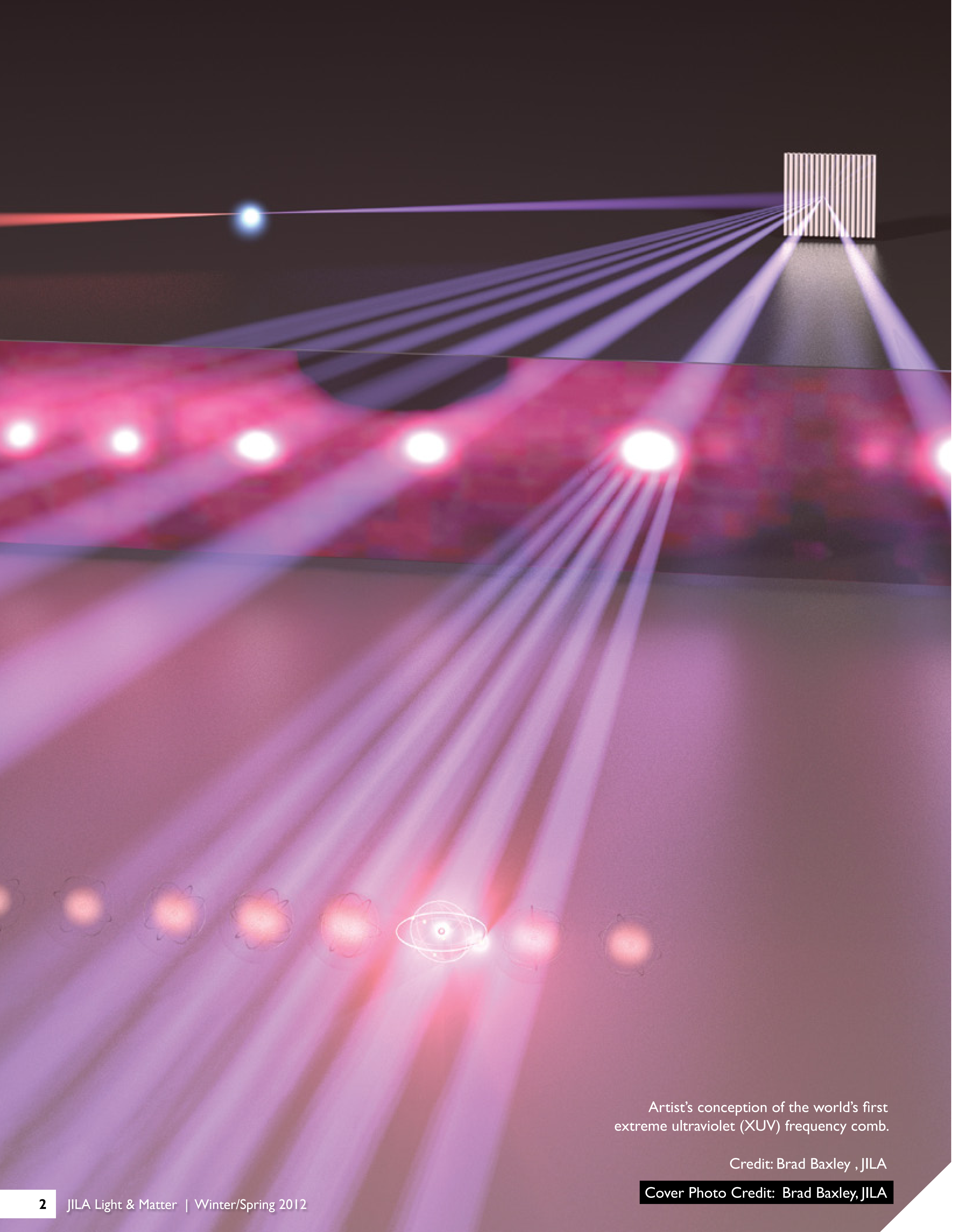
JILA Light & Matter

Winter/Spring 2012

X-WING



Artist's conception of the world's first extreme ultraviolet (XUV) frequency comb.

Credit: Brad Baxley , JILA

Cover Photo Credit: Brad Baxley, JILA

The Indomitable Ruler of Light

The Ye group has created the world's first "ruler of light" in the extreme ultraviolet (XUV). The new ruler is also known more formally as the XUV frequency comb. The comb consists of hundreds of equally spaced "colors" that function in precision measurement like the tics on an ordinary ruler. The amazing thing about this ruler is that XUV colors have such short wavelengths they aren't even visible to the human eye. The wavelengths of the XUV colors range from about 120 nm to about 50 nm — far shorter than the shortest visible light at 400 nm. "Seeing" the colors in the XUV ruler requires special instruments in the laboratory. With these instruments, the new ruler is opening up whole new vistas of research.

Recently, the Ye group used the XUV ruler to precisely measure very short-wavelength electronic transitions between different quantum states in argon and neon atoms. This experiment confirmed the presence of the XUV comb. It has also opened the door to exploring the internal quantum states of many different atoms and molecules. With the XUV ruler, scientists will be able to look at exactly how electrons arrange themselves in high-energy states inside molecules. The new ruler may also make it possible to develop new clocks based on the behavior of the nuclei of atoms. The team responsible for these exciting prospects includes research associates Arman Cingöz and Tom Allison, graduate student Dylan Yost, Fellow Jun Ye, and their colleagues from IMRA, America who provided the infrared laser used to make the XUV comb.

The creation of the XUV comb was a major milestone in the goal of designing frequency combs that span the entire electromagnetic spectrum. The invention of the XUV comb's famous cousin, the optical frequency comb, earned its creators a Nobel Prize. The optical frequency comb is a stable pulsed laser that can create millions of equally spaced colors of visible light.

Unfortunately, it's impossible to build a pulsed XUV laser stable enough to be a frequency comb. To make an XUV comb, the scientists had to come up with a method to transfer visible or infrared comb lines up to XUV frequencies without losing the delicate and coherent comb structure. The Ye group has done just that.

In a nutshell, here's how it works. First, the Ye group commissioned the high-power infrared ytterbium-fiber frequency comb developed by their collaborators at IMRA, America. Second, the researchers optically coupled the laser into an enhancement cavity that was carefully engineered to add laser pulses constructively. After 200 round trips through the enhancement cavity, the original laser pulse still had the same coherent structure, but it had reached a high enough intensity to initiate high-harmonic generation, or HHG. HHG is a process that results in the emission of high-frequency photons, or harmonics, of the original pulse.

Finally, the Ye group fed atoms of xenon or krypton into the cavity at the point where the light was most intense, setting the stage for high-harmonic generation to happen. The high-intensity electric field inside the cavity first stripped the outer electrons from the atoms, then shoved them back in the atoms, where they recombined. The recombined electrons emitted excess energy from this violent process as photons of light with XUV frequencies.

The researchers detected multiple high harmonics from HHG with both xenon and krypton. By looking at the spots of light associated with each harmonic, they were able to show that each burst of the high-frequency XUV light had a fine comb structure! They verified this finding by performing spectroscopy with the XUV combs inside the 13th and 17th harmonic light speckles. The researchers detected (for the first time ever) high-resolution signals from high-frequency electronic transitions in both argon and neon.

With this accomplishment, the Ye group now wants to make precision measurements of the quantum states of helium atoms as well as other exotic atoms and molecules. One of the group's first goals is to experimentally test new theories of the internal structure of simple atoms. And, future research prospects are rich and varied. The new XUV ruler has opened up a whole new landscape that can be "combed" for hidden treasures. — Julie Phillips

References

Arman Cingöz, Dylan C. Yost, Thomas K. Allison, Axel Ruehl, Martin E. Fermann, Ingmar Hartl, and Jun Ye, *Nature* **482**, 68–71 (2012).

