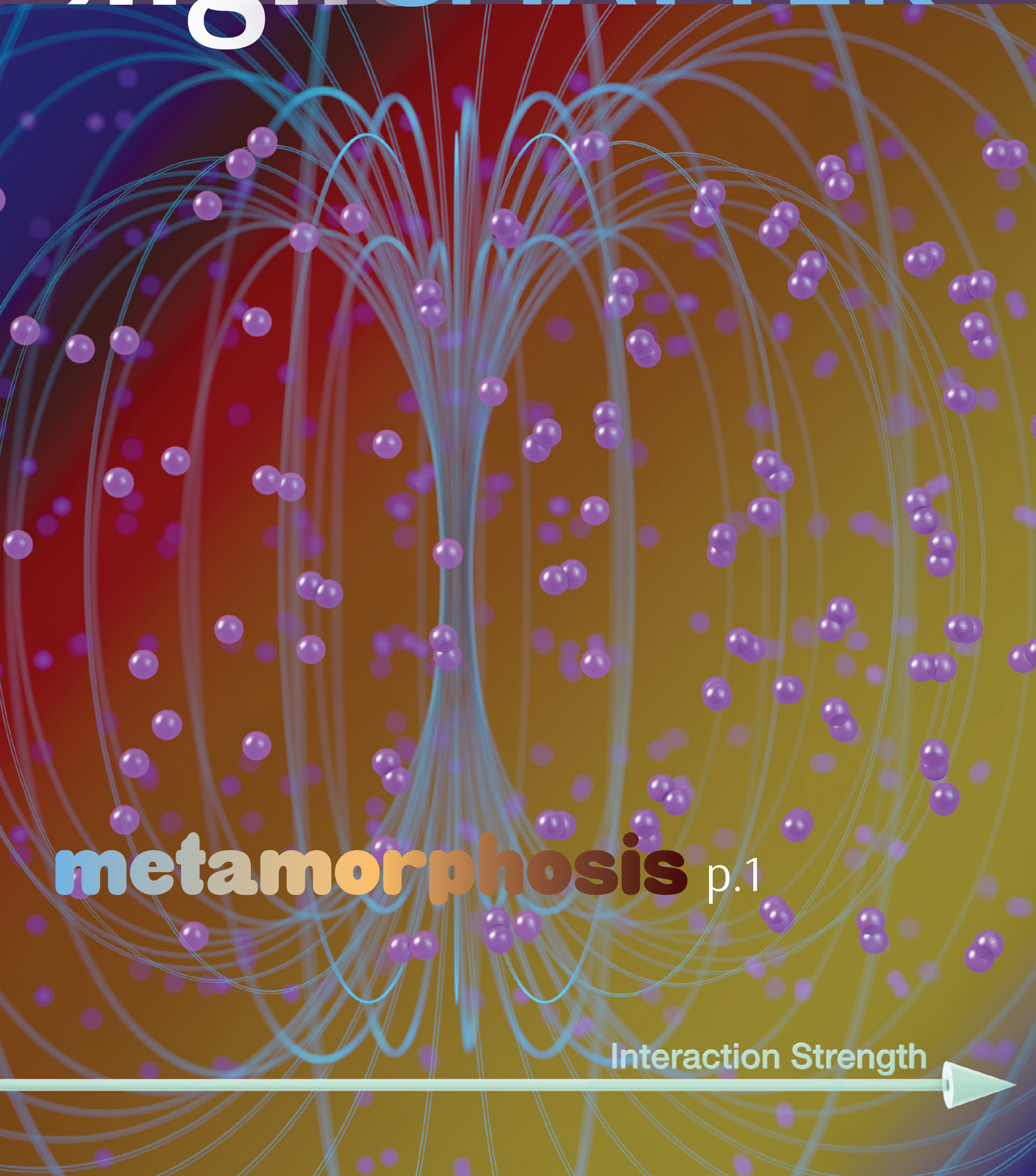
Summer 2015 | jila.colorado.edu

JILA light & MATTER



metamorphosis p.1

On June 23, JILAns participated in the annual summer hike along Boulder's Mesa Trail. The hike ended at the Chautauqua Dining Hall, where the hikers and their coworkers enjoyed breakfast outside on the porch. Credit: Julie Phillips

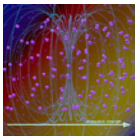
JILA Light & Matter is published quarterly by the Scientific Communications Office at JILA, a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology.

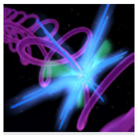
The editors do their best to track down recently published journal articles and great research photos and graphics. If you have an image or a recent paper that you'd like to see featured, contact us at: communications@jila.colorado.edu.

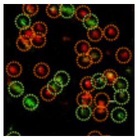
Please check out this issue of *JILA Light & Matter* online at https://jila.colorado.edu/publications/jila/light-matter.

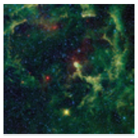
Kristin Conrad, Project Manager, Design & Production
Julie Phillips, Science Writer
Steven Burrows, Art & Photography
Gwen Dickinson, Editor

Stories


Metamorphosis 1


Every Generation Needs a New Revolution 3


Custom Made RNA 9


Multitalented Lyman-α 11

Features

I Say Hello, and You Say Goodbye 5
Puzzle: Spot the Differences 7
In the News 13
JILA Summer Fun Days 14
How Did They Get Here? 15
JILA Annual Photo 16

metamorphosis

A grand challenge of ultracold physics is figuring out how fermions become bosons. This is an important question because the tiniest quantum particles of matter are all fermions. However, these fermions can form larger chunks of matter, such as atoms and molecules, which can be either fermions or bosons.

An interesting feature of fermions and bosons is that they behave very differently at ultracold temperatures. Fermions prefer to go it alone, while bosons tend to hang out together. To learn more about the quantum processes that cause quantum particles to change their character so much, the Jin group investigated what happens to potassium atoms that are fermions when they become attracted to each other in an ultracold gas. The group included former research associate Yoav Sagi (Technion Israel Institute of Technology), newly minted Ph.D. Tara Drake, graduate students Rabin Paudel and Roman Chapurin as well as Fellow Deborah Jin.

