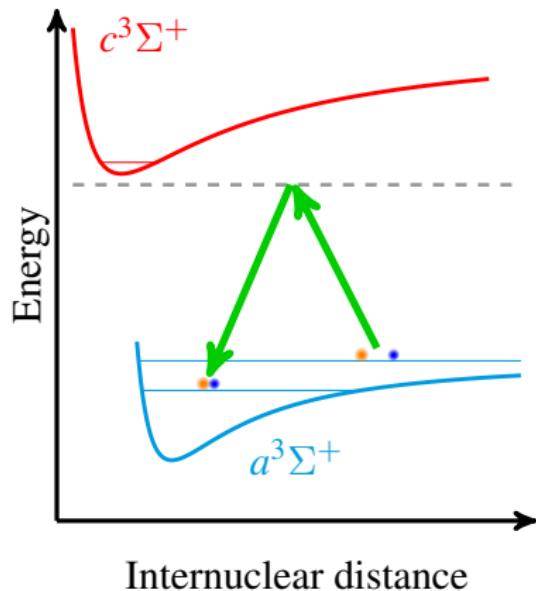
- Sparsely spaced
- Allow larger detuning
- Lower scattering

Raman transfer

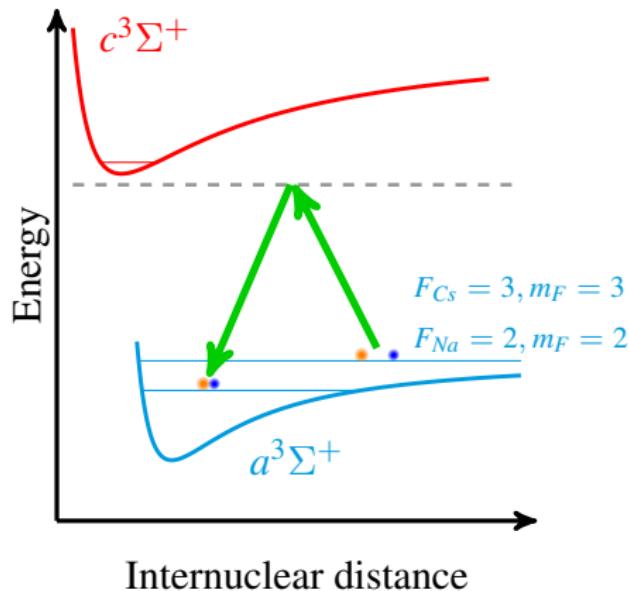
Near threshold states

Deeply bound states

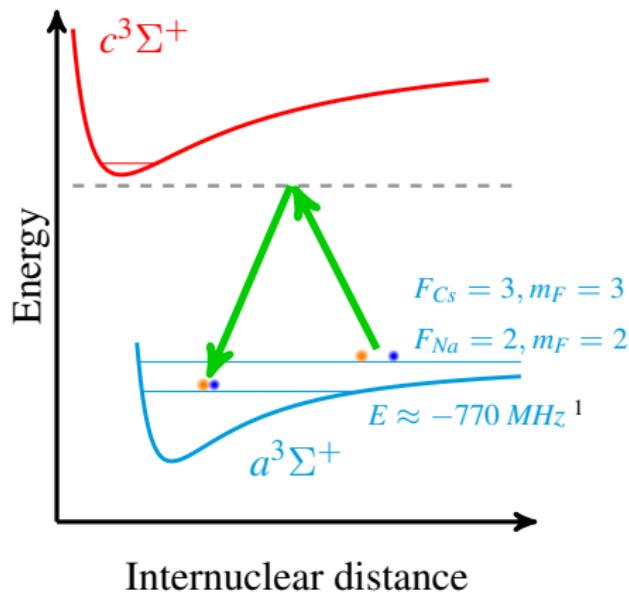