T. K. Allison, A. Cingöz, D. C. Yost, and J. Ye, *Physical Review Letters* **107**, 183093 (2011).

Schrödinger Cats Light the Way

We can get valuable information about a material by studying how it responds to light. But up to now, researchers have been forced to ignore how some of light's stranger quantum behavior, such as being in a superposition of one or more intensity states, affects these measurements. New research from the Cundiff group (with newly minted Ph.D. Ryan Smith and graduate student Andy Hunter) has shown that it is possible to back-calculate how a semiconductor responds to light's quantum features even though we can't directly create light with those features. This work was built upon theory developed by collaborators at the Philipps-Universität Marburg in Germany. The resulting new method of "quantum spectroscopy" opens the door to a deeper understanding of semiconductor properties.

Spectroscopy is a time-tested method for investigating the properties of materials such as semiconductors. Researchers shine a laser on a sample and see what happens. They infer information about the material from these observations. This process is similar to deducing information about a piece of window glass by looking at the transmitted sunlight on the other side.

In the laboratory, scientists can vary aspects of the probe laser such as its color and intensity or how long it shines on the sample. But there is more to light than these familiar wave-like properties. A beam of light can also be seen as a stream of particles called photons, which have hidden — and often strange — quantum mechanical properties. For instance, we do not yet have the technological capability to look inside light and see superpositions of different intensities. And accurate theoretical predictions are challenging in complicated systems like semiconductors. Consequently, researchers have remained in the dark about how these properties of light might affect spectroscopy experiments.

To illuminate the effects of light's quantum features, Cundiff and his colleagues have been working on developing a new type of spectroscopy. Since they can't tune a laser to emit light with particular quantum properties, they instead measure a sample's response as the light intensity from a typical laser is varied. Using this information and theory developed by the group at Philipps-Universität Marburg, they back-calculate how the system would respond if they had manipulated the quantum nature of the light in what is called a "Schrödinger Cat" state.

This technique works because light in a Schrödinger Cat state can be mathematically reconstructed by adding together two different intensities of normal laser light. But, here's where the quantum weirdness comes in: If we could make a detector that could measure the intensity of Schrödinger Cat light, it either would measure one or the other of two intensities, but not something in between. Like the mythical cat of the same name (which is simultaneously both "alive" and "dead" until you open the box), Schrödinger Cat light has two intensities simultaneously. Even though they can't yet make such light in the lab, the Cundiff team was able to reconstruct the effects of Schrödinger Cat light on the sample by adding together the effects of the regular laser light intensities that make up cat light.

Naturally, the response of a material to light's quantum behavior isn't straightforward: it only shows up as higher-order "wiggles" in the material's absorption that are only visible when the light is intense enough. It's like hitting a piano key hard. If you bang on the key, you not only hear that note, but also several other higher tones set off by the hammer. These overtones are called higher harmonics.

The Cundiff group "listened" for those higher harmonics in the absorption of the semiconductor. To see them, the researchers hit a sample of a gallium-arsenide (GaAs) semiconductor with laser pulses of varying high intensities and correlated the laser intensity with resulting changes in the sample's absorption of a probe laser pulse.

"That's not particularly new," Cundiff says. "People have been doing this forever." "The key thing is that we did it carefully." Adding together the results of careful measurements allowed the researchers to then reconstruct the response of the sample to Schrödinger Cat light.

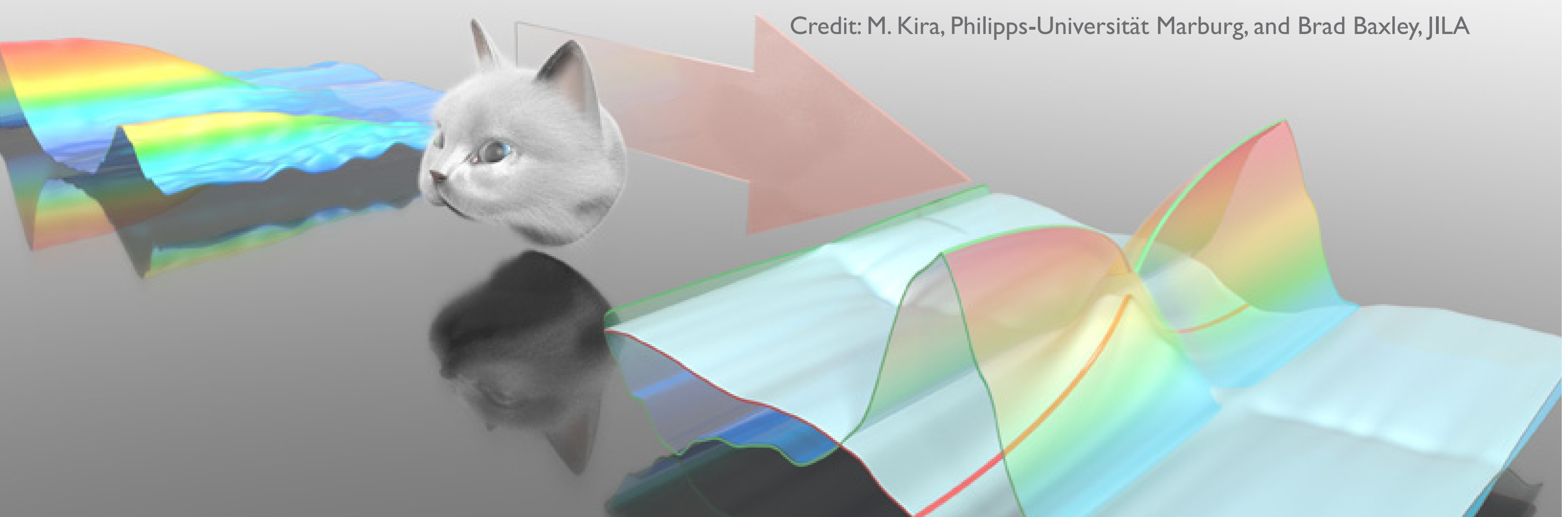
This work is particularly exciting because it shows that light's quantum features are important in how a material responds to light. And, the method suggests a way to apply this quantum-optical spectroscopy in a variety of complex materials. The understanding gained from these experiments could lead to customized optoelectronics devices such as semiconductor lasers.
— Stephanie Chasteen