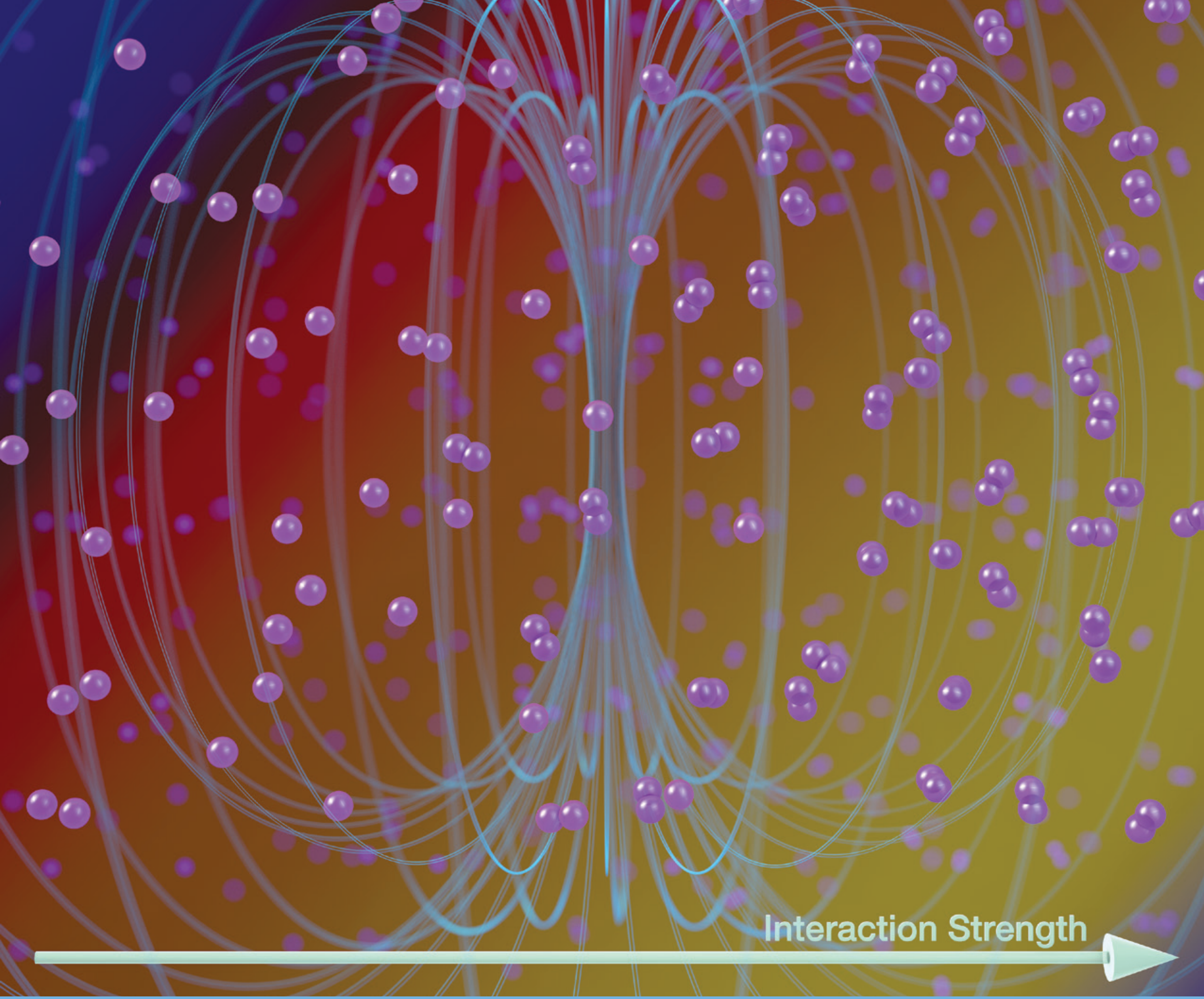
In the experiment, the researchers found that as they increased the attractions between the potassium atoms (fermions), atom pairs appeared that acted like bosons. The researchers also discovered an intriguing crossover, with fermions on one side and bosons on the other side. But in the crossover, the atoms behaved both like fermions and bosons. Since atoms and molecules can either be fermions or bosons, the Jin group's goal was to learn more about what happens in the crossover that changes fermions into bosons.

The bosons and fermions in this experiment were quantum particles with quite different behaviors at ultracold temperatures. Independent-minded fermions like the potassium atoms in this experiment never occupy the same quantum state because the laws of quantum mechanics don't allow it. At zero temperature (Kelvin), fermions occupy energy levels in a ladder-like fashion, with one fermion per energy state. In contrast, copycat bosons like the pairs of potassium atoms in this experiment can fall into the same low-energy state at zero temperature, forming a superatom, or Bose-Einstein condensate.

The trick to making the Jin group's experiment work was getting the potassium atoms to be strongly attracted to each other, which is something potassium atoms don't normally feel. Sagi and his colleagues encouraged them by making small changes in the magnetic field around a Feshbach resonance. A Feshbach resonance is a special magnetic field strength where small changes have dramatic effects on the interactions of atoms in an ultracold gas. With these interactions turned on, the individualistic potassium-atom fermions started to act more like bosons.

However, the transition from fermions to bosons didn't happen right away as happens at zero temperature, where even weak attractions immediately cause potassium atoms to pair up. In this experiment, even when the interactions between atoms were moderately strong, the atoms didn't form pairs at all. Instead they formed a Fermi liquid.

A Fermi liquid is like a single atom trying to make its way through a crowded party of atoms. As the atom moves along, other atoms stop to interact with it, slowing its progress. However, the self-reliant atom simply isn't drawn to any other atom strongly enough to form a pair, so it just keeps on moving along.

