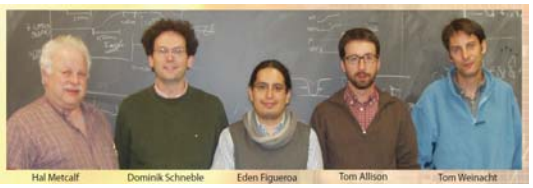
Experimental Research in Atomic, Molecular and Optical Physics



Stony Brook University

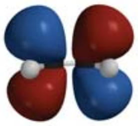
Experimental research in
AMO Physics

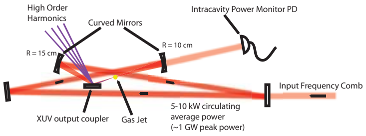
amo.physics.sunysb.edu/AMO/

•Optical forces and laser cooling •Ultracold quantum matter •Quantum information technology •Frequency combs and ultrafast chemical physics •Ultrafast control and spectroscopy

Allison group

- In the Ultrafast Frequency Comb group we develop new light sources and measurement techniques and apply them to resolving molecular dynamics.



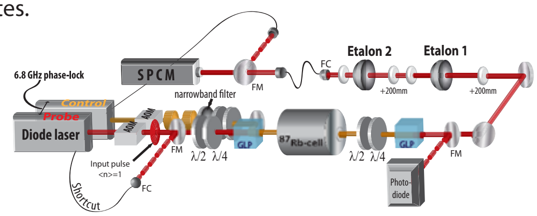


- We investigate frequency combs, high harmonic generation, ultrafast imaging of molecular electronic structure and ultrafast vibrational dynamics of clusters.

Figueroa group

- In the Quantum Information group we develop and expand the toolbox of quantum technology.

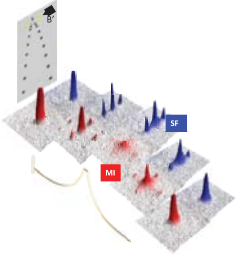
- We are aiming to develop scalable quantum memory technologies as well as designing and implementing novel quantum transistors and gates.



Schneble group

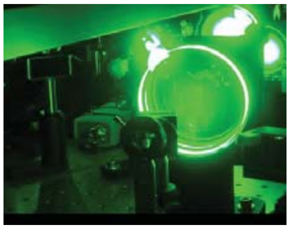
- In the Ultracold Atomic group we create, control, and manipulate quantum-degenerate atomic gases.

- We are working to produce "designer materials" with precisely controllable quantum properties that will allow for fundamental studies at the boundary between atomic physics, quantum optics, solid-state physics, mathematical physics, and quantum information science.



Weinacht Group

- In the Quantum Control & Ultrafast Spectroscopy group we control and measure molecular dynamics using shaped ultrafast laser pulses.

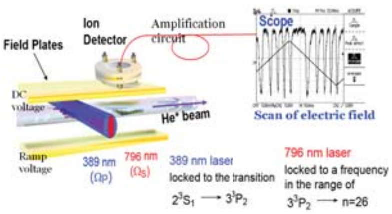


- We are developing new tools for control over electronic and nuclear motion, and we are using nonlinear spectroscopy to understand the physics underlying the photoprotection of DNA.

Metcalf group

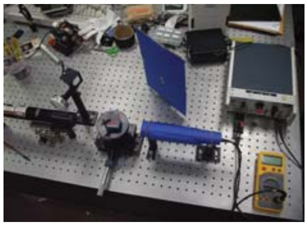
- In the Laser Cooling group we study the interaction of Helium atoms with polychromatic laser beams in order to create and understand optical forces.

- We investigate adiabatic rapid passage, bichromatic optical forces, neutral atom lithography and stimulated rapid adiabatic passage for metastable helium atoms.



Laser Teaching Center

- The Laser Teaching Center is a permanent facilty within the Department of Physics and Astronomy for hands-on instructional programs in optical physics and technology.

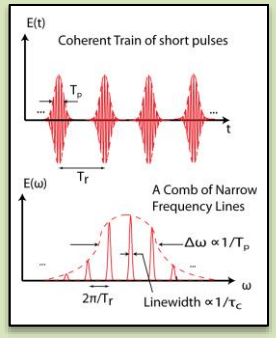


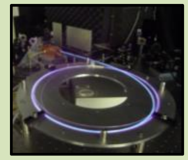
- Our core educational program is learning through the collaborative development of simple, creative projects and demonstrations of everyday devices or phenomena related to light and optics.