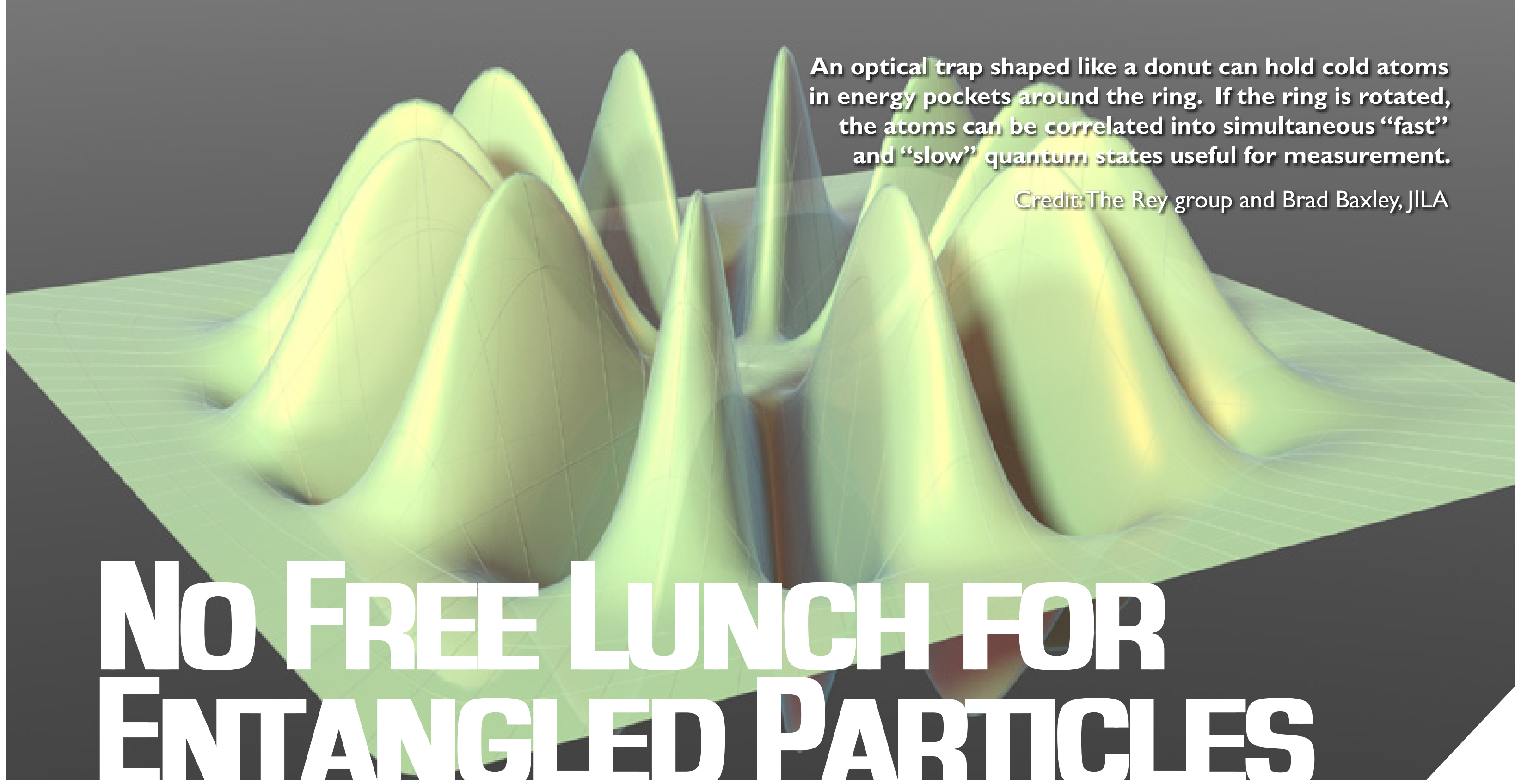
Reference

M. Kira, S.W. Koch, R. P. Smith, A. E. Hunter, & S.T. Cundiff, *Nature Physics* **7**, 799–804 (2011).

From the response of the material to normal laser light (left), the effects due to a Schrödinger Cat state can be calculated (right).

Credit: M. Kira, Philipps-Universität Marburg, and Brad Baxley, JILA





An optical trap shaped like a donut can hold cold atoms in energy pockets around the ring. If the ring is rotated, the atoms can be correlated into simultaneous "fast" and "slow" quantum states useful for measurement.

Credit: The Rey group and Brad Baxley, JILA

No Free Lunch for Entangled Particles

Incredibly sensitive measurements can be made using particles that are correlated in a special way (called entanglement.) Entanglement is one of the spooky properties of quantum mechanics in which two particles interact and retain a connection, even if separated by huge distances. If you do something to one of the particles, its linked partners will also respond.

However, entangled quantum states are notoriously fragile. This fragility is an inherent part of their nature. Even so, a recent publication suggested an experimental setup using atoms trapped in a rotating ring of laser light as a way to create entangled particles that are protected from destruction. Unfortunately, new work by Fellow Ana M. Rey (with Andreas Nunnenkamp of Yale University and Keith Burnett of the University of Sheffield) shows that this work doesn't hold water when you consider what is actually possible in the lab. Rey and her colleagues have helped experimentalists avoid fruitless attempts to use the rotating-ring assembly to produce stable entangled particles.

The fragility of entangled particles makes it a challenge to use them in quantum measurement. Physicists often use beams of "normal" non-entangled particles — of light or matter — to precisely measure various physical properties. However, such measurements can be made even more precise by using particles with the quantum properties of entanglement and superposition. Superposition is a state in which a particle holds two different properties — such as red and blue, or spin-up and spin-down, at the same time. Once particles in a superposition state are entangled with one another, it's possible to obtain much more information by measuring a whole group of correlated particles than by measuring any single particle.

Unfortunately, measuring entangled superposition states can destroy them. Because the particles are linked together, if you measure one particle (to determine if it is red or blue, for example), the other one "knows." This knowing causes the particles to lose their entanglement and superposition; in other words, they become normal independent particles with a single property (i.e., one is red, the other blue).

One way for an entangled state to be more robust is if there is a big step in energy between the entangled state and the rest of the world. With such a large energy gap, little nudges to the entangled state are less likely to destroy it. But there's a problem here, too: The more particles in the entangled state, the smaller the protective energy gap. Thus, the challenge is to find a way to make entangled states with enough particles to be useful, but with an energy gap sufficiently wide to protect it from destruction.

One common way to make entangled states is to place atoms in an optical trap shaped like a donut, or toroid. Atoms are trapped at certain locations within that toroid by a criss-crossing pattern of laser beams that create comfortable resting places for the atoms, as shown in the figure. If the optical trap is then rotated, the atoms naturally rotate along. However, because of the strange nature of quantum mechanics, the atoms can only rotate with certain restricted rotational speeds. If the toroid is rotated at a particular speed that is forbidden to the atoms, then the atoms will try to rotate both with a speed that is lower than that speed and a speed that is higher than that speed. Now the atoms are in a superposition of fast and slow.

As these fast/slow atoms bump into one another, they start to act in sync, achieving the coveted — but delicate — state of entanglement called a "cat state." In a cat state, all the particles are in two diametrically opposed states, such as fast and slow, at the same time. However, cat states — like other entangled states — are extremely fragile; the more atoms in the ring, the smaller the protective energy gap. For this reason, only a few atoms can be put into a cat state at once.

Recently, a researcher in New Zealand claimed to have found a way around this problem by placing a tiny bump-like barrier in the donut somewhere. This barrier is a repulsive point where the atoms can't go. If the bump is so thin that it has zero width, the protective energy gap of the cat states supposedly increases as the number of particles increases. However, Rey and her colleagues realized that this mathematical result is physically unrealistic.

