

# Multistage Zeeman Deceleration: Stopping and Trapping Cold Beams of Hydrogen

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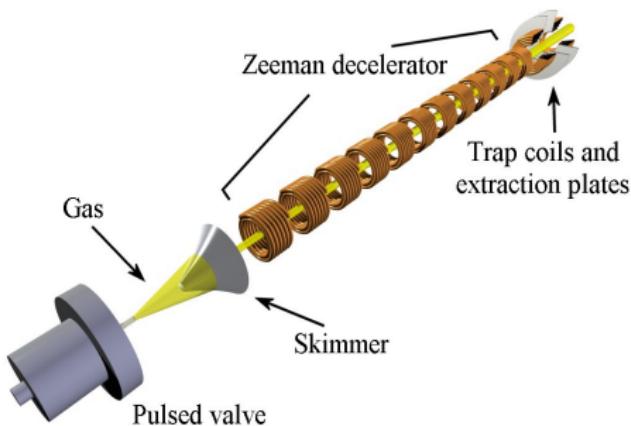
International Symposium on Molecular Spectroscopy  
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# Motivation

Goal: Slow quantum-state-selected molecular samples

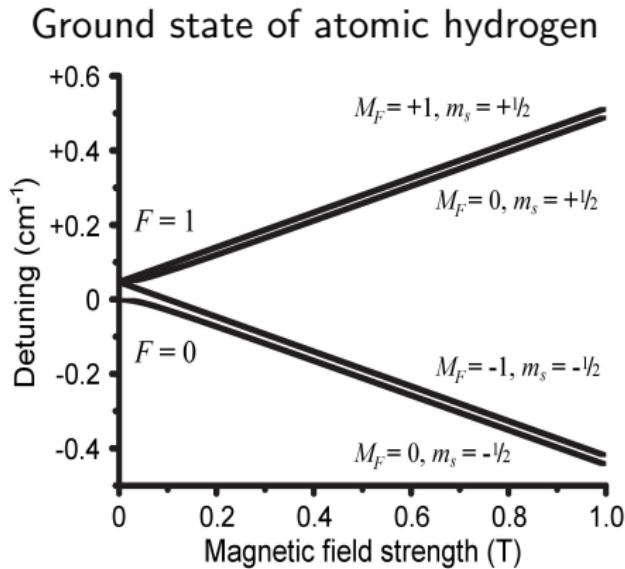
- High-resolution spectroscopy
- Cold reactive collisions