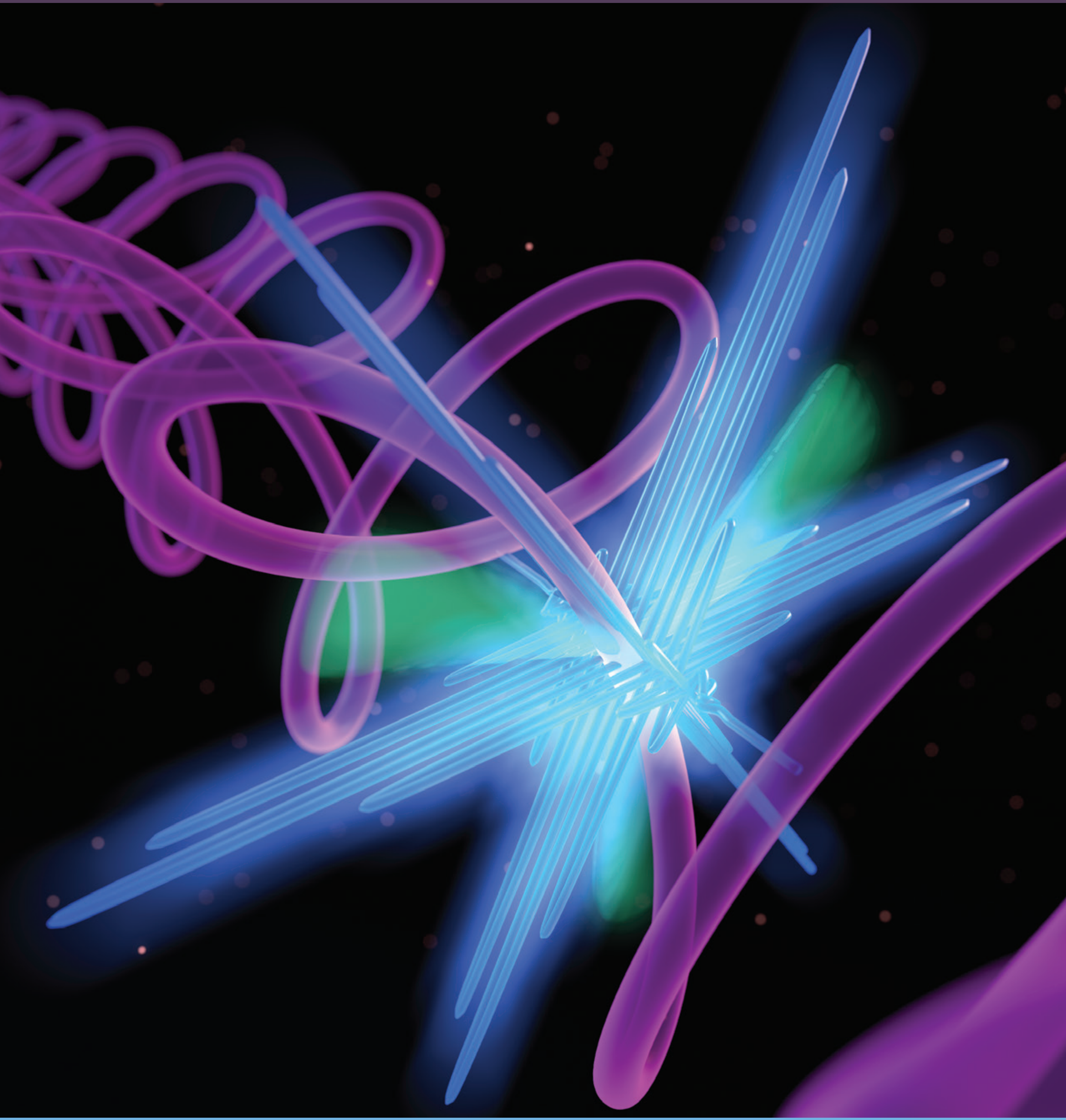


The Jin group discovered that an ultracold gas of potassium atoms with tunable interactions exhibits a crossover with potassium atoms that are fermions on one side of the crossover and potassium-atom pairs that are bosons on the other side. In the crossover, potassium atoms behave both like fermions and bosons! Credit: The Jin group and Steve Burrows, JILA

However, as the night goes on and the strength of the interactions increases, the atom eventually finds a partner to hang out with. And, when all of the potassium atoms find partners, the Fermi liquid disappears, leaving behind a gas of paired potassium atoms, which act like bosons.

However, since an ultracold gas isn't actually a party, there is still a lot more to learn about the details of how fermions become bosons. Understanding this process may shed light on superconductivity, a process that occurs when electrons (which are fermions) carry electricity with no losses.

Yoav Sagi, Tara E. Drake, Rabin Paudel, Roman Chapurin, and Deborah S. Jin, *Physical Review Letters* **114**, 075301 (2015).



Artist's conception of high-harmonic generation of extreme ultraviolet (EUV) beams, as shown on the cover of the May 1, 2015, issue of *Science*. Electrons (green) are ripped from noble gas atoms by a combination of circularly polarized red and blue femtosecond laser fields (purple). Some electrons recombine with their parent ions to generate intense flashes of circularly polarized x-rays (blue). Millions of atoms working together create the first bright circularly polarized EUV beam that can be used to study magnetic materials and molecules. Credit: The Kapteyn/Murnane group and Steve Burrows, JILA

Every Generation Needs A New Revolution

For decades after the invention of the red ruby laser in 1960, bright laser-like beams were confined to the infrared, visible, and ultraviolet region of the spectrum. Today there's an exciting revolution afoot: new coherent x-ray beams are now practical, including the extreme ultraviolet (EUV) beams gracing the cover of the May 1, 2015, special issue of *Science* honoring 2015 as the International Year of Light. The same issue features an article entitled "Beyond Crystallography: Diffractive Imaging Using Coherent X-ray Light Sources" that celebrates the revolutionary advances in both large- and small-scale coherent x-ray sources that are transforming imaging in the 21st century. The article's authors are JILA Fellow Margaret Murnane, Jianwei Miao (UCLA), Tetsuya Ishikawa (RIKEN, Japan), and Ian K. Robinson (University College London).

While all the new x-ray light sources are remarkable, tabletop high-harmonic generation pioneered at JILA by the Kapteyn/Murnane group is quite unique. Harnessing a new ability to manipulate the fastest motions of electrons using visible lasers, the K/M group has demonstrated exquisite control over all aspects of x-ray beams.

While all the new x-ray light sources are remarkable, tabletop high-harmonic generation (HHG) pioneered at JILA by the Kapteyn/Murnane group is quite unique. Harnessing a new ability to manipulate the fastest motions of electrons using visible lasers, the K/M group and its collaborators have demonstrated exquisite control over all aspects of x-ray beams, including what colors are emitted, how long the x-ray bursts last, their polarization, and even the direction that the x-ray beams emerge. What's more, by using the power of quantum mechanics, laser beams can tweak x-ray waves with sub-angstrom and sub-attosecond precision to generate x-ray beams that span the entire electromagnetic spectrum from the ultraviolet to the soft x-ray region. These HHG pulses produce bursts ranging from tens of attoseconds (10^{-18} s) to hundreds of femtoseconds (10^{-15} s).

In parallel with the emergence of the first bright laser-like x-ray beams, a new approach for microscopy called lensless coherent diffractive imaging (CDI) is making it possible to make stunning images of the nanoworld. This new approach is important because, until very recently, x-ray microscopes were severely limited by imperfections in x-ray optics. However, in a lensless microscope, a coherent laser beam illuminates an object, and the scattered light is collected on a detector. The image of the object is then recovered via application of a special set of mathematical rules known as an algorithm. This approach is opening up entire new research frontiers in physics, materials, and biology.

As the revolution in coherent x-ray light sources of all sizes continues, x-ray microscopes based on CDI will make it possible to make a real-time movie of the fastest events in the nanoworld. Stay tuned for exciting future developments.

Jianwei Miao, Tetsuya Ishikawa, Ian K. Robinson, and Margaret M. Murnane, *Science* **348,** 530–535 (2015). *Featured on cover.*

I Say Hello, and You Say Goodbye

Reception is JILA's Arrival and Departure Station

(Left to right) Hannah Raab (pre-law and sociology major at CU), Reception Supervisor Kim Monteleone, Hannah Nathanson (recent CU graduate in Psychology who will attend nursing school), Megha Sree Yadla (CU graduate student in electrical and computer engineering), Jessica Tooker (recent graduate in Business from CU-Boulder who will launch a career in event planning and hotel management), and Galit Weinfeld (CU-Boulder Dance major). Credit: Steve Burrows, JILA

JILA's five reception student workers provide a multitude of services. They greet new arrivals, sign them in, take their photograph, make mailboxes for them, introduce them to others, and help them find their new offices . They check out keys to the labs and staff offices. Plus, they assist people leaving JILA with a comprehensive checkout form, collect keys, and return key deposits.

