Forbidden atomic transitions driven by an intensity-modulated laser trap

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ARTICLE

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Forbidden atomic transitions driven by an intensity-modulated laser trap

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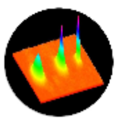
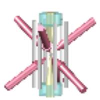
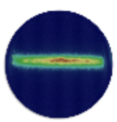


Bose-Einstein Condensation (David Anderson, Stephanie Miller)
A BEC consists of many atoms in the same quantum state. BECs are of interest because they are large objects that behave quantum mechanically. We intend to explore interactions between BECs and ior

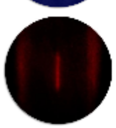
Ponderomotive Optical Lattice Trap (Kaitlin Moore, Yun-Jhih Chen, Andira Ramos)
We use the ponderomotive force to trap and study Rydberg atoms in optical lattices.



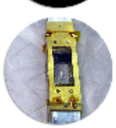
Cavity-Generated Optical Lattice Trap (Yun-Jhih Chen)
We use an in-vacuum near-concentric optical cavity to generate deep potentials to study Rydberg atoms.



Strong Magnetic Field Atom and Plasma Trap (Eric Paradis)
A superconducting Ioffe magnet has been developed to confine cold atoms at ~3 Tesla, and is coupled to a Penning trap for plasmas. Exotic Rydberg atoms, strongly magnetized cold plasmas, and pote system.

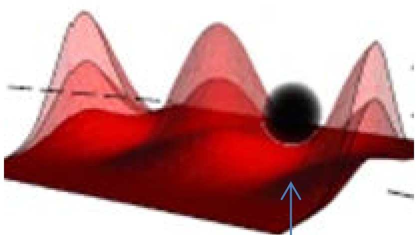


Continuous-wave Atom Laser (Mallory Traxler)
By mapping the evaporative cooling necessary to achieve BEC into space rather than time (as is conventionally done), it will be possible to realize a truly continuous BEC. By adding a the correct output cc



Ion-imaging Tip (Andrew Schwarzkopf, Nithiwadee Thaicharoen)
We hope to probe the physical distributions of Rydberg atom systems and plasmas.

Main features of this paper



Intensity modulated lattice
($T=2\pi/\Omega$)

Rydberg atoms (85Rb)

Target transition(Ω =38.7685GHz)