Possible solutions: Slow down pulses generated in supersonic expansions

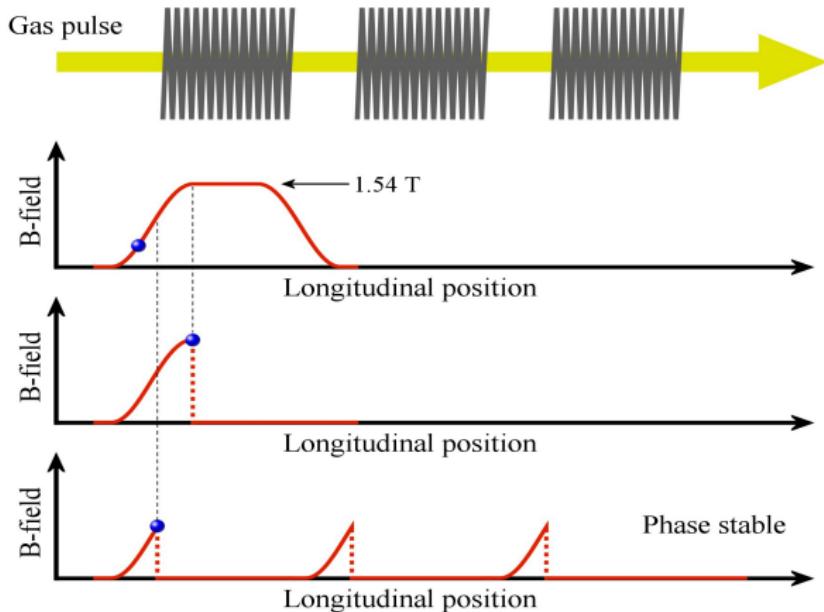


# Zeeman effect in hydrogen

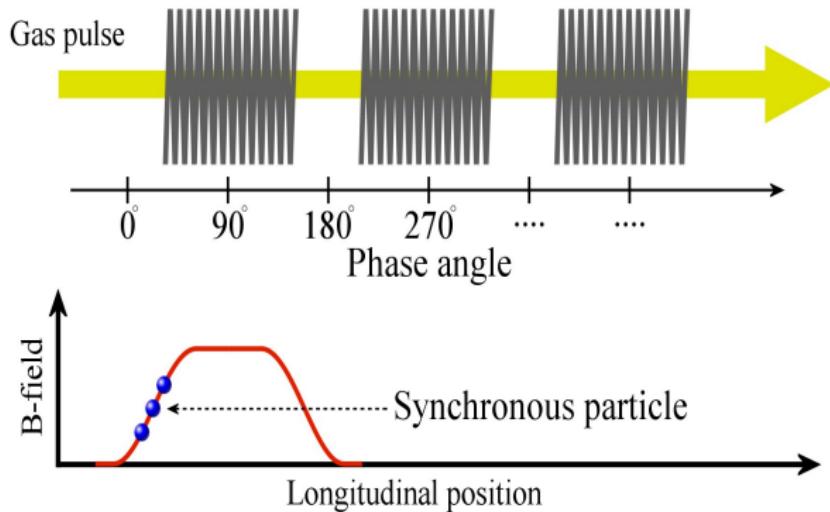
Interaction of paramagnetic atoms or molecules with a magnetic field → Zeeman effect



# Deceleration principle



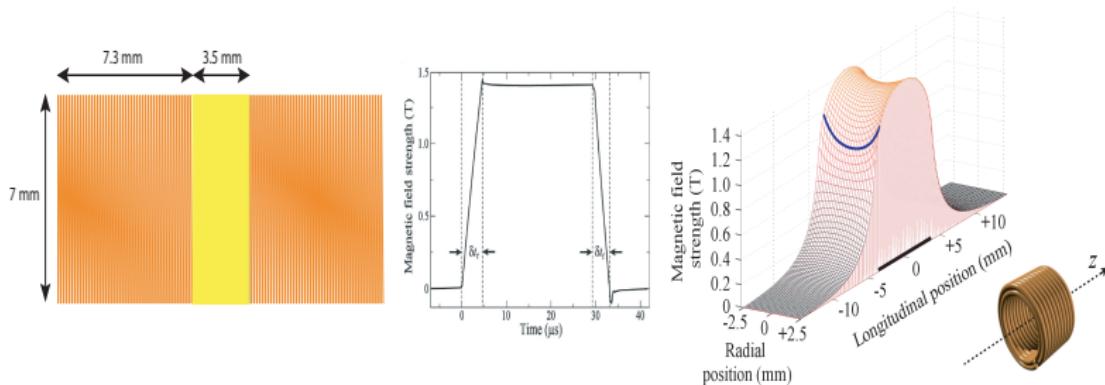
## Phase stable deceleration



<sup>1</sup>Bethlem et al., Phys. Rev. Lett. **65**, 053416 (2002)