Experiment



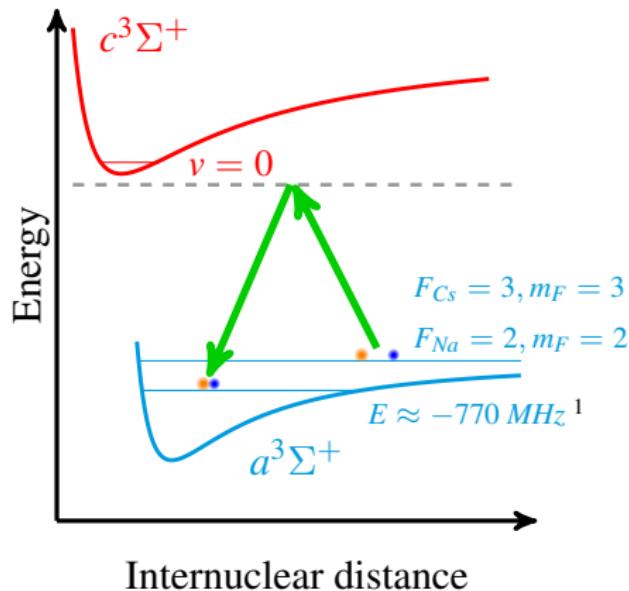
Experiment



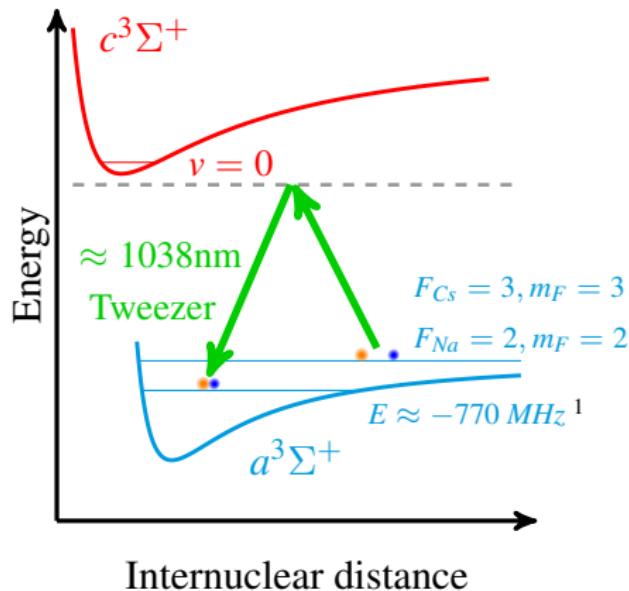
Experiment



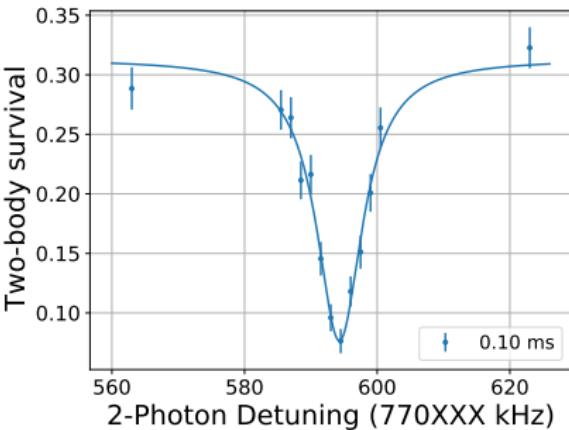
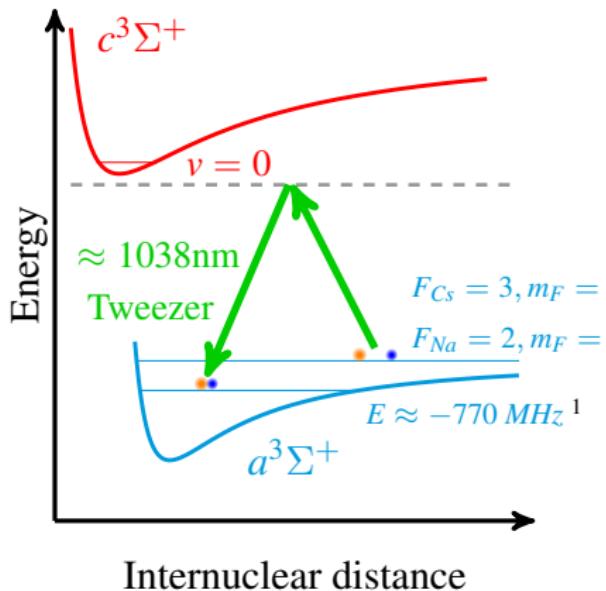
Experiment



