LIGHT+ MATTER

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