It's simply not possible to create a barrier that is truly infinitesimally thin. When Rey and her colleagues redid the New Zealand team's calculations using a barrier of measureable (but very thin) width, they found the same thing that they had always found: Once the particles are in a cat state, the protective energy gap dwindles quickly as more particles are added to the system. In fact, experimentalists may be hard-pressed to create entangled cat states with more than about six particles. This limitation poses a challenge for the use of cat states in precision quantum measurement.
— Stephanie Chasteen

Reference

A. Nunnenkamp, A. M. Rey, and K. Burnett, *Physical Review A* **84**, 053604 (2011).

X-Wing Story

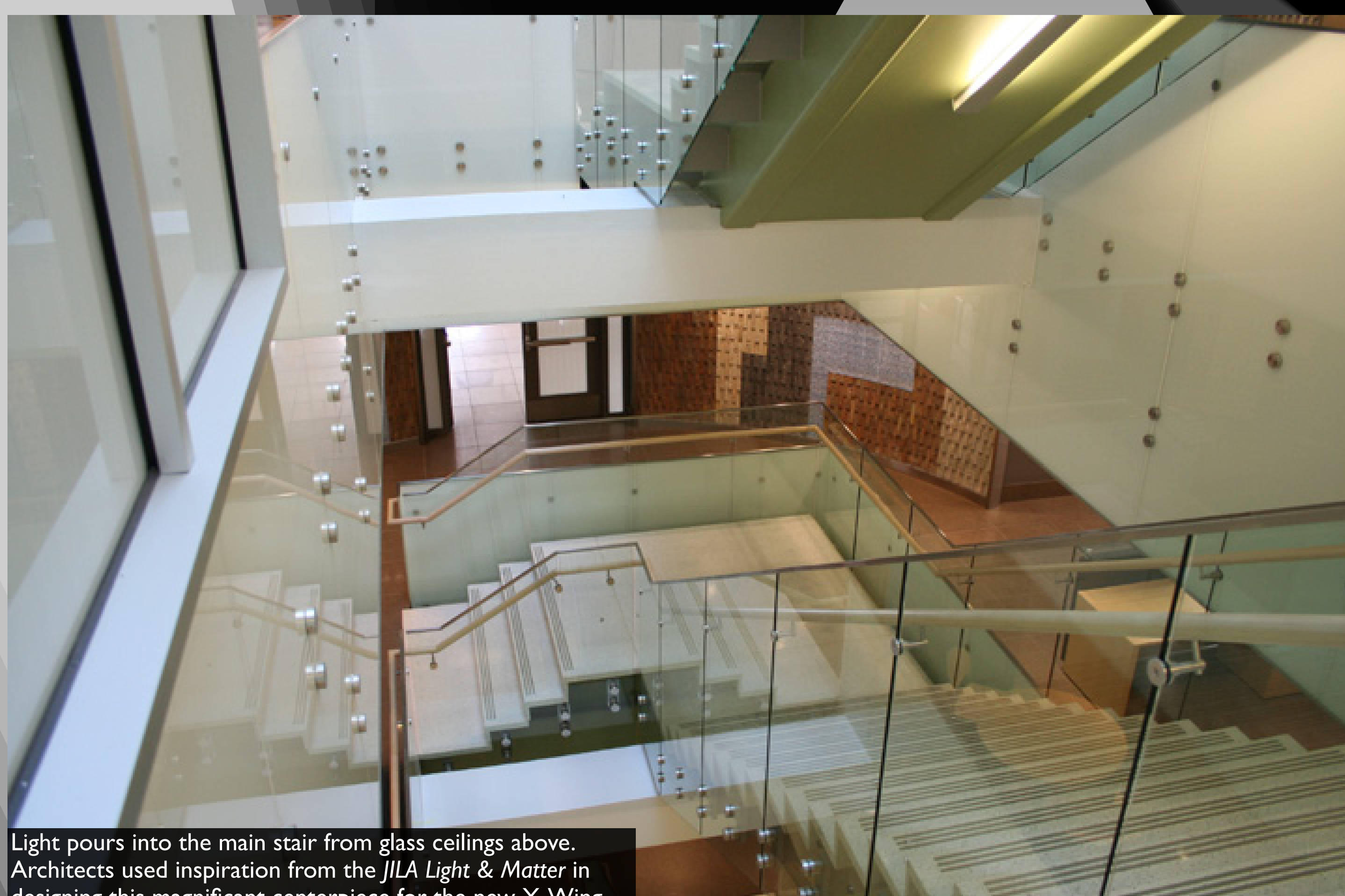
Photo Credits: Brad Baxley

It once was a hole...

Construction reaches S-Wing 2nd floor!

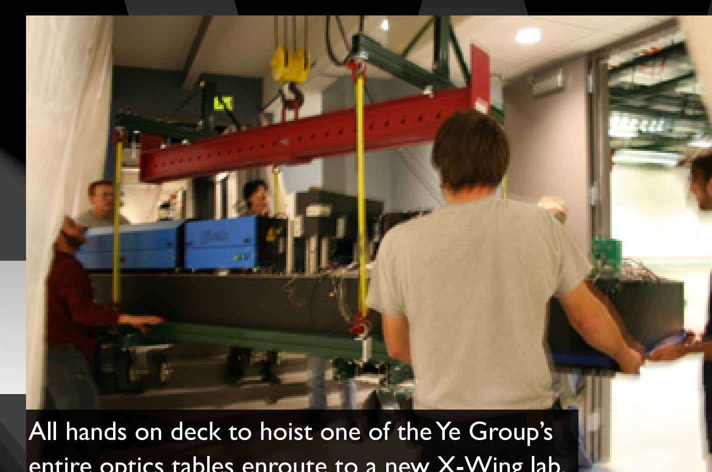
Everyone gets a peak at what's been going on...very interesting stuff.

Up, up, and we have a building!



Light pours into the main stair from glass ceilings above. Architects used inspiration from the *JILA Light & Matter* in designing this magnificant centerpiece for the new X-Wing.

Noah Fitch of the Lewandowski Group and Hans Green from the Instrument Shop install delicate apparatus in a new X-Wing lab.



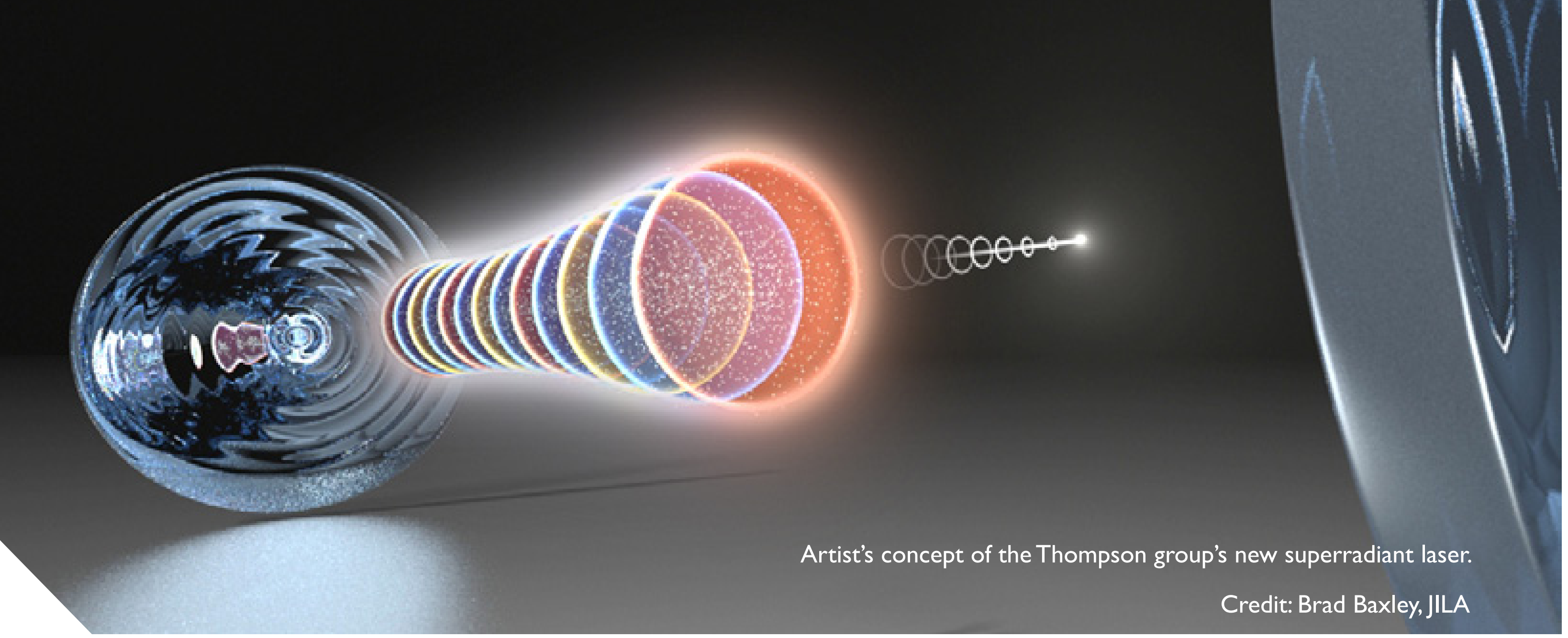
All hands on deck to hoist one of the Ye Group's entire optics tables enroute to a new X-Wing lab.