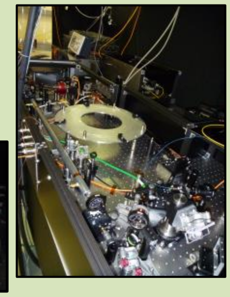
Allison Group
Ultrafast Molecular Dynamics

Frequency Comb Lasers

- 2005 Nobel Prize for revolutions in metrology.
- Optical frequency waveform synthesizer.
- Fiber lasers enable high power.
- Pulses can be coherently added and stored in a passive optical resonator.
- Can convert to ***Mid-IR, XUV, Soft X-ray…***



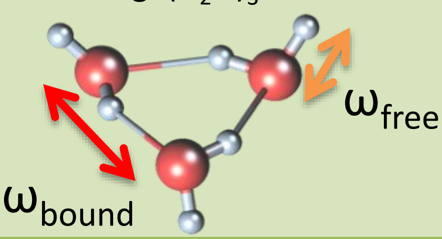




Ultrafast Vibrational Dynamics

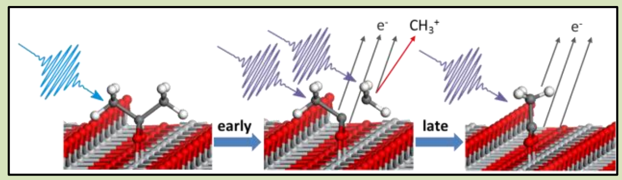
- How are vibrational motions coupled in liquids: can we learn from clusters?

e.g. $(H_2O)_3$



Ultrafast Electron Dynamics

- How does electronic excitation efficiently drive a chemical reaction?



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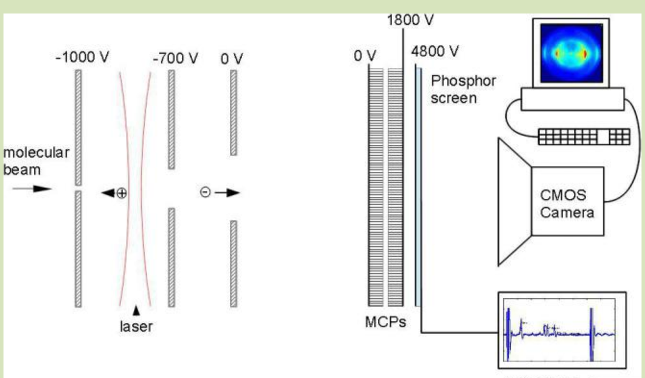
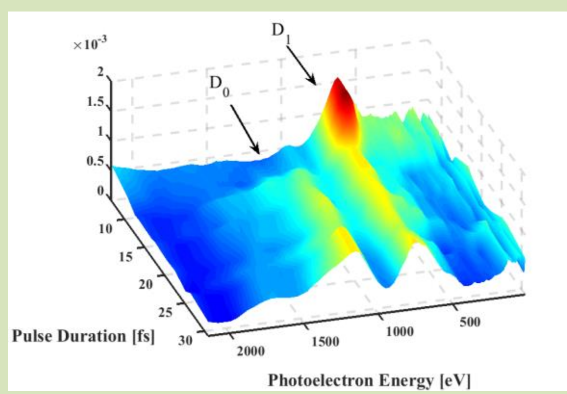
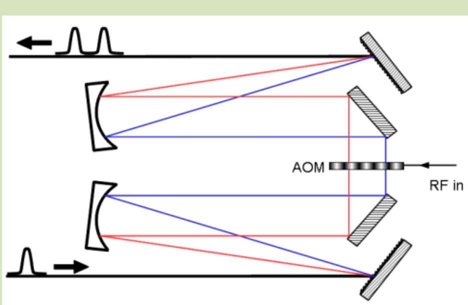
Weinacht Group
Time Resolved Spectroscopy and Quantum Control