# Coil design

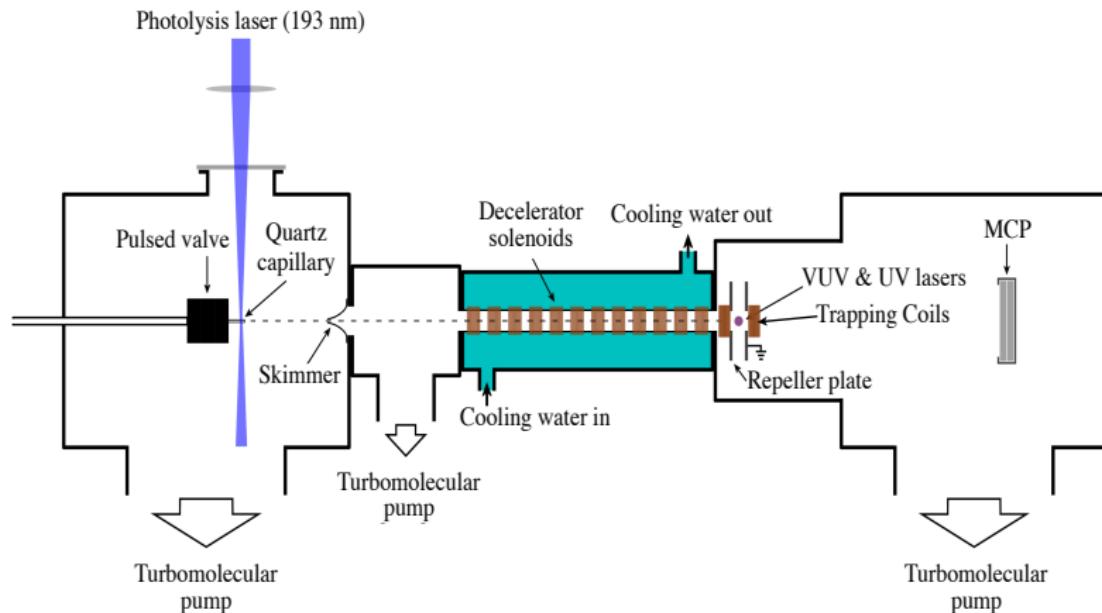
windings	64 (400 $\mu\text{m}$ wire)
max. field strength on axis (300 A)	2.17 T
rise and fall times	$\sim 5 \mu\text{s}$
repetition rate	10 Hz



<sup>2</sup>Vanhaecke et al., Phys. Rev. A, vol. **75**, 031402 (2007)

<sup>3</sup>Hogan et al., Phys. Rev. A, vol. **76**, 023412 (2007)

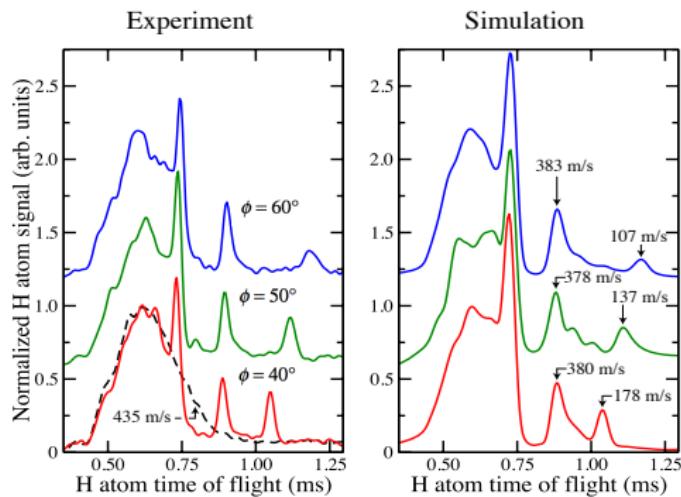
# Experimental setup



<sup>4</sup>Hogan et al., J. Phys. B, vol. 41 081005 (2008)

# Slow beams of hydrogen atoms

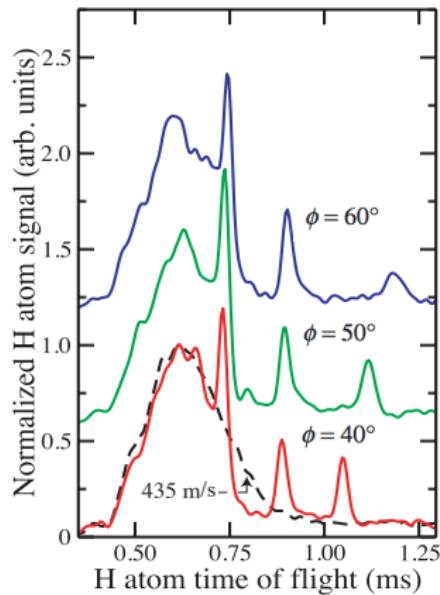
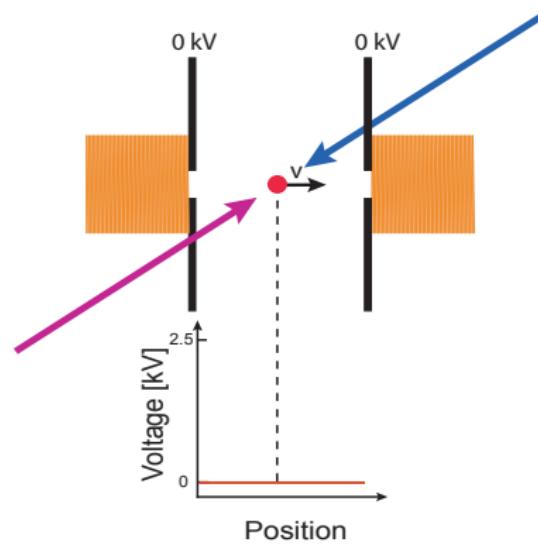
12 stage decelerator,  $I = 285 \text{ A}$  ( $1.46 \text{ T}$ )  
 $> 95 \%$  of the kinetic energy removed