Unpacking a new lab.

First event in the new X-Wing: All JILA Lunch on March 21, 2012, Rm X325.

José, Yujun, and Jia of the Greene group enjoy the new common space in the X-Wing.

The Laser with Perfect Pitch



Artist's concept of the Thompson group's new superradiant laser.

Credit: Brad Baxley, JILA

The Thompson group, with theory help from the Holland group, recently demonstrated a superradiant laser that escapes the "echo chamber" problem that limits the best lasers. To understand this problem, imagine an opera singer practicing in an echo chamber. The singer hears his own voice echo from the walls of the room. He constantly adjusts his pitch to match that of his echo from some time before. But, if the walls of the room vibrate, then the singer's echo will be shifted in pitch after bouncing off of the walls. As a result, if the singer initially started singing an A, he may eventually end up singing a B flat, or a G sharp, or any other random note — spoiling a perfectly good night at the opera.

In a laser, there is an entire choir composed of atoms that don't sing, but instead emit light. The atoms in the laser also "hear" and adjust their pitch to match their own echo that comes from the emitted light reflected back to them by the laser mirrors surrounding the atoms. Even if the laser is placed in the quietest room imaginable, the mirrors will still vibrate because atoms simply can't hold completely still. As a result, a normal laser's pitch, or frequency, will wander around — spoiling a perfectly good night at the lab.

The new superradiant laser avoids the echo chamber distortions because emitted light quickly leaks out of its mirrors much faster than the choir of atoms loses track of the note it is singing. But, there is more involved in building a laser with nearly perfect pitch. For instance, it's critical to avoid bad singers. To accomplish this, the Thompson group hired a pretty talented choir composed of a million laser-cooled and trapped rubidium atoms.

Because of its talented choir and its much smaller echo, the new laser's pitch is ten thousand times less likely to be altered by rippling mirrors than is the pitch in a normal laser. As a result, its pitch is a hundred times sharper than the best normal lasers. The new laser was built by Fellow James Thompson and graduate students Justin Bohnet, Zilong Chen, and Josh Weiner. Former postdoctoral researcher Dominic Meiser of the Holland group provided theory support.

Naturally, there are tradeoffs for getting perfect pitch. The leaky mirrors mean that the laser operates in a strange regime where an average of less than one photon of light bounces between the mirrors. This small amount of light acts like a very weak telephone line between the atoms, allowing them to agree to sing the same note.

The atoms are trapped in stacks of 5000 by a one-dimensional crystal of light. Not only do the atoms in each crystal sing the same note, but they also sing in just the right way. Consequently, the rate at which the light is emitted increases as the square of the number of atoms, making the laser much brighter.

A similar effect can occur when crickets start chirping. At first, the crickets seem to chirp at random. But, if the chirping keeps on, pretty soon the crickets get synchronized. In the laser, not only do the atoms chirp at the same time, but they also chirp in the same direction (a feature that is very handy in a laser). When all the crickets get synchronized, the loudness of the chirping increases as the square of the number of crickets — just like the light emitted by atoms in a superradiant laser.

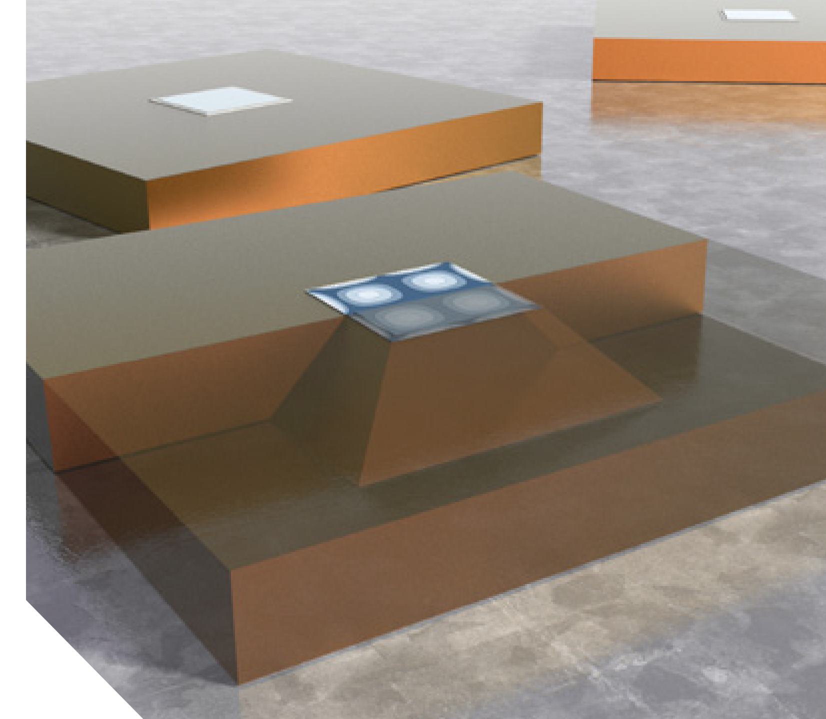
In the laser, entire chains of atoms inside each light crystal go back and forth in unison between being in an excited state and a calm (ground) state. And, because at least one photon is communicating between the crystals, all the stacks of atoms soon oscillate in unison. As soon as all the atoms inside the laser are moving in sync, they form a "super spring." The super spring loses energy by emitting much "louder" laser light than would be possible if the atoms sang alone.

The new superradiant laser may lead to better atomic clocks, more precise distance measurements, and searches for new fundamental physics. For instance, with different atoms, it could be an optical atomic clock itself! In the future, superradiant lasers may be used to create rulers spanning the distance from the Earth to the Sun or to improve Fellow Jun Ye's strontium optical lattice clock by leaps and bounds. The invention of the new superradiant laser is a classic example of the great benefits of JILA's culture of collaboration.
— Julie Phillips and James Thompson

Reference

J. G. Bohnet, Z. Chen, J. M. Weiner, D. Meiser, M. J. Holland, and J. K. Thompson, *Nature* **484**, 78–81 (2012).

The Quantum Drum Song



Looking into one of the Regal group's tiny, two-layer drums. The drum's dampening pattern is shown on the surface.