59s

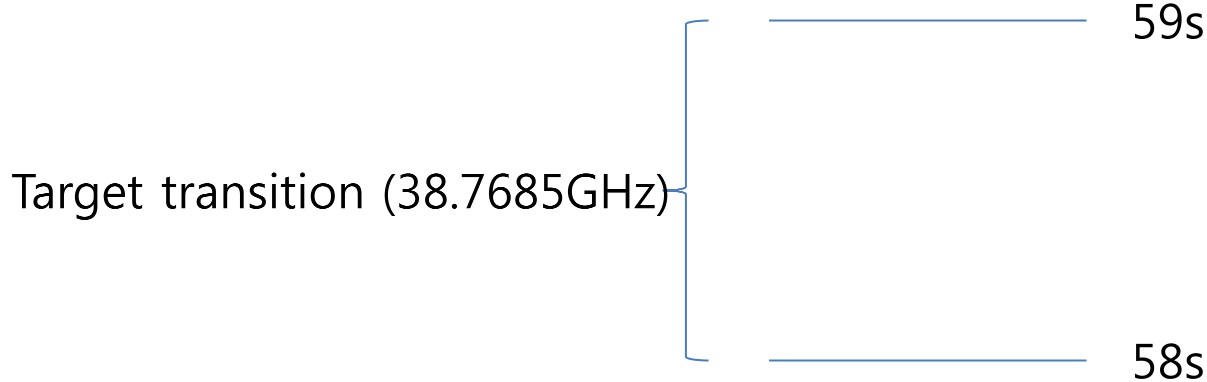
58s

Main features of this paper

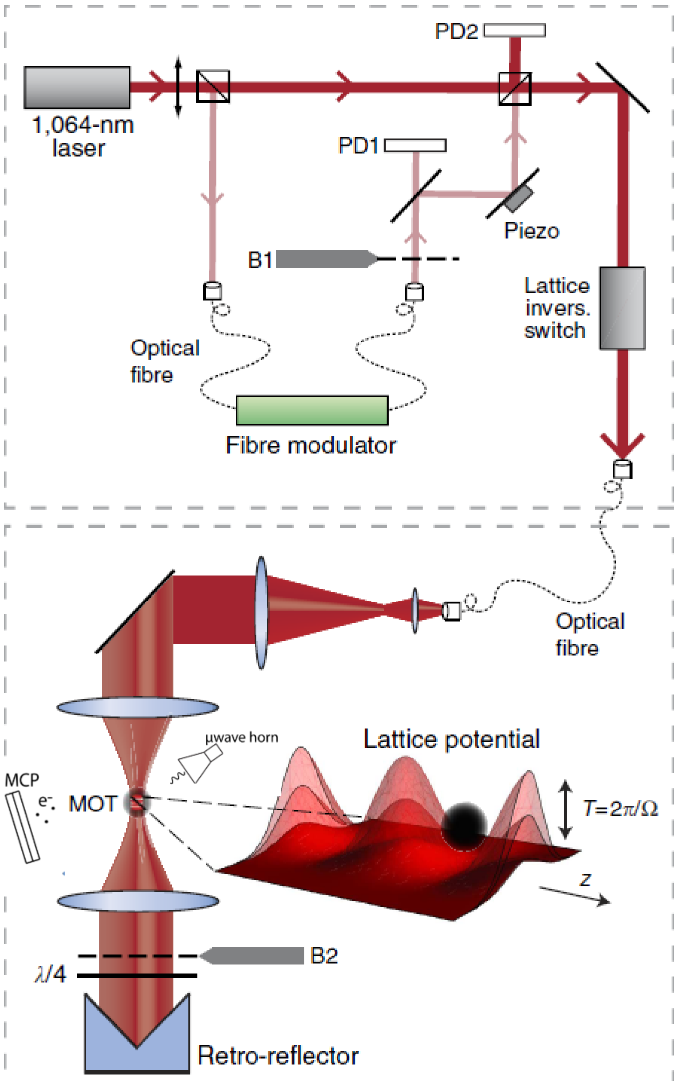
$$V_{int} = \frac{1}{2m_e}(2|e|\boldsymbol{A}\cdot\boldsymbol{p} + e^2\boldsymbol{A}\cdot\boldsymbol{A})$$

Forbidden by selection rule (electric-dipole transition)

Drive transition by ponderomotive term



setup

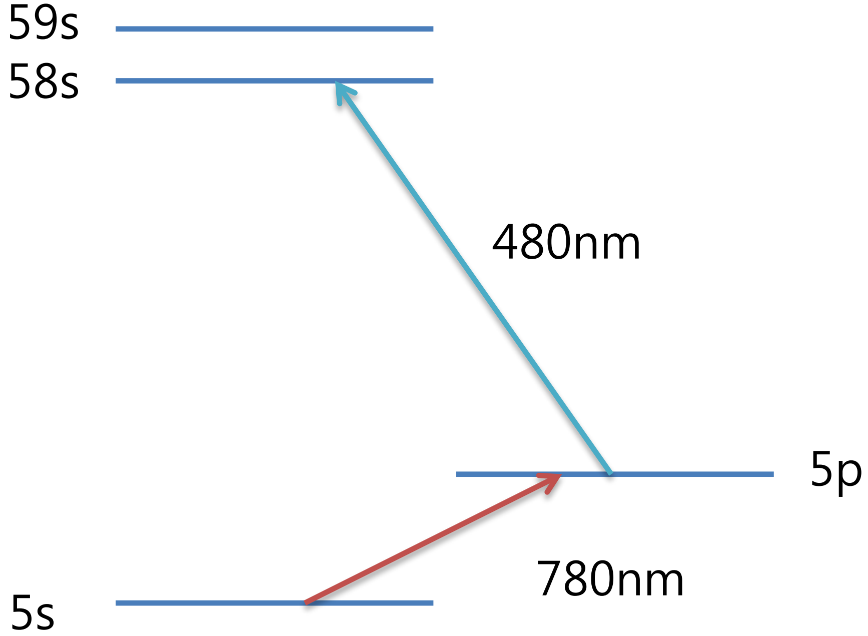


- MOT
- Optical Lattice
  - Unmodulated high power beam(3.9W)
  - Modulated low power beam(190mW)
  - Mach Zehnder-type interferometer
    - Coherent recombination