<sup>4</sup>Hogan et al., J. Phys. B, vol. 41 081005 (2008)

# Velocity measurement

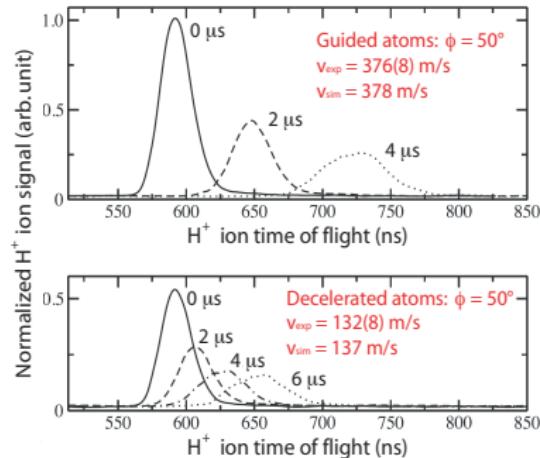
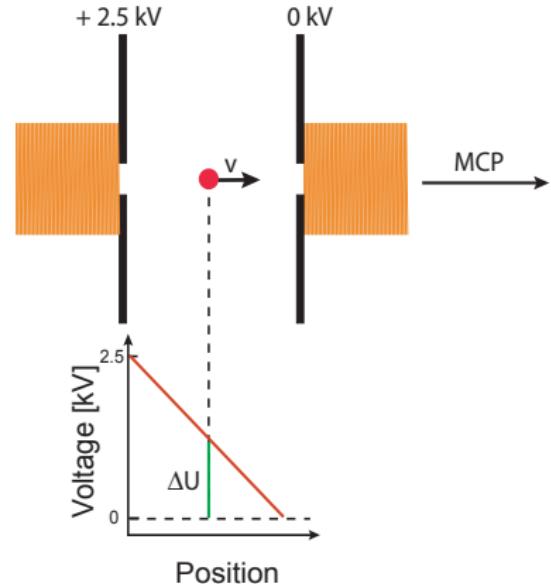
Excitation to Rydberg states  $t = 0$



<sup>4</sup>Hogan et al., J. Phys. B, vol. 41 081005 (2008)

# Velocity measurement

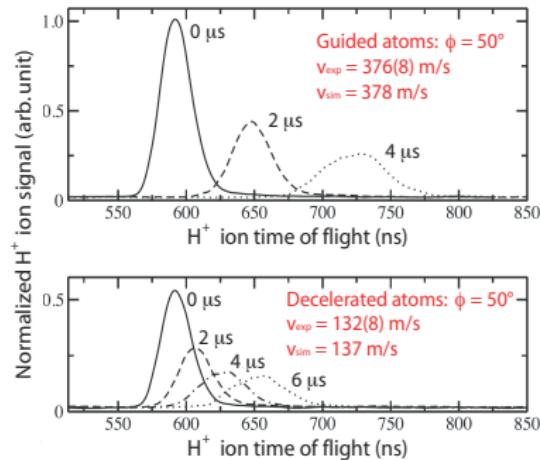
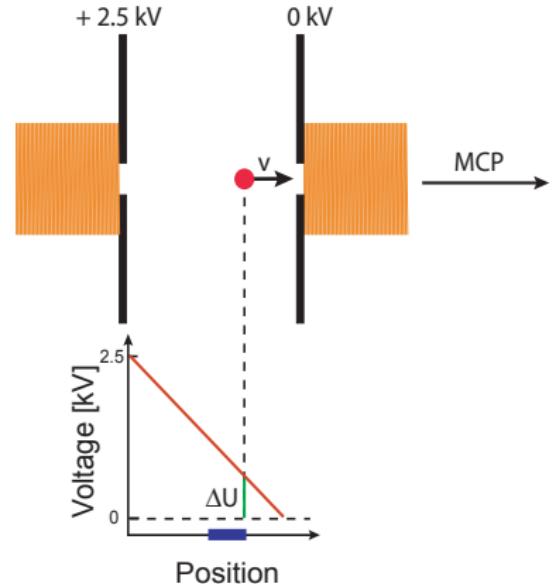
Field ionization at time  $t = 0$