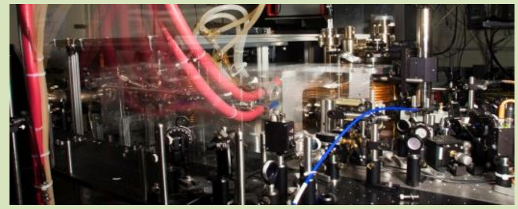


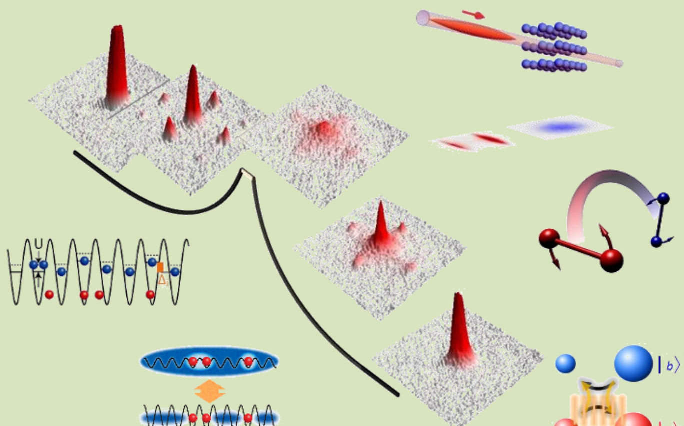
In our laboratory we control the quantum dynamics of molecules using ultrashort laser pulses. We develop time resolved measurements of molecular dynamics, and design tailored light pulses in order to control the dynamics that we observe. Ultimately we are interested in making movies of how electrons and nuclei move during fundamental molecular processes.

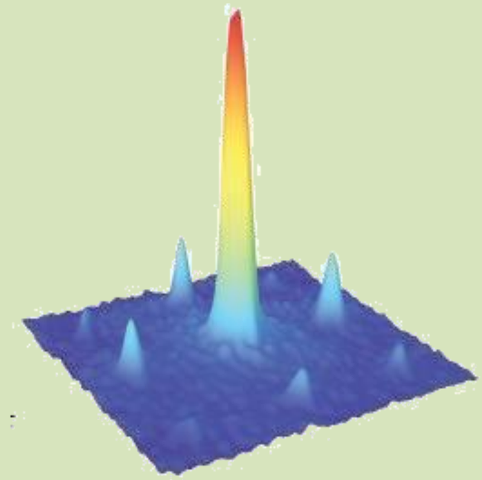
ultrafast.physics.sunysb.edu/

Schneble Group
Ultracold Quantum Matter

We create, control, and manipulate quantum-degenerate atomic gases. We produce designer materials - a billion times less dense and cooler than conventional materials with precisely controllable quantum properties. Our focus is on Bose-Einstein condensates in optical lattices and on their many body quantum behavior.







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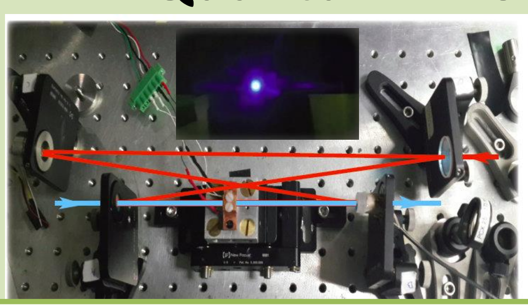
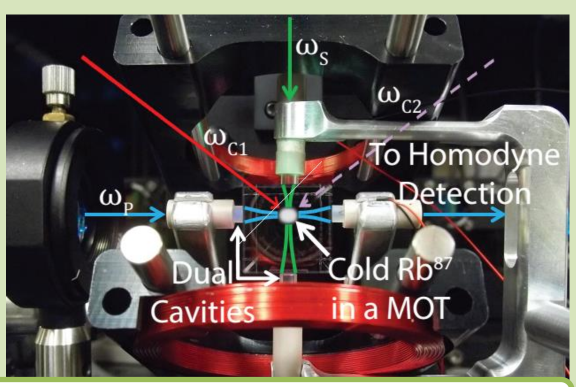
Figueroa Group
Quantum Information Technology Group

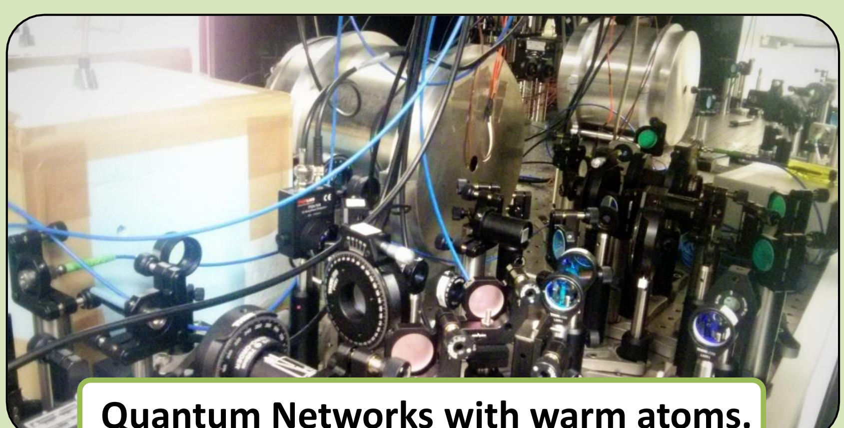


Quantum states resonant to Rb.

