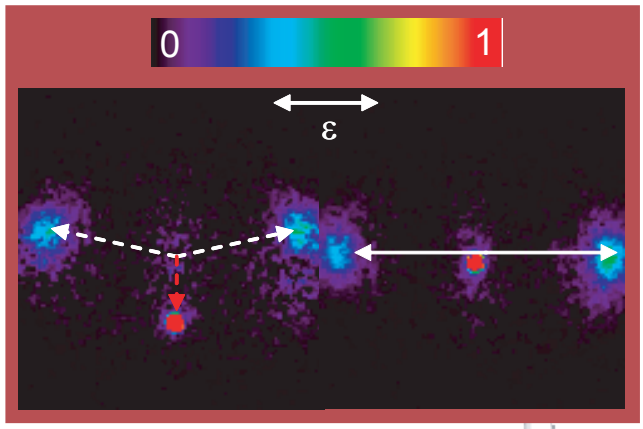
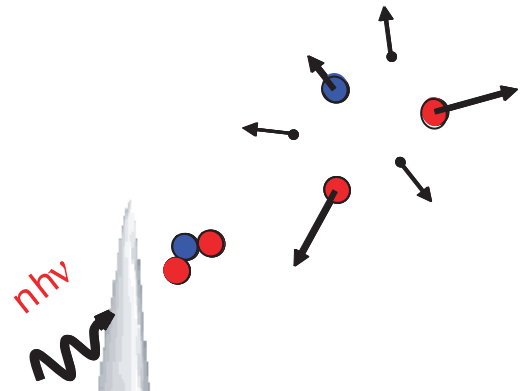
Freezing Ultra-Fast Dynamics with Light

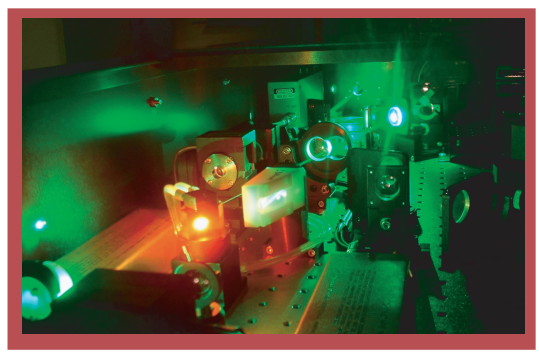




Intense femtosecond laser pulses are employed to view and follow the collective motion of atoms in small molecules. State-of-the-art technologies (pulse shaping, genetic feedback algorithms and fast-frame imaging) are exploited to decouple fundamental modes (bending, stretching, dissociation and ionization). Above, CO_2 is captured exploding from two specific bond angles after six electrons have been stripped by the ultra-short laser pulse. Freezing the atomic motion allows the dynamics to be controlled and specific decay channels to be enhanced.

Current Projects Include:

- Freezing dynamics with Coulomb imaging;
- Shaping 25-100 fs pulses, genetic feedback algorithms to control dyanmics; and
- Probing correlation via n-body coincidence.



Recent Publications:

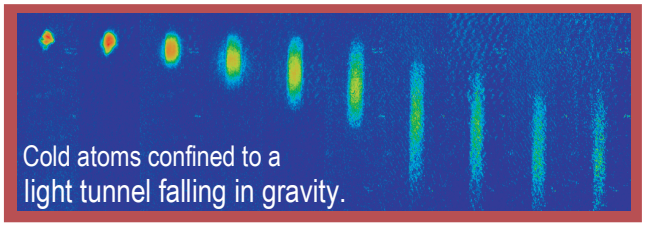
K. Zhao, *et al*., Opt. Express **9**, 42 (2001)
K. Zhao, *et al*., Rev. Sci. Instrum. **73**, 3044 (2002)
K. Zhao, *et al*., Phys. Rev. A **68**, 063408 (2003)

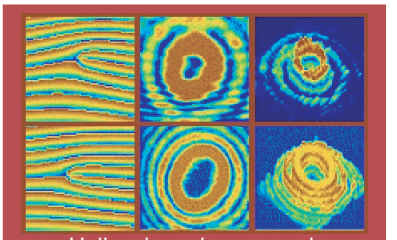
Supporting Agency:

National Science Foundation (NSF)

COMPUTER MATHEMATICAL & PHYSICAL SCIENCES

Atom Optics and Quantum Information

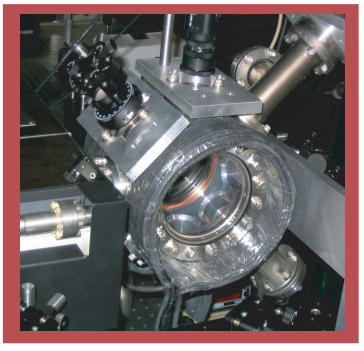

Cold atoms confined to a
light tunnel falling in gravity.


Hollow laser beams and
2-D phase masks (left)

A variety of free-space elements for atom optics (waveguides, funnels, beam splitters, etc.) based on hollow (vortex) laser beams are being developed to manipulate cold neutral atoms. Two-dimensional spatial light modulators are exploited to create nearly diffraction-free (Bessel) beams with one or more dark channels. From the coherent transport of entangled atoms to the study of atoms in restricted dimensions, hollow laser beams are providing a unique environment for developing new technology and studying fundamental physics.

Current Projects Include:

- Building atom waveguides, funnels and splitters;
- Designing single-mode channels for coherent transport of atoms;
- Coupling free-space and hollow core fiber guides; and
- Coupling and entangling light and matter orbital momenta



Recent Publications:

Y. Song, *et al.*, Opt. Lett. **24**, 1805 (1999)

N. Chattrapiban, *et al.*, Opt. Lett. **28**, 2183 (2003)

Supporting Agencies:

U.S. Army Research Office

National Institute for Standards and Technology

Photonics Technology Access Program

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