"Reception is like the face of JILA, the human part," says Hannah Raab, who's studying pre-law and sociology at CU-Boulder. "We're like the main people to go to at JILA with a question because we can direct them to different resources."

"We're like traffic cops," adds Hannah Nathanson, who recently graduated from CU-Boulder with a degree in Psychology. She plans to start nursing school in the spring of 2016. "We figure out who's supposed to be where, and we greet people when they first come."

JILA's receptionists perform basic office work, including answering phones, sending faxes, distributing the stacks of mail that arrive every morning, as well as purchasing and setting out bagels and cream cheese every morning to help get everyone's day off to a healthy start.

However, JILA's bagel policy is one thing Raab would like to change. "I think it would be good to have a stricter bagel policy," she says. "There are many people who don't pay their bills for the bagels, and that means we don't have enough money to buy bagels for the people who do pay." It's not that much fun to be the local collection agency. Fortunately, receptionists are assigned many other fun and creative tasks, including helping with JILA's summer fun days and other special events.

"In the JILA Reception area, everyday someone will ask us: Can you do this? Can you do that?" Raab explains, adding that the students' job is to figure out how to make things happen. With summer fun days, for instance, they work with Chief of Staff Beth Kroger to plan what food will be at what event. Then they make sure that people know about the event.

"The day of the event, we have to make sure everything runs smoothly," Raab says. "Sometimes we go out and buy the food and bring it in. Then our job is to make sure that everybody is having a good time and that there's food, because snacks are really important at JILA."

There's an atmosphere of fun and camaraderie at JILA, according to Galit Weinfeld, a dance major at CU-Boulder. "Everyone's really friendly, and you can talk to everyone." The job Weinfeld likes best in Reception is using Illustrator to make posters and fancy signs, something she was able to learn while working at JILA.

For Jessica Tooker, a great part of the Reception job is her boss, Kim Monteleone. "Kim is really great. She is really interested in us and wants to be sure that everything is okay outside of work, too. She'll ask you about what you're doing for the weekend and how you're feeling. I know she cares about me as a person." Tooker is a recent graduate of CU-Boulder, with a major in Business. She recently began a new career in event planning and hotel management. She's crossing her fingers that she'll have a new boss as nice as Monteleone.

Such sentiments make Monteleone very happy. She's put a lot of effort into supervising the Reception students as part of her current job as Executive Assistant to the JILA Chair and to the Chief of Staff. Monteleone is an enthusiastic supporter of "her" students.

"I like young people a lot," she says. "I like their energy; I like watching them and seeing what makes them tick." Her philosophy is simple: She treats the reception students with respect and cares about them as people.

"I want them to always feel appreciated, so one of the things I decided to do in the beginning was to do everything with them," she explains. "I never wanted to order them around and say, 'Go set up for an event,' or 'Go change the chairs.' So I say, Let's go do this together."

"One thing I've learned from the students is that I wasn't giving them enough credit in the beginning for what they could do," Monteleone says. "No matter how high I set the bar, they achieve what I set out for them to do. I just love working with them."

Monteleone acknowledges that her own project-oriented approach to management (as opposed to assigning every individual task) has contributed to transforming the group of Reception students into a well-functioning team—all to the benefit of JILA.

"Lauren Mason (now a JILA Sponsored Project Specialist) was in on the beginning of the transformation of the Reception area at JILA," Monteleone remembers. "She took so much on. She'd say, 'What else can I do? How can I help you? How about if we revamp this? How about if we overhaul that?' And, I said, 'Perfect. Take it on.'" And, over time, something magical happened: The students began to love working at JILA, and, at the same time, made much greater contributions to the Institute.

This transformation was complete by the time Megha Sree Yadla started working in Reception at JILA in December of 2014. Yadla, JILA's first Reception graduate student (in electrical and computer engineering) says, "Basically, I love working here because of the environment and the people I'm working around. I think I have the best job with the best people. The day I got the job, I thought, 'Oh my God, I can't believe this. I kept telling my mom (in India) how much I like working here.'"

When Yadla returned from a visit in India she brought sweets her mother had made to share with people at JILA. It was her way of saying thanks to all of us for making her feel so welcome.

In fact, a sense of being welcome and at home in JILA is something the Reception students are proud to provide. They encourage everyone to not only ask for help, but also stop by and get acquainted. Anyone taking them up on this offer will be glad they did.

Erving Goffman Comes to JILA

Erving Goffman came to JILA on June 23, 2015. Goffman, a tortoise, is the much-loved pet of receptionist Hannah Raab. Raab named him after the late Canadian sociologist and writer Erving Goffman.

"Erving Goffman is one of my favorite sociologists because he has a theory of dramaturgy," said Raab, a pre-law and sociology student at CU-Boulder. "Basically, we have a front stage where we show people who we are, and that's why people look at us, and if you ask them to describe yourself, that's what they would say.

"But then, there's a back stage. And, that's who we are on the inside that we don't really show a lot of people. So, I thought that was sort of like a tortoise because they can have their arms and legs all the way out, and they're doing their thing way out in the open.

"And then, they step back into their shell, and pow! They hide like they're inside, like a rock. So, I thought about it, and Erving is just a good name for a tortoise. I like to say it's the dramaturticle (instead of dramaturgical) approach."

Erving Goffman the tortoise's visit to JILA was jam-packed with excitement. He hung out in reception most of the day and made a lot of new friends. He investigated the telephone and the computer keyboard, walked around, and hung out on Raab's lap.

Erving even went outside and walked around in the grass, where he got scared by a rabbit. He also had his picture taken for the *JILA Light & Matter*.

"He wasn't nervous or scared at JILA," Raab said. "He was just having a good day walking around and climbing up stuff." Raab said the nice thing about Erving is that he will live for more than 50 years, for most of the rest of her life.