We create and manipulate quantum information using quantum states encoded in light and atomic ensembles. We currently have three main experiments dedicated to creating an elementary quantum processor.



Quantum Gates using cold atoms.



Quantum Networks with warm atoms.

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Metcalf Group
Optical Forces without spontaneous emission

Laser Cooling without Spontaneous Emission

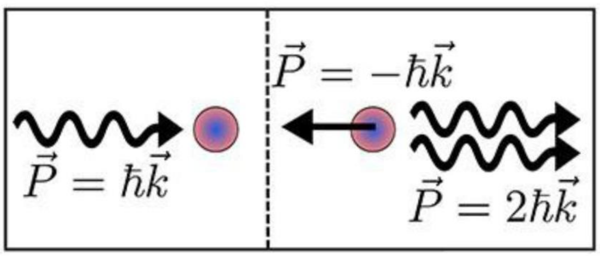
It has long been assumed that laser cooling cannot work without spontaneous emission. We have shown that this is not true by cooling with the bichromatic force produced by stimulated emission only.

The paper had big impact.

EDITORS' SUGGESTION

Christopher Corder, Brian Arnold, and Harold Metcalf
Phys. Rev. Lett. **114**, 043002 (2015)

Laser Cooling without Spontaneous Emission

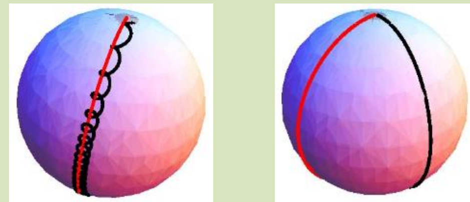


Atom-light interactions using polychromatic laser fields permit energy and momentum exchange for laser cooling without spontaneous emission.

Adiabatic Rapid Passage

Adiabatic: the frequency sweep time is much longer than the Rabi oscillation time (left trajectory). We have found that violating this still allows for rapid inversion and momentum transfer (right trajectory).

It works with much lower intensity.



Rapid: the frequency sweep time is shorter than the excited state lifetime. Coherent momentum exchange between atoms and a frequency-chirped light field produces enormous forces.

Repeated, short, pulsed sweeps inhibit spontaneous decay: *"Quantum Bang-Bang"*.

www.stonybrook.edu/metcalf/

Stony Brook AMO Research Highlights

PRL **116**, 063002 (2016) PHYSICAL REVIEW LETTERS week ending 12 FEBRUARY 2016

Strong Field Molecular Ionization in the Impulsive Limit: Freezing Vibrations with Short Pulses

Péter Sándor,[1] Vincent Tagliamonti,[1] Arthur Zhao,[1] Tamás Rozgonyi,[2] Matthias Ruckenbauer,[3] Philipp Marquetand,[3] and Thomas Weinacht[1]
[1]*Department of Physics and Astronomy, Stony Brook University, Stony Brook, New York 11794-3800, USA*

SCIENTIFIC REPORTS

OPEN

Quantum Process Tomography of an Optically-Controlled Kerr Non-linearity

Received: 10 June 2015
Accepted: 16 October 2015

Connor Kupchak, Samuel Rind, Bertus Jordaan & Eden Figueroa

Research Article Vol. 3, No. 3 / March 2016 / Optica 311

optica

Cavity-enhanced ultrafast spectroscopy: ultrafast meets ultrasensitive

Melanie A. R. Reber,† Yuning Chen,† and Thomas K. Allison*
Stony Brook University, Stony Brook, New York 11794-3400, USA
**Corresponding author: thomas.allison@stonybrook.edu*

Received 3 December 2015; revised 20 January 2016; accepted 7 February 2016 (Doc. ID 255049); published 17 March 2016

ARTICLES

nature physics

PUBLISHED ONLINE: 20 MAY 2012 | DOI: 10.1038/NPHYS2320

Probing an ultracold-atom crystal with matter waves

Bryce Gadway, Daniel Pertot†, Jeremy Reeves and Dominik Schneble*

PRL **114**, 043002 (2015) PHYSICAL REVIEW LETTERS week ending 30 JANUARY 2015

Laser Cooling without Spontaneous Emission

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