  - PD1 for precise modulation
  - PZT and PD2 for phase matching

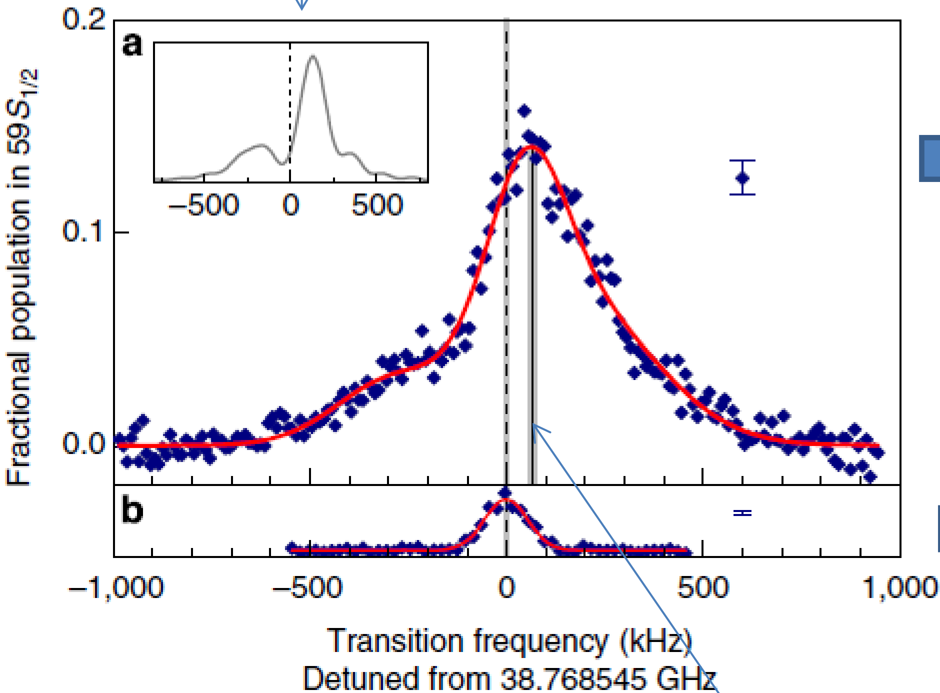
Experiment scheme

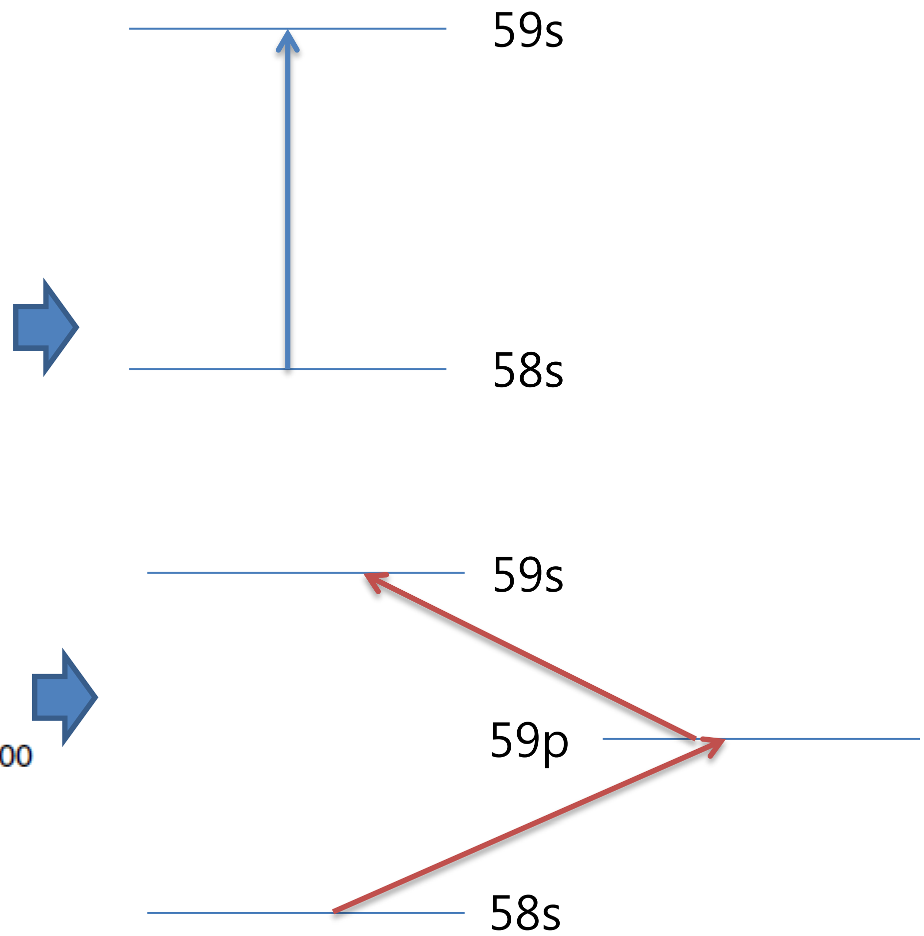
Load MOT and optical lattice (intensity modulation) → Turn off MOT beam and load atom to Rydberg state (B-field remained) → Interaction time t(3~9μs) → Detection (ionization by ramped E-field)



Results (spectroscopy signal)