Spot the Differences

There are 10 differences between the two photos of the JILA Instrument Shop's annual brat cookout. Either circle them on the photos or write them below. The first person to turn in a correct list to Kristin Conrad (S264) will win a $25 gift card.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

9. ______________________________

10. ______________________________

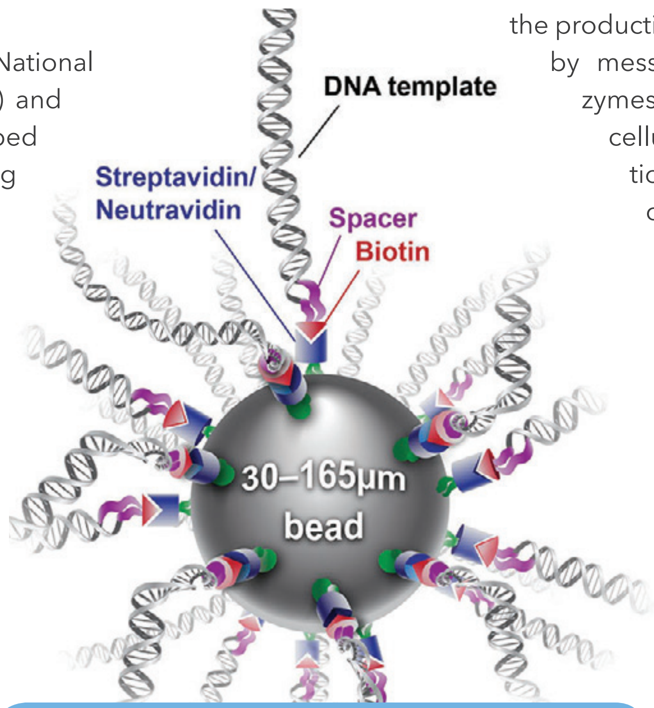
Congratulations to Erica Mady (Administration), winner of the $25 gift card for solving the Spring 2015 "Spot the Differences" puzzle.

CUSTOM MADE RNA

New method may lead to the regulation of gene expression, the development of new drugs, and improved prospects for gene therapy.

A wildly successful JILA (Nesbitt Group)-NIH collaboration is opening the door to studies of RNA behavior, including binding, folding, and other factors that affect structural changes of RNA from living organisms. Such structural changes determine RNA enzymatic functions, including the regulation of genetic information.

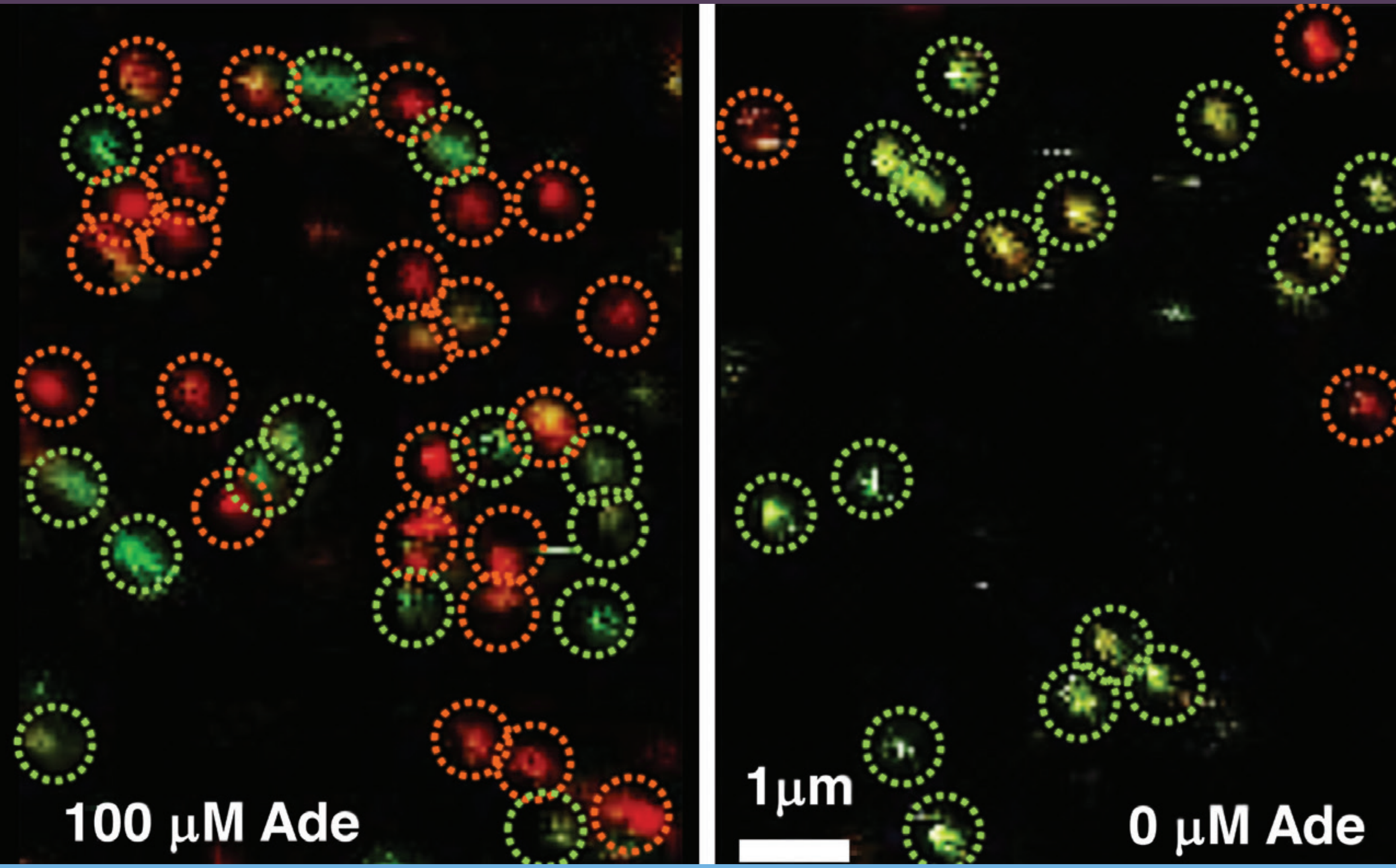
Yun-Xing Wang of the National Institutes of Health (NIH) and his collaborators developed a novel method for making small RNA strands consisting of dozens of structural units called nucleotides, and also precisely placed radioactive or fluorescent-dye labels in targeted locations along the RNA strand. Then Fellow David Nesbitt and recent JILA Ph.D. Erik Holmstrom used their lab's single-molecule Fluorescence Resonance Energy Transfer (smFRET) method to prove that Wang's innovative method for custom-making RNA worked as advertised



DNA templates made for custom-building RNA strands developed by National Institutes of Health researchers. The custom-built DNA templates are attached to polymer beads. Special enzymes called RNA polymerases use these DNA templates to produce custom-made RNA. Credit: Joseph Meyer, Scientific Publications, Graphics & Media, Leidos Biomedical Research, Inc.

Such studies are critically important in science and medicine. Small RNAs play key roles in the biochemistry inside cells. For example, inside a cell small RNAs called riboswitches regulate the production of proteins encoded by messenger RNA and ribozymes, which can catalyze cellular biochemical reactions. Other small RNAs called aptamers are currently under study for drug development, work many researchers hope will also improve the prospects for gene therapy.