<sup>4</sup>Hogan et al., J. Phys. B, vol. 41 081005 (2008)

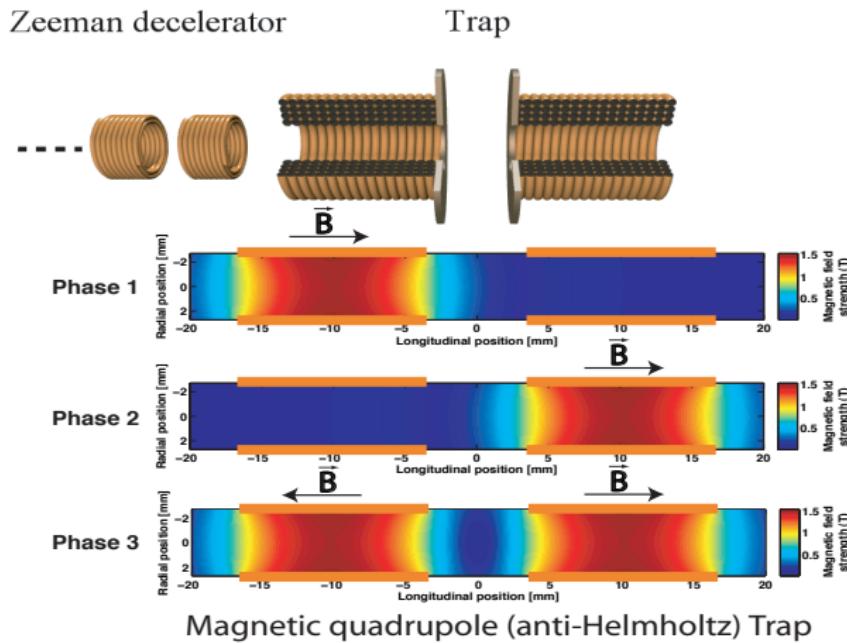
# Velocity measurement

Field ionization at time  $t + \Delta t$

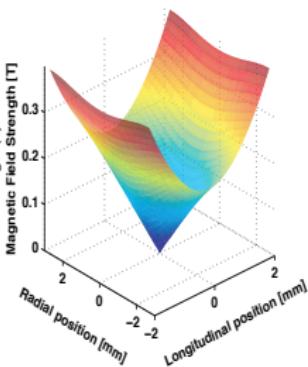
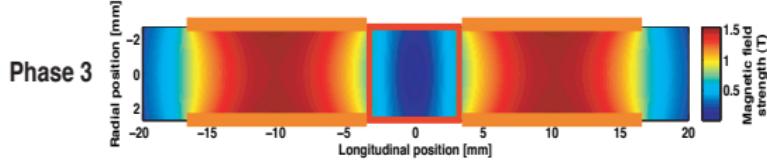
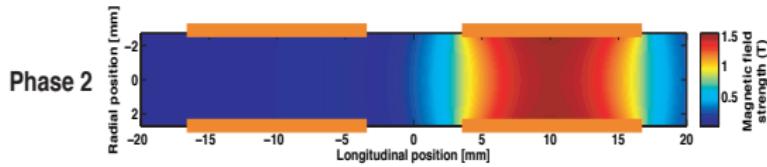
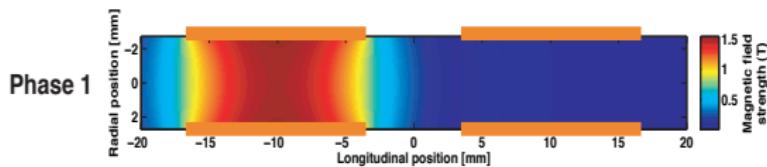