simulation

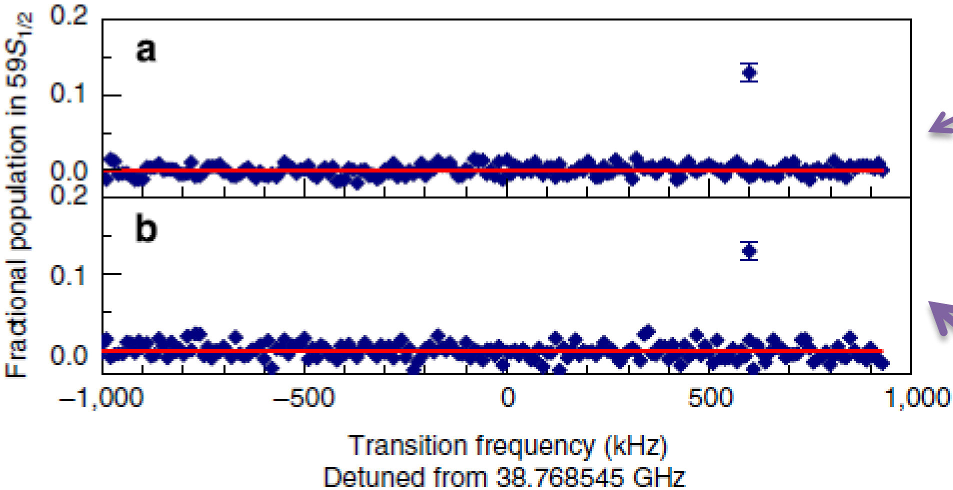




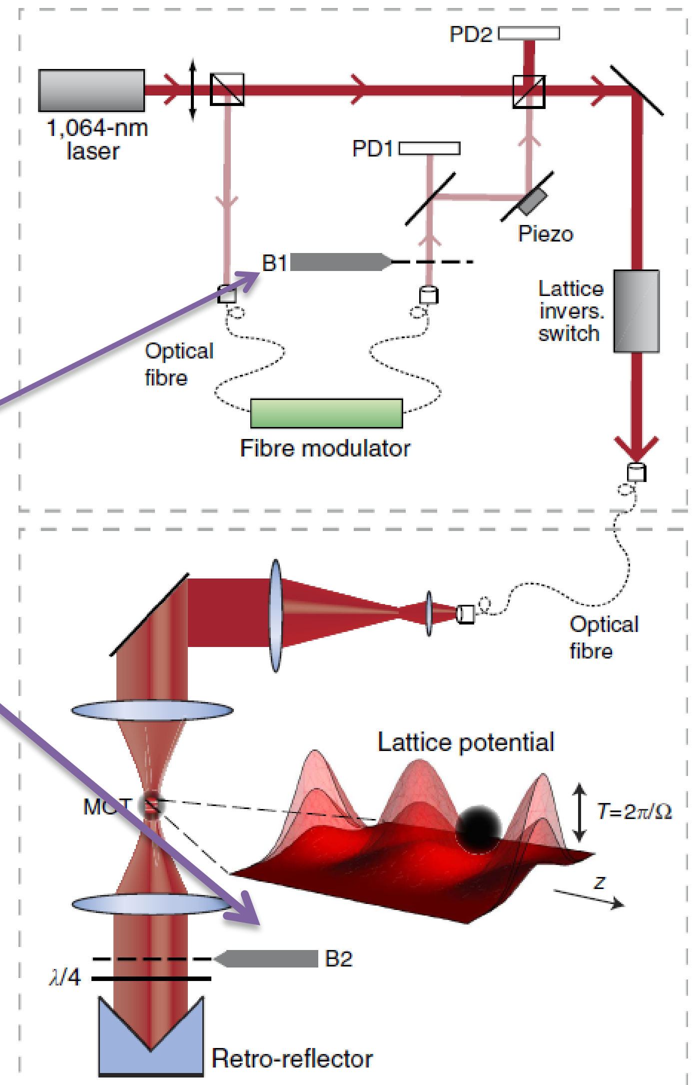
Due to light shift from optical lattice

Results (testing the results)