Plus, the ability to custom-make strands of RNA may also lead to the creation of designer drugs and RNA-based molecular sensors. The development of new RNA-based

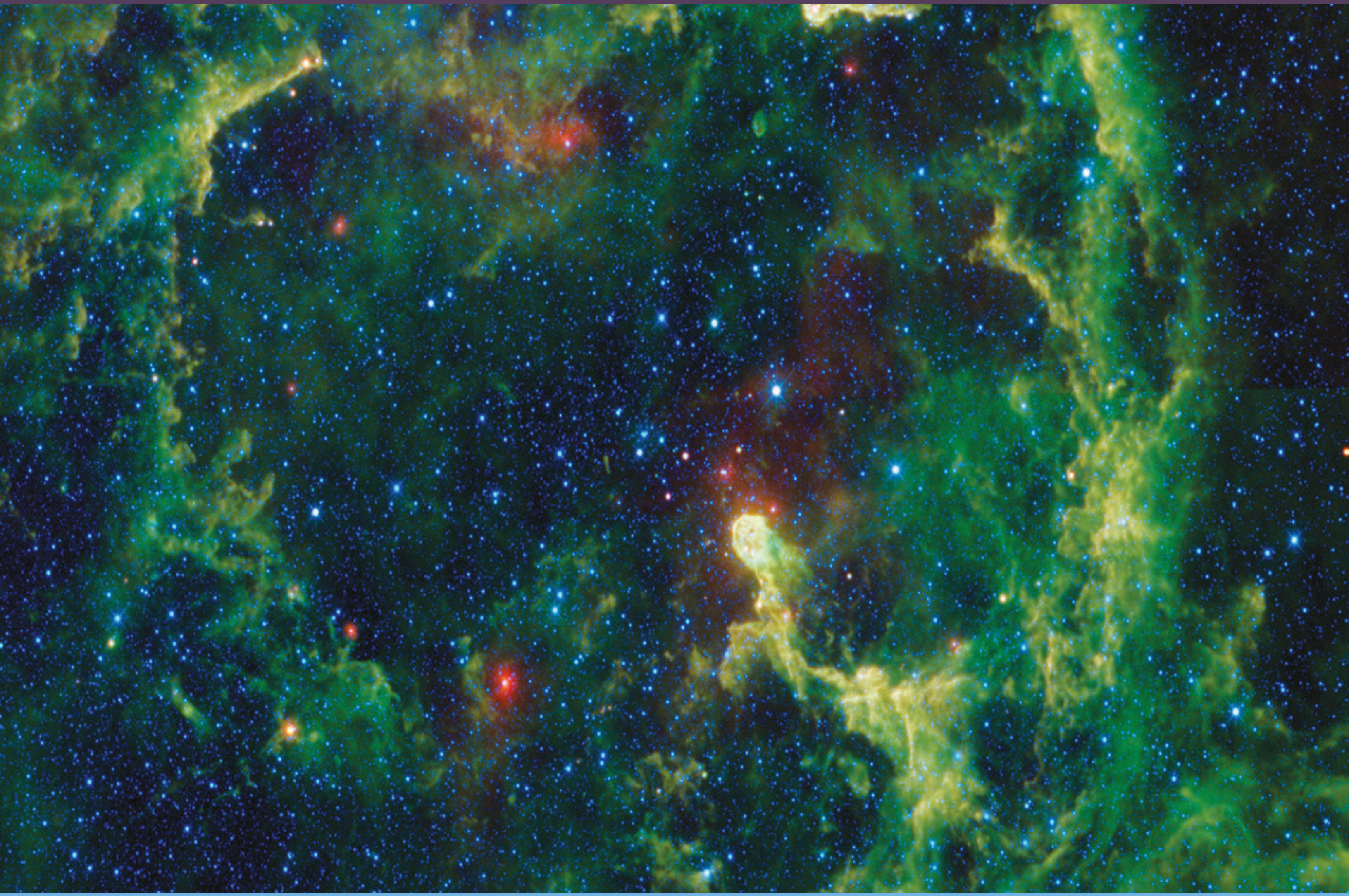


Results of an smFRET experiment by the Nesbitt group performed on custom-made RNA strands. The JILA experiment confirmed that the RNA strands folded exactly as predicted, validating NIH's new method for custom-making RNA strands. Credit: The Nesbitt group, JILA

technologies and fundamental research in the biophysics of RNA action in cells will both profit from the new method for custom-making RNA.

The new method employed an automated robotic platform consisting of DNA templates (blueprints for a variety of custom-made RNA strands) bonded to a solid bead. The RNAs produced by the robotic platform were labeled with radioactive isotopes (for NMR studies) or fluorescent dye molecules at specifically determined locations (for smFRET studies). The dye molecules allowed Nesbitt and Holmstrom to show that the RNA strands were folding exactly as predicted, confirming the validity of the method developed by Yu Liu, Jason R. Stagno, Jinfa Ying, and Yun-Xing Wang of the National Institutes of Health and their colleagues from the National Heart, Lung, and Blood Institute; Frederick National Laboratory for Cancer Research; and the University of Texas Health Science Center.

Yu Liu, Erik Holmstrom, Jinwei Zhang, Ping Yu, Jinbu Wang, Marzena A. Dyba, De Chen, Jinfa Ying, Stephen Lockett, David J. Nesbitt, Adrian Ferré-D'Amaré, Rui Sousa, Jason R. Stagno, & Yun-Xing Wang, *Nature* **522**, *368–372* (2015).



The Elephant Trunk Nebula is an example of the effects of stellar winds, which astrophysicists investigate with the Lyman-α spectral line of atomic hydrogen. Here, clouds of dust and gas are being "blown away" by the stellar wind of a massive star (the uppermost star of a triangle of three bright blue stars near the center of the image). The stellar triangle is above and slightly to left of the glowing ball of gas at the tip of what looks like the trunk of an elephant. The bright "trunk" is a dense cloud that is resisting the star's powerful stellar wind even as other gas and dust are being swept away. Credit: NASA/JPL-Caltech/UCLA

Multitalented Lyman-α

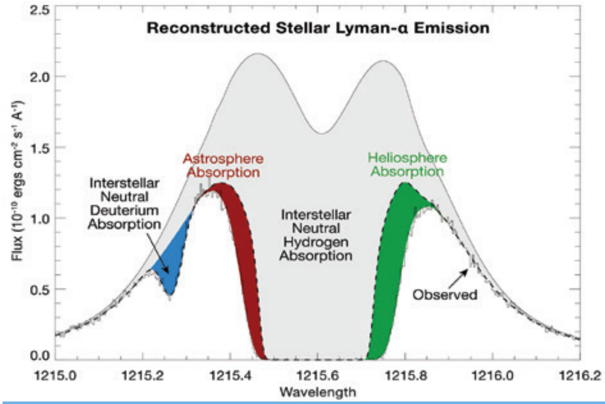
For astrophysicists like Fellow Jeff Linsky, the Lyman-α spectral line of atomic hydrogen is a powerful tool for investigating the stellar winds emitted by stars, the deuterium/hydrogen (D/H) ratio in the Galaxy, the excited states of hydrogen molecules and carbon monoxide in the environments around young stars, and photochemical processes that create oxygen in the atmospheres of planets around other stars, or exoplanets. These diverse phenomena have been identified using the Lyman-α line by both the Space Telescope Imaging Spectrograph and the Cosmic Origins Spectrograph on the Hubble Space Telescope.