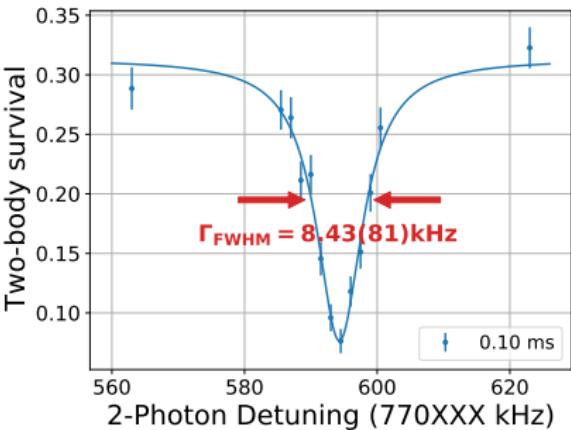
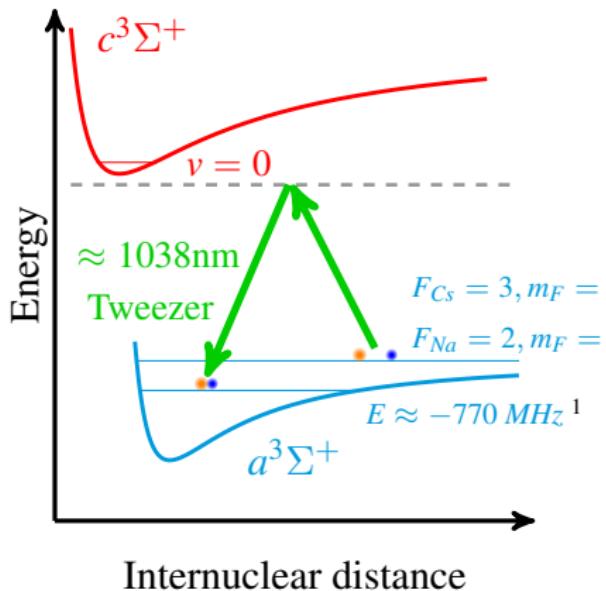
Experiment



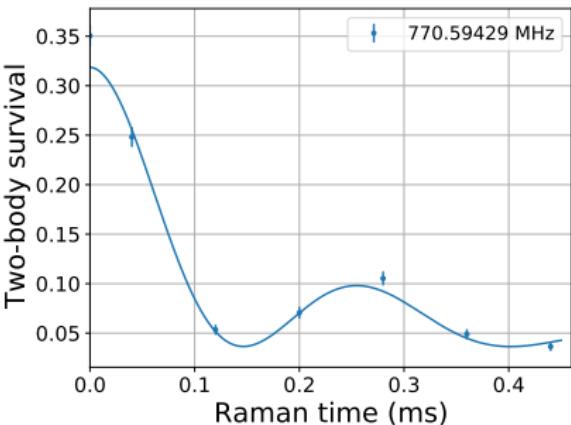
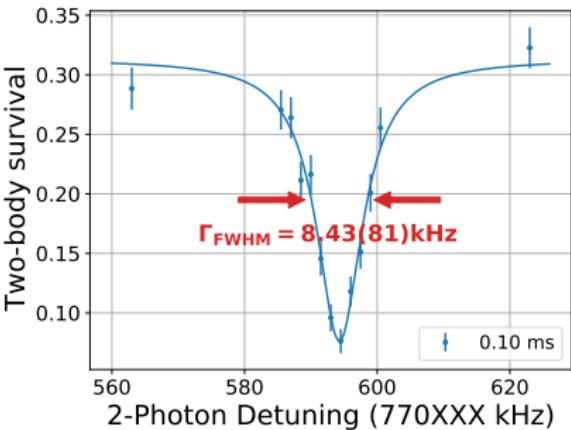
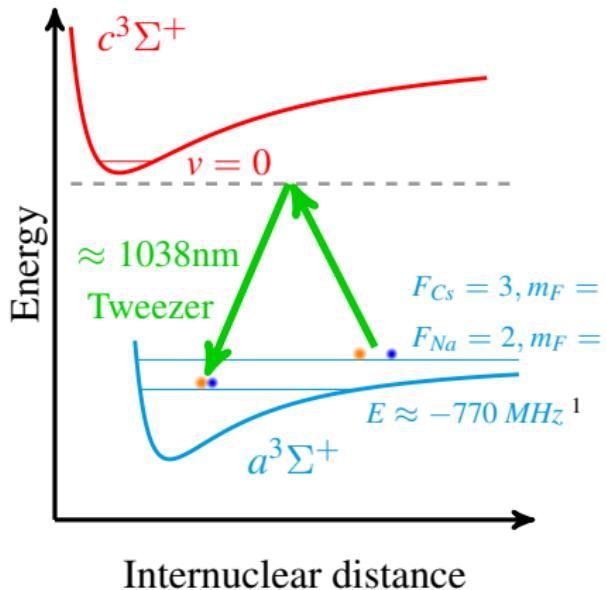
Experiment



Experiment



Experiment



Outlook