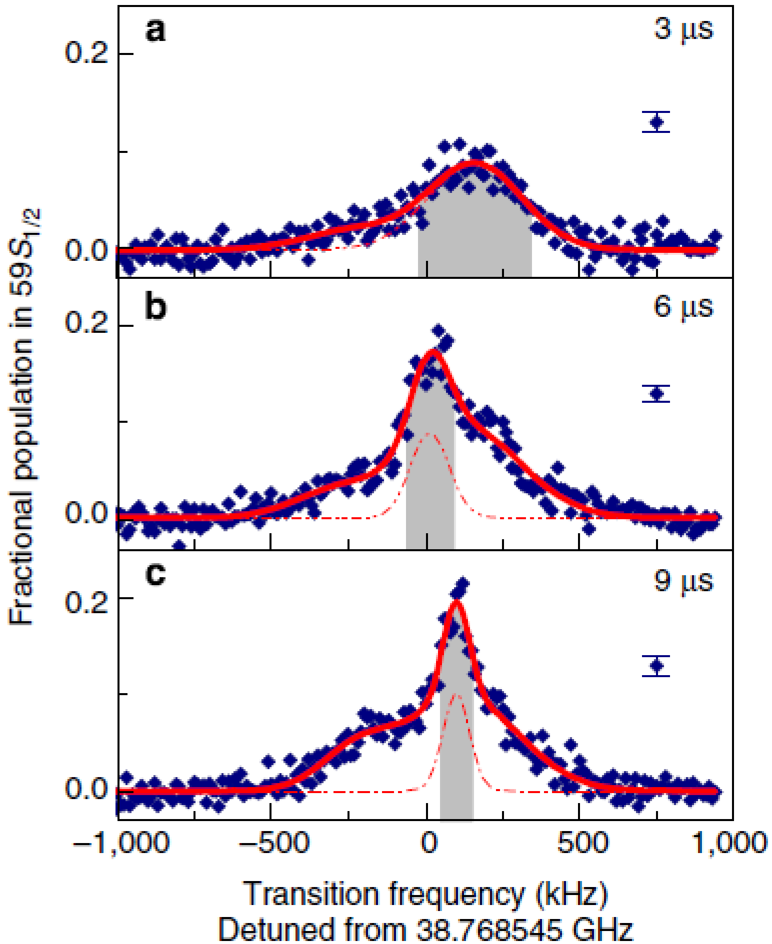
Testing microwave leakage



Testing two-step process
second $(\boldsymbol{A} \cdot \boldsymbol{p})$ coupling



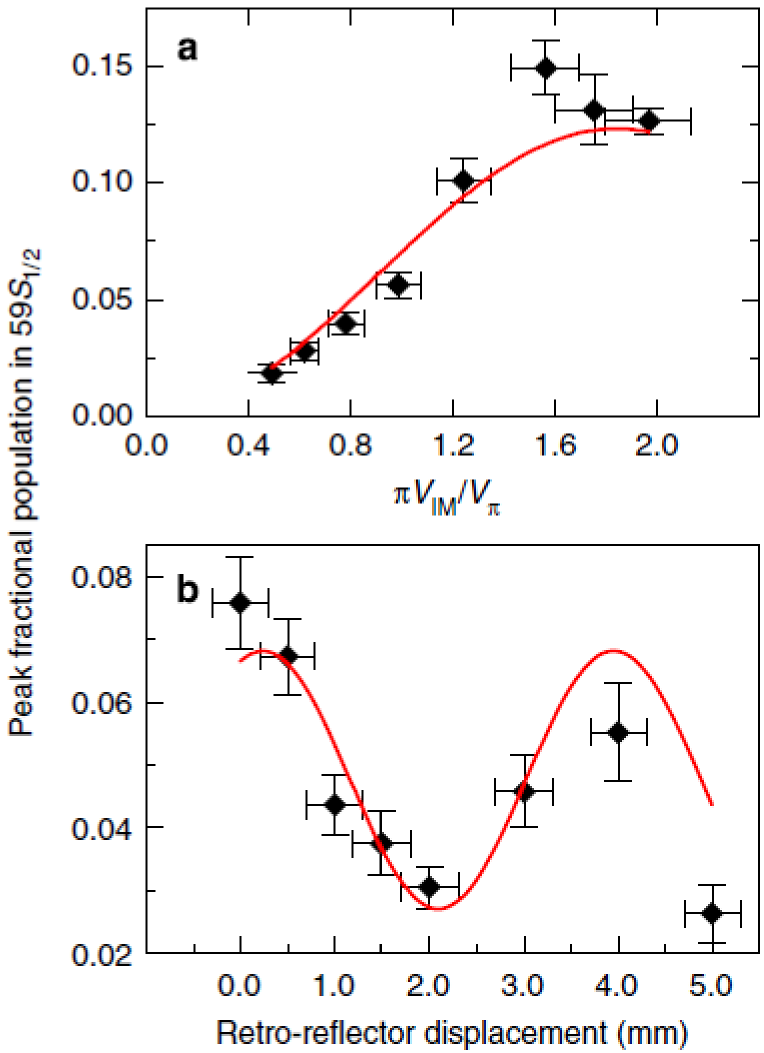
Results (interaction time)



$as\ t_{int}$ increases, FWHM decreases and height increases.

50~100kHz of Rabi frequency estimated (theory : 100kHz)

Results (position, voltage)



$$\chi \approx \sqrt{\varepsilon}\frac{e^2}{\hbar m_e c \epsilon_0 \omega^2} I_{0\,\mathrm{inc}}^{\mathrm{mod}} \mathrm{J}_1\left(\frac{\pi V_{\mathrm{IM}}}{V_\pi}\right)\left[1+\sqrt{\frac{2I_{0\,\mathrm{inc}}^{\mathrm{unmod}}}{I_{0\,\mathrm{inc}}^{\mathrm{mod}}}}\right] D_{n,l,m}^{n',l',m'},$$

$$(\chi t_{\mathrm{int}})^2 \propto J_1^2(\pi \hat{V}_{\mathrm{IM}}/V_\pi).$$

χ: *Rabi frequency*

Time delay between reflected and incident pulse

→ Sinusoidal varying

Conclusion

- Demonstration of poderomotive spectroscopy

- Advantages
  - Flexible selection rule
  - High spatial addressability
  - Possibility of suppressing AC stark shift

- Possible application
  - Quantum computing (single site addressability)
  - Precision measurement of atomic characteristics and physical constants
    - Rydberg constant (leading to proton size)

Information of EOM