Lyman-α's astrophysical applications are due to its being the strongest emission line in the ultraviolet (UV) spectra of Sun-like stars and as strong as the entire UV spectrum of the relatively low-temperature M dwarf stars. Nevertheless, AMO physicists tend to think of Lyman-α simply as a well-characterized high-energy UV line of the simplest element hydrogen. So, Lyman-α astrophysical investigations must have been a piece of cake, right? Not quite.

Unlocking of the secrets of stellar winds, young stars, and exoplanet atmospheres has been challenging. First, the atmospheres of young stars, and the dusty environments around them, simply aren't very transparent to Lyman-α radiation. Second, there's hydrogen in a star and around the star–the Universe is filled with massive clouds of hydrogen that absorb most of the Lyman-α radiation passing through them. Finally, we observe the Universe because the Hubble telescope uses the Lyman-α line of hydrogen as a probe of what it sees. Observers see all these things at the same time superimposed.

The ability to unravel this complicated picture improved when Linsky and his colleagues figured out the reason for variations in the interstellar concentration of deuterium, an isotope of hydrogen with similar behavior and a spectral line located close to the Lyman-α line. Deuterium binds to dust grains in quiet regions of the interstellar medium and is released from the dust grains by shock waves produced by supernova explosions. The ability to determine consistent D/H ratios has led to important discoveries that rely upon using the Lyman-α line.

First, it's now possible to measure the rates at which dwarf stars like the Sun lose mass, which is important for understanding stellar evolution. Astrophysicists have discovered that charge exchanges occur between protons in stellar winds and hydrogen atoms flowing toward the star from the interstellar medium. Charge exchange causes H atoms to form a "hydrogen wall" inside stellar



The Lyman-α profile of a middle-aged star observed with the Hubble Space Telescope Imaging Spectrograph. Stellar Lyman-α emission must be reconstructed from the observed emission to correct for its absorption by interstellar hydrogen and neutral hydrogen in the hydrogen walls of the Sun and other stars. Credit: The Linsky group and Steve Burrows, JILA

astrospheres ("bubbles" formed by stellar winds relatively far away from the host star). The astrosphere of our Sun, for example, extends beyond all eight major planets.

Second, stellar Lyman-α emission lines play a role in the study of planet formation in circumstellar disks around very young stars. In circumstellar disks, the Lyman-α line can probe trace amounts of hydrogen molecules and carbon monoxide gas left over near the end of the planet-forming process.

Finally, Lyman-α emission-line studies have increased our understanding of exoplanets. Gas giant exoplanets lose hydrogen though outflows, including comet-like tails. Lyman-α emission lines also control the photochemistry of water, carbon dioxide, and methane in exoplanet atmospheres. Simulations have shown that oxygen atoms and molecules as well as ozone can be produced without requiring the presence of living organisms.

Linsky's colleagues will have to identify a signal other than just the presence of oxygen for detecting life on exoplanets. But regardless of what happens in the search for alien life, the amazing Lyman-α line will continue to play an important role in increasing our understanding of the Universe.

Jeffrey L. Linsky, NEWSLETTER Space Telescope Science Institute **32,** 02 (2015). (http://www.stsci.edu/institute/newsletter)

IN THE NEWS

A selection of news, awards, and what is happening around JILA

Deborah Jin to Become Chair-Elect of the APS Nominating Committee

Deborah Jin has been selected as chair elect of the American Physical Society (APS) Nominating Committee. Beginning January 1, 2016, she will serve one year as Chair Elect, a year as Chair, and a year as Past Chair of the committee. The committee is charged with preparing a slate of at least two candidates for the positions of Vice President, Treasurer, Chair Elect of the Nominating Committee, and the vacant positions of General Councilor and International Councilor for APS elections each year.

"The American Physical Society is a great resource for our community and an important advocate for physics," Jin wrote in her candidate statement. She added that the success of APS is built on the willingness of its members to serve in various capacities.

Margaret Murnane awarded University College Dublin Honorary Degree

University College Dublin conferred an honorary degree of Doctor of Science on Margaret Murnane, June 16, 2015, at a ceremony on the campus in Dublin, Ireland. This award, the highest awarded by the university, is given to remarkable individuals who have achieved distinction in their fields of endeavour. It is given on Bloomsday in honor of UCD alumnus James Joyce.

NSF highlights the Ye Lab's development of laser frequency comb applications

A National Science Foundation Discovery feature highlights the work of the Ye Lab in their dramatic development of laser frequency comb applications that have, according to the article "transformed basic scientific research and led to new technologies in so many different fields--timekeeping, medical research, communications, remote sensing, astronomy, just to name a few."

Learn more about this research by reading the article, *Combing frequencies: NSF-funded center provides spectrum of new research, technology* at http://goo.gl/piVDaG.

JILA's Strong Field Science Team Wins $7.5 million MURI Award

JILA's Strong-Field Science Team has won a $7.5 million, five-year Multidisciplinary University Research Initiative (MURI) award from the U. S. Department of Defense, the department announced on June 2, 2015. The award was for "Harnessing Strong-Field Mid-IR Lasers: Designer Beams of Relativistic Particles and Thz to X-Ray Light." The University of Colorado's experiment team includes Fellows Margaret Murnane and Henry Kapteyn as well as Senior Research Associate Tenio Popmintchev. The theory team includes Fellow Andreas Becker and Associate Fellow Agnieszka Jaroń-Becker. The team also includes collaborators from the Universities of Michigan, Arizona, and Maryland as well as Columbia University.

"Our strong-field science team at JILA was delighted to learn that we had won a DOD MURI award," said Murnane. She said her team plans to explore the best routes for using mid-infrared lasers to achieve exquisite control, high energy density, and increased efficiency with light-matter interactions. The group also plans to create designer beams of relativistic charged particles and x-ray light by controlling their spectral, temporal, spatial, and polarization properties.