Credit: Brad Baxley, JILA

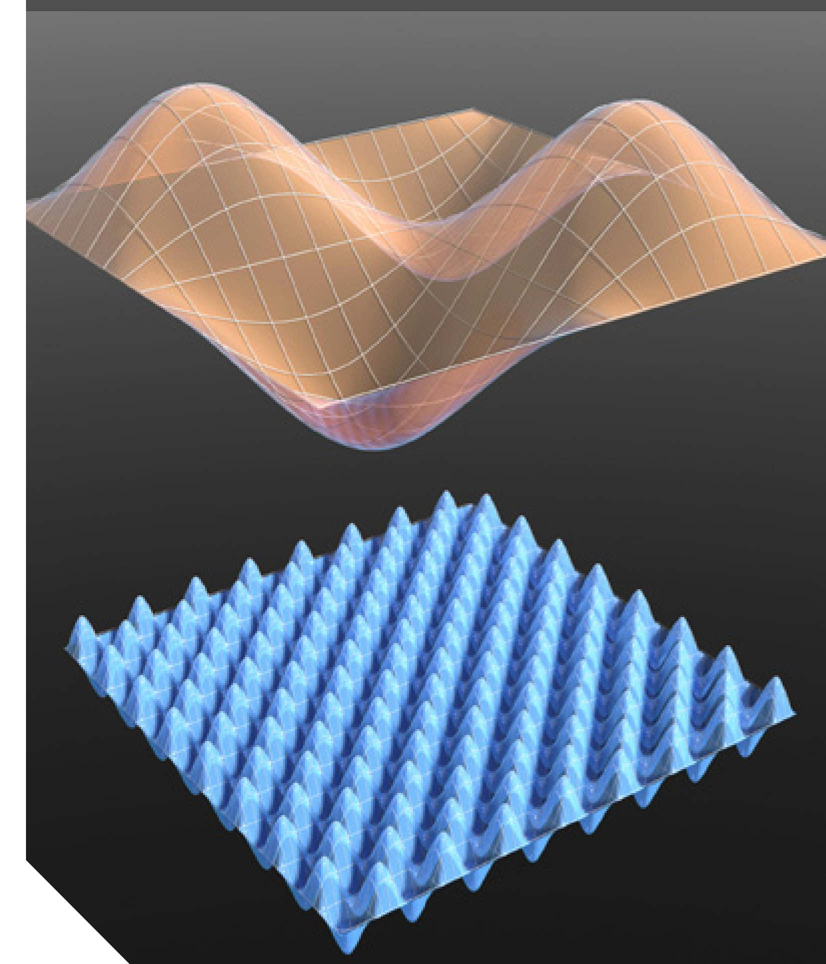
Fellows Konrad Lehnert and Cindy Regal are collaborating on an ambitious undertaking to explore the quantum behavior of tiny mechanical systems that are large enough to be visible to the naked eye (as opposed to systems exhibiting quantum behavior that are no bigger than a few tens of atoms). At the same time, they have been looking for ways to prolong vibrations in mechanical objects such as drums or strings. Prolonging vibrations makes it possible to laser cool objects to temperatures where it is possible to observe quantum mechanical motion.

The Regal lab has recently completed a set of experiments that increased its understanding of the properties of tiny drums that influence the lifetime of their vibrations. The group made and characterized a series of microscopic two-layer drums of aluminum metal and silicon nitride (Si_3N_4) that are 100 nm thick and approximately 1 mm long. The aluminum layer was important because it represents a class of materials that offers some advantages for use in tiny drums, but which are also "bad materials" in the sense they often suppress vibrations. The studies were conducted by graduate student Pen-Li (Ben) Yu, research associate Tom Purdy, and Fellow Regal.

At first, the researchers observed that layering aluminum metal on a Si_3N_4 membrane made drum vibrations disappear more quickly. This effect was not unexpected. However, it opened the door to discovering exactly how the vibrations were disappearing for different vibrational patterns.

Many tiny mechanical objects vibrate like bridges, but the Si_3N_4 membranes studied by Yu and his colleagues pulsate more like drums. So, the researchers modeled the vibrations and their disappearance for drums. The model showed that the behavior of the vibrating drum at its very edge (only a thousandth of a millimeter wide) was responsible for most of the rapid demise of the drum's vibrations. The researchers were able to modify their two-layer drum to prove that the vibration near the very edge was the culprit. They applied aluminum metal to most of the center of a square Si_3N_4 drum, but left a very narrow strip around the edge uncovered.

The newly designed drum's vibrations lasted just as long at room temperature as did those of a simple one-layer Si_3N_4 drum. The success of this design raises the prospect of using patterned-metal drums to circumvent the problems inherent in using bad materials. The researchers learned enough from crafting their quantum drum to help them design advanced hybrid drums for future investigations.



Two different vibrational patterns in a two-layer drum with silicon nitride on the bottom and aluminum metal on the top. Both patterns exhibit effects in a very narrow strip at the edge of the drum that cause vibrations to rapidly disappear.

Credit: Pen-Li Yu & Brad Baxley, JILA

Reference

P.–L. Yu, T. P. Purdy, and C. A. Regal, *Physical Review Letters* **108**, 083603 (2012).

Simulating a Starquake

Stars die dramatically – the light from the supernova explosion of a distant massive star can outshine an entire galaxy. But this event isn't the endgame for the star — the dense remnants (called neutron stars) of some of these explosions can spit out light rays over thousands of years.

Astronomers have noticed that some neutron stars emit bursts of high-energy light (x-rays and gamma-rays) at puzzlingly irregular intervals. Recently, Fellow Rosalba Perna and her colleague Jose Pons at the Universitat d'Alacant, performed calculations that may help dispel the mystery. They started with the fact that some neutron stars have very strong magnetic fields — the strongest known to humans. They are dubbed magnetars. Perna and Pons were able to connect the magnetic field strength and geometry in magnetars to stellar shake-ups known as starquakes. Starquakes are responsible for the resulting bursts of light rays from neutron stars.

Neutron stars are hot and dense. The inside of a neutron star consists of a liquid soup of free-floating subatomic particles, but its cooler outer surface forms a solid crust. This crust can crack under strain during a starquake. These starquakes occur when internal magnetic fields, which shift and rearrange themselves over time, overcome the strength of the crust, and the crust cracks. The crust then rearranges itself into a more stable position.

This process has an analogy on Earth, where the buildup of energy due to shifting plates and faults beneath the surface is released through earthquakes. On a neutron star, the resulting release of magnetic energy shakes the particles in its atmosphere, creating bursts of light. Thus, the high-energy light emitted by a magnetar is believed to occur during starquakes when the crust of the neutron star cracks.

However, many questions about these bursts of light are still unanswered: What controls the seemingly random frequency of these light-ray bursts? Why do some neutron stars display bursts, while others with similar magnetic fields do not?

"So the question was, OK, if the magnetic field is responsible for everything, then how is it that we can still have this variety of behaviors among different objects?" said Perna.