<sup>4</sup>Hogan et al., J. Phys. B, vol. 41 081005 (2008)

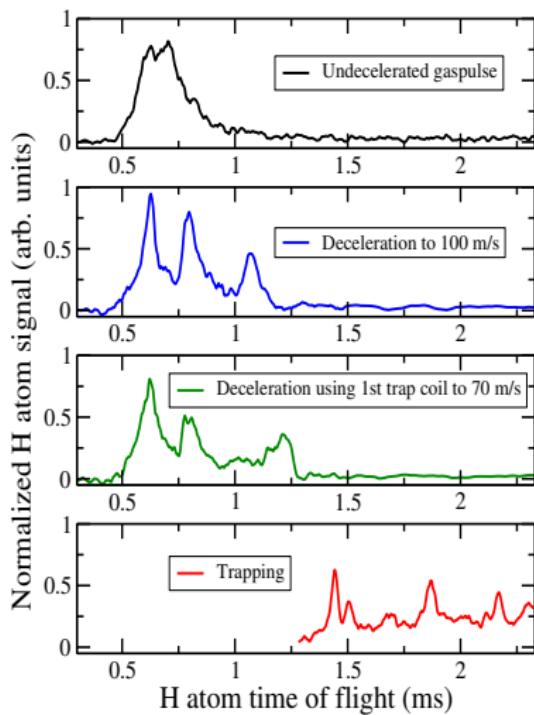
# Loading a magnetic trap



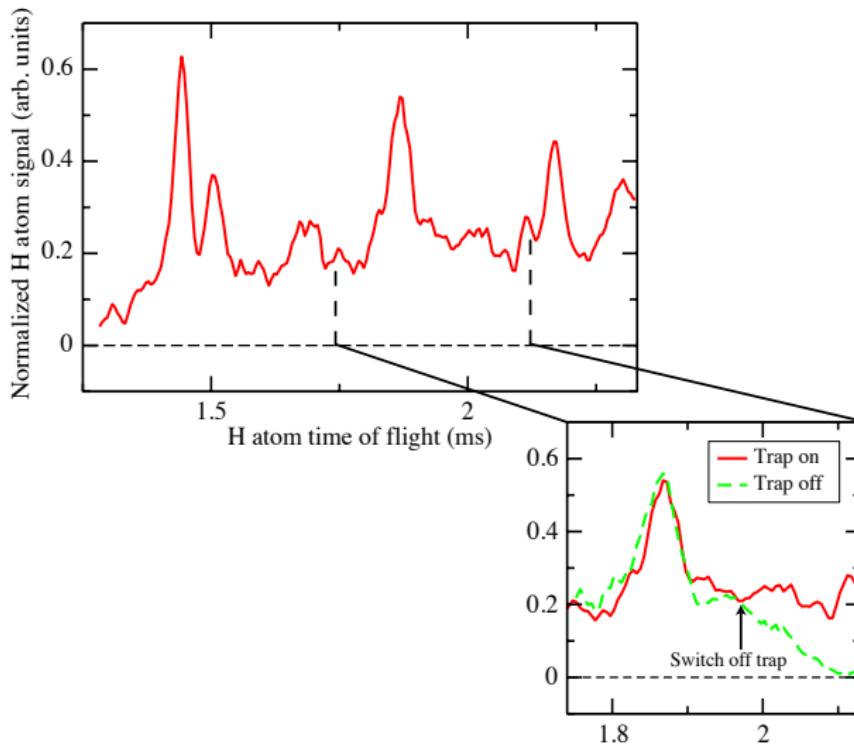
# Loading a magnetic trap



# Trapping hydrogen atoms



# Trapping hydrogen atoms



# Conclusions

- Demonstrated multistage Zeeman deceleration of H atoms
- H atoms can be stopped in the laboratory frame
- Quantitative agreement between experiments and simulations
- Velocity measurement by ion time of flight mass spectrometry following Rydberg excitation
- Magnetic trapping of Zeeman decelerated hydrogen atoms