Margaret Murnane Awarded Honorary Doctorate from Trinity College Dublin

Margaret Murnane was awarded an Honorary Doctorate from Trinity College Dublin on June 26, 2015. The Trinity College presentation cited her ground-breaking work in laser science that has transformed the field of ultrafast laser and x-ray science. She has not only engaged in fundamental research, but also used her discoveries to found a start-up company (KMLabs) with her collaborator and husband, Henry Kapteyn.

She has been able to capture the movements of the smallest particles in nature, including the dance of electrons in atoms and molecules. She has engineered coherent x-ray beams that can distinguish important biomolecules. Her accomplishments are expected to have applications ranging from entertainment to surgery and new pharmaceuticals.

Murnane was born in County Limerick, Ireland, and fell in love with science when she was 8 years old. Her passion for discovery took her first to University College Cork, then to the University of California at Berkeley for graduate work, and then to academic positions at Washington State University, the University of Michigan, and finally to the University of Colorado Boulder, where she is Distinguished Professor of Physics and Fellow of JILA. Murnane has received 30 awards and honors for her accomplishments, including the 2011 Boyle Medal of the Royal Dublin Society.

"She is an enthusiastic supporter of the Trinity School of Physics, but, more than anything else, she is a shining model for women in science," the presentation concluded.

Kevin Cox Wins Outstanding Presentation Award

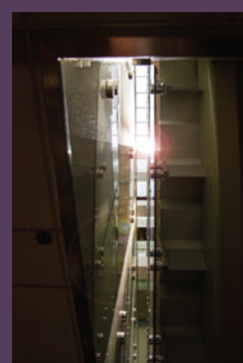
Kevin Cox received an Outstanding Presentation Award at the July 15, 2015, NIST Boulder Laboratories Postdoctoral Poster Symposium. Cox was recognized for his presentation "17 dB of Spin Squeezing with QND Measurements." Cox is a graduate student in the James Thompson group at JILA. He co-authored the poster with Graham Greve, Joshua Weiner, and Thompson.

The award citation read, "The Outstanding Presentation Award is a special recognition for selected poster presenters at the Boulder Laboratories Postdoctoral Poster Symposium. This recognition was selected by senior scientists who circulated through the poster session and noted outstanding quality in both preparation of a poster and its oral presentation.

"This award was initiated at the 1st symposium held in 2004, which was organized in honor of the Boulder Laboratories 50 Year Anniversary. The sponsor of this event is the Boulder Labs Diversity Council."

JILA Summer Fun Days

National Sugar Cookie Day



Summer Solstice

Crazy T-shirt Contest

...and more to come

Credit: Steve Burrows, JILA

How Did They Get Here?

JILA Chair Deborah Jin is an atomic physicist at JILA, a joint institute of the University of Colorado Boulder (CU-Boulder) and the National Institute of Standards and Technology (NIST). She is a NIST Fellow in the Quantum Physics Division and an Adjoint Professor of Physics at CU-Boulder. In 2003, Jin received a MacArthur Fellowship (commonly known as the "genius grant") from the John D. and Catherine T. MacArthur Foundation. In 2013, she was named the L'Oreal-UNESCO For Women in Science Laureate for North America.

Her other honors include a 2000 Presidential Early Career Award in Science and Engineering, NIST's 2001 Samuel W. Stratton Award, the American Physical Society's 2002 Maria Goeppert-Mayer Award and 2005 I. I. Rabi Prize, the 2002 National Academy of Sciences Award for Initiatives in Research, the 2003 Arthur S. Flemming Award, the 2004 Service to America Medal, a 2004 Scientific American Research Leader of the Year, the 2006 Bonfils-Stanton Foundation Award in Science and Medicine, the Franklin Institute's 2008 Benjamin Franklin Medal in Physics, Sigma Xi's 2009 William Proctor Prize for Scientific Achievement, a 2011 Department of Commerce Gold Medal, the 2014 Comstock Prize in Physics from the National Academy of Sciences, and the 2014 Isaac Newton Medal from the Institute of Physics. Jin is a Fellow of the American Academy of Arts & Sciences, the American Association for the Advancement of Science, and the American Physical Society, as well as a member of the National Academy of Sciences.

Jin explores the physics of atomic gases at ultracold temperatures and investigates the link between superconductivity and Bose-Einstein condensation, which occurs when particles known as bosons are cooled to just a few millionths of a degree above absolute zero (-459.67 °F). She has developed innovative technical systems to study the behavior of ultracold Fermi gases, whose atoms are particles known as fermions and can form a superfluid, or Bose condensate, if they become organized as correlated atom pairs. In 2003,

her group made the first ultracold fermionic condensate. Since 2004, her group has conducted detailed studies of the behavior of Fermi gases in the regime of strong interactions, or correlations.

In 2008, Jin collaborated with Professor Jun Ye, also at JILA, to create the first ultracold gas of polar molecules in the quantum regime. Using ground-state potassium-rubidium (KRb) molecules, Jin and Ye have explored ultracold chemistry and are now using ultracold KRb molecules in a quantum simulator to investigate quantum magnetism and other quantum behaviors.

Jin earned an A. B. in physics from Princeton in 1990 and a Ph.D. in physics from the University of Chicago in 1995. From 1995 to 1997, she was a National Research Council research associate at JILA. She was hired at JILA in 1997 as a NIST physicist and assistant professor adjoint at CU-Boulder.

JILAns gathered for the annual photo. Squinting into the June sun they still look like a happy lot.

JILA is a joint institute of the University of Colorado Boulder and the National Institute of Standards and Technology

University of Colorado **Boulder** NIST

About JILA

JILA was founded in 1962 as a joint institute of CU-Boulder and NIST. JILA is located at the base of the Rocky Mountains on the CU-Boulder campus in the Duane Physics complex.

JILA's faculty includes two Nobel laureates, Eric Cornell and John Hall, as well as three John D. and Catherine T. MacArthur Fellows, Margaret Murnane, Deborah Jin, and Ana Maria Rey. JILA's CU members hold faculty appointments in the Departments of Physics; Chemistry and Biochemistry; Astrophysical and Planetary Sciences; and Molecular, Cellular, and Developmental Biology as well as in the School of Engineering. NIST's Quantum Physics Division members hold adjoint faculty appointments at CU in the same departments.

The wide-ranging interests of our scientists have made JILA one of the nation's leading research institutes in the physical sciences. Our scientists explore some of today's most challenging and fundamental scientific questions about quantum physics, the design of precision optical and x-ray lasers, the fundamental principles underlying the interaction of light and matter, and processes that have governed the evolution of the Universe for nearly 14 billion years. Research topics range from the small, frigid world governed by the laws of quantum mechanics through the physics of biological and chemical systems to the processes that shape the stars and galaxies. JILA science encompasses eight broad categories: Astrophysics, Atomic & Molecular Physics, Biophysics, Chemical Physics, Laser Physics, Nanoscience, Precision Measurement, and Quantum Information.

To learn more visit:
jila.colorado.edu.