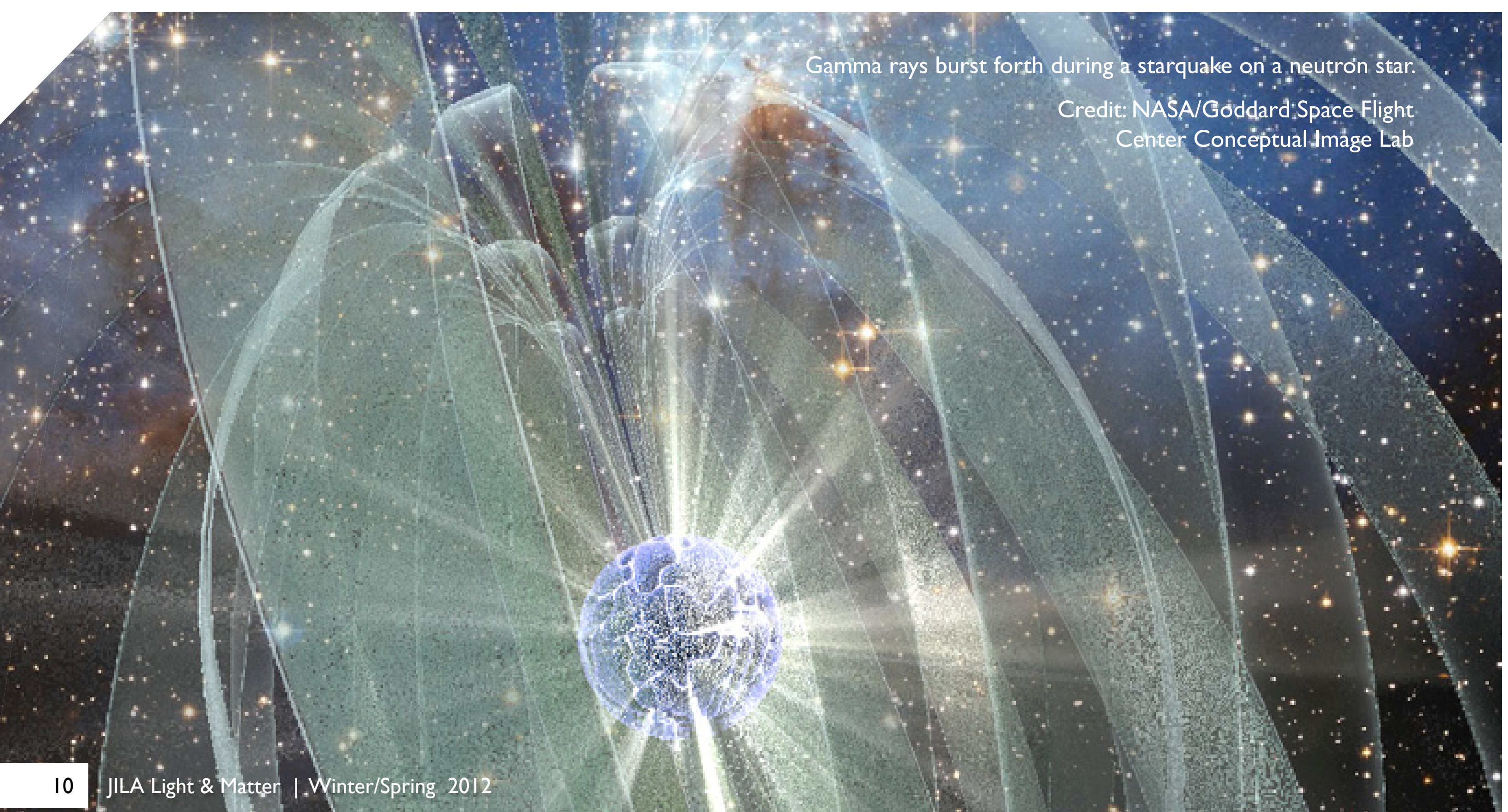
Perna and Pons used numerical simulations of the magnetic field in the crust of a magnetar to see both how the magnetic field changes over time and when the stresses due to the magnetic field result in a starquake and a light burst. Their model took into account not just the overall strength of the magnetic field, but its geometry, or how it is oriented throughout space. After setting such parameters of the simulation as the initial temperature and the magnetic field of the magnetar, they used their code to calculate the new magnetic fields at regular intervals during the life of the hypothetical magnetar over a period of up to 100,000 years. Every time the magnetic stresses were sufficient to break the crust, a starquake was predicted.

"What we found was that younger magnetars tend to be more active, and older magnetars tend to be less active," said Perna, adding that starquakes typically occur more often in younger objects, where they also release more energy. For both older and younger magnetars, the occurrence of starquakes is not simply related to the strength of the magnetic field, however. The geometry of the magnetic field also plays a very important role. The results of Perna's and Pons' simulations match some key observations such as the fact that astronomers have documented fewer giant flares than smaller bursts and the occurrence of bursts in neutron stars with relatively low magnetic fields.

Until now, researchers understood many of the details of how gamma and x-ray bursts occur. However, Perna and Pons have helped explain (1) why the bursts occur at seemingly irregular intervals, (2) why the same magnetar might behave differently at different times over its life span, and (3) why some objects with apparently similar magnetic fields have very different light-ray-bursting behavior. — Stephanie Chasteen

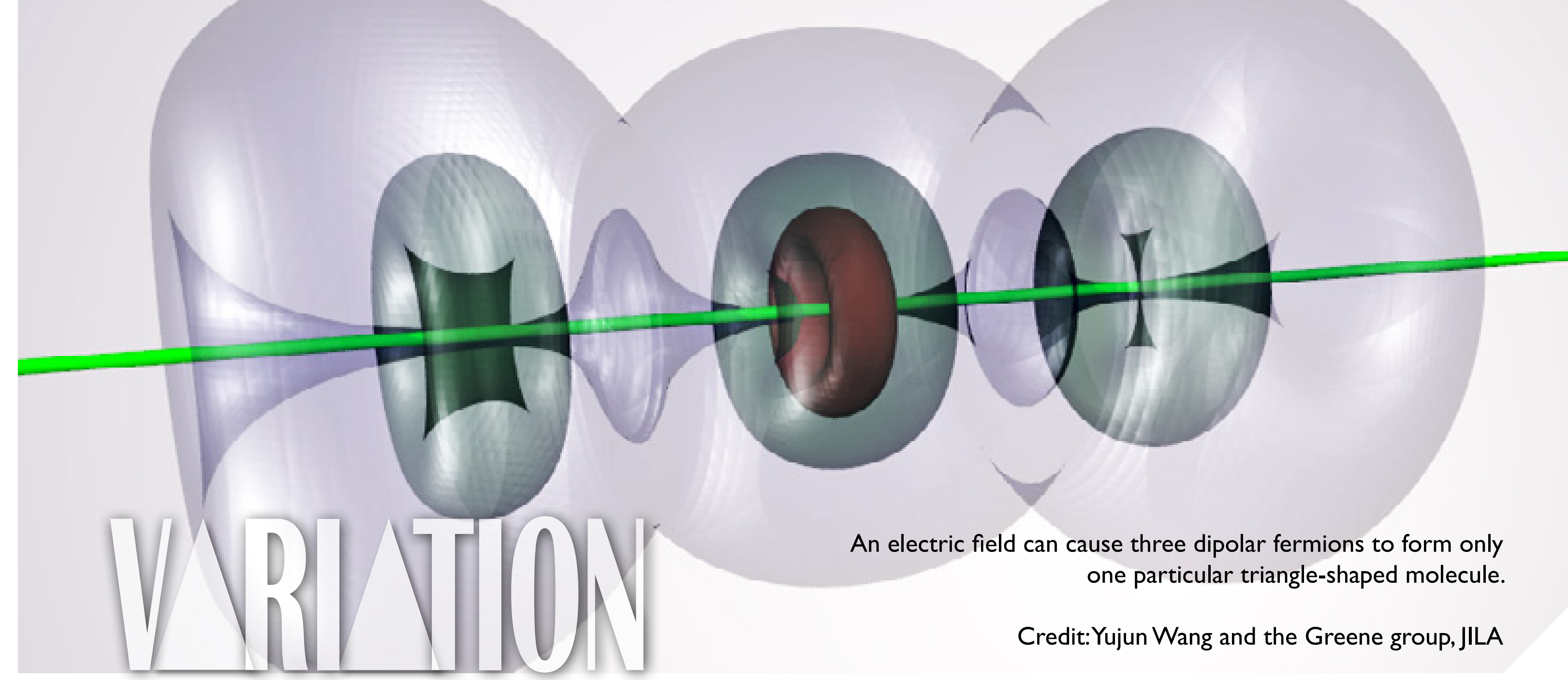
Reference

Jose A. Pons and Rosalba Perna, *The Astrophysical Journal* **741**, 123 (2011).



Gamma rays burst forth during a starquake on a neutron star.

Credit: NASA/Goddard Space Flight Center Conceptual Image Lab



An electric field can cause three dipolar fermions to form only one particular triangle-shaped molecule.

Credit: Yujun Wang and the Greene group, JILA

Variation of an Infinity of Triangles

The Greene group has just discovered some weird quantum states of ultracold fermions that are also dipoles. Dipoles are particles with small positively and negatively charged ends. Atoms (or molecules) that are fermions cannot occupy the same quantum state — unlike the neighborly bosons that readily occupy the same state and form Bose-Einstein condensates at ultracold temperatures. The new theoretical study was interesting because it explored what would happen to dipolar fermions under the same conditions that cause dipolar bosons to form an endless sea of three-atom molecules even though no two bosons ever form a molecule under these conditions!

The physics underlying the formation of the triatomic molecules is called Efimov physics after Russian theoretical physicist Vitaly Efimov, who predicted the strange states in 1970. The Greene group has made major contributions to the study of Efimov physics since the 1990s. The new study is the first to investigate what would happen to dipolar fermions under the same conditions that cause dipolar bosons to form triatomic Efimov molecules. The study was performed by research associate Yujun Wang, senior research associate Jose D'Incao, and Fellow Chris Greene.

What the researchers found was that three dipolar fermions should not form an Efimov state. However, as the attraction among the dipolar fermions reached the magic point where an Efimov state would have formed with bosons, the fermions formed only one kind of triangular molecule, the one shown in the picture. This picture appeared on the cover of *Physical Review Letters* the week ending with Dec. 2, 2011.

This triangular cluster always had the same shape — unlike a true Efimov state in which the three particles can have almost any configuration. However, as with the previously studied Efimov states, the attraction between the dipolar fermions could be completely controlled by changing the strength of the electric field around them. Interestingly, the ability to form the single triangular molecule by changing the electric field only worked for dipolar fermions. Nonpolar fermions didn't exhibit anything remotely resembling the Efimov effect.

Wang and his colleagues predict that fermions with stronger dipoles will lead to longer-lived bound states (molecules). Thus, their new results may be useful to experimentalists. The long lifetime makes it easier to manipulate the new triangular-shaped molecules in the laboratory.

The team also found that two dipolar fermions could form a bound state and create an even more stable molecule. This relatively long-lived particle could act as a sort of stabilizer in delicate experiments with ultracold gases. — Stephanie Chasteen

Reference

Yujun Wang, J. P. D'Incao, and Chris H. Greene, *Physical Review Letters* **107**, 233201 (2011).

HAPPY BIRTHDAY, JILA!
April 13, 2012

5th JILA CU-Boulder and NIST 1962 - 2012

Artwork: Kristin Conrad

Scientific Achievment Award

On January 25, 2012, JILA held a reception to honor the Ye group's Arman Cingöz, Dylan Yost, and Tom Allison. The young scientists received the JILA Scientific Achievement Award in recognition of their exceptional ideas that made possible the creation of the world's first frequency comb in the extreme ultraviolet (XUV). The three worked together to (1) scale up the power of the XUV comb, (2), understand plasma instabilities in their optical cavity, and (3) perform spectroscopy of atomic/molecular transitions using a single comb mode in the wavelength range of 50–100 nm. Jun Ye (l) is shown in the JILA grove with award winners Dylan Yost, Tom Allison, and Arman Cingöz.

As part of the celebration, Cingöz, Allison, and Yost were presented with cakes baked especially for the occasion; they shared them with staff members and other scientists.

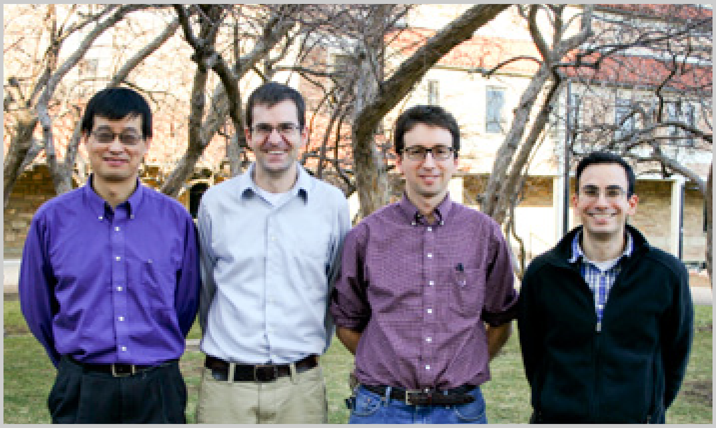


Photo Credits: Brad Baxley, JILA

Kudos to...

Blaine Horner for receiving the PRA Exemplary Contribution Award in recognition of his thoughtful, effective and sensitive leadership of JILA's Instrument Shop for twelve years.

Tracy Keep, Hans Green, and Todd Asnicar for receiving the PRA Exemplary Contribution Award for successfully managing an unusually complicated and intricate move of Ye group lab equipment into the new X-wing lab in January 2012. Their creative moving solutions benefitted multiple lab transitions into the X-wing.

Judah Levine for being selected for a 2011 Presidential Rank Award. He was recognized as a world leader in early applications of lasers for precision measurements; precision time and frequency measurements based on systems of atomic clocks, including the use of satellites for time and frequency distribution; and continual improvements of NIST network time services.

Melanie McKinney for receiving a JILA PRA Exemplary Contribution Award for (1) improving travel forms for JILA and OCG, (2) streamlining data entry for QPD Shops and Labor into the new Marketplace purchasing system, and (3) helping improve JILA administrative processes and volunteering for special JILA events.

Margaret Murnane for being awarded the prestigious RDS Irish Times Boyle Medal for her pioneering work in the field of ultrafast laser and x-ray science. The Medal is Ireland's premier science award and carries a cash prize of 20,000 Euros ($26,462).

Margaret Murnane for being appointed Chairman of the President's Committee on the National Medal of Science.

Jun Ye for being elected as a Director at Large of the Optical Society of America. He began his board service January 1, 2012.

Steve Cundiff and **Doug Johnson** for their contributions to the new X-Wing. Cundiff was instrumental in obtaining support and funding for the project, while Johnson worked to ensure that the building was functional and aesthetically pleasing. Both received custom-made crystal trophies.

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The editors do their best to track down recently published journal articles and great research photos and graphics. If you have an image or a recent paper you'd like to see featured in the newsletter, contact us at sro@jila.colorado.edu.

Please check out this issue of *JILA Light & Matter, Winter/Spring 2012* online at http://jila.colorado.edu/research/ where you can find supplemental multimedia that may be associated with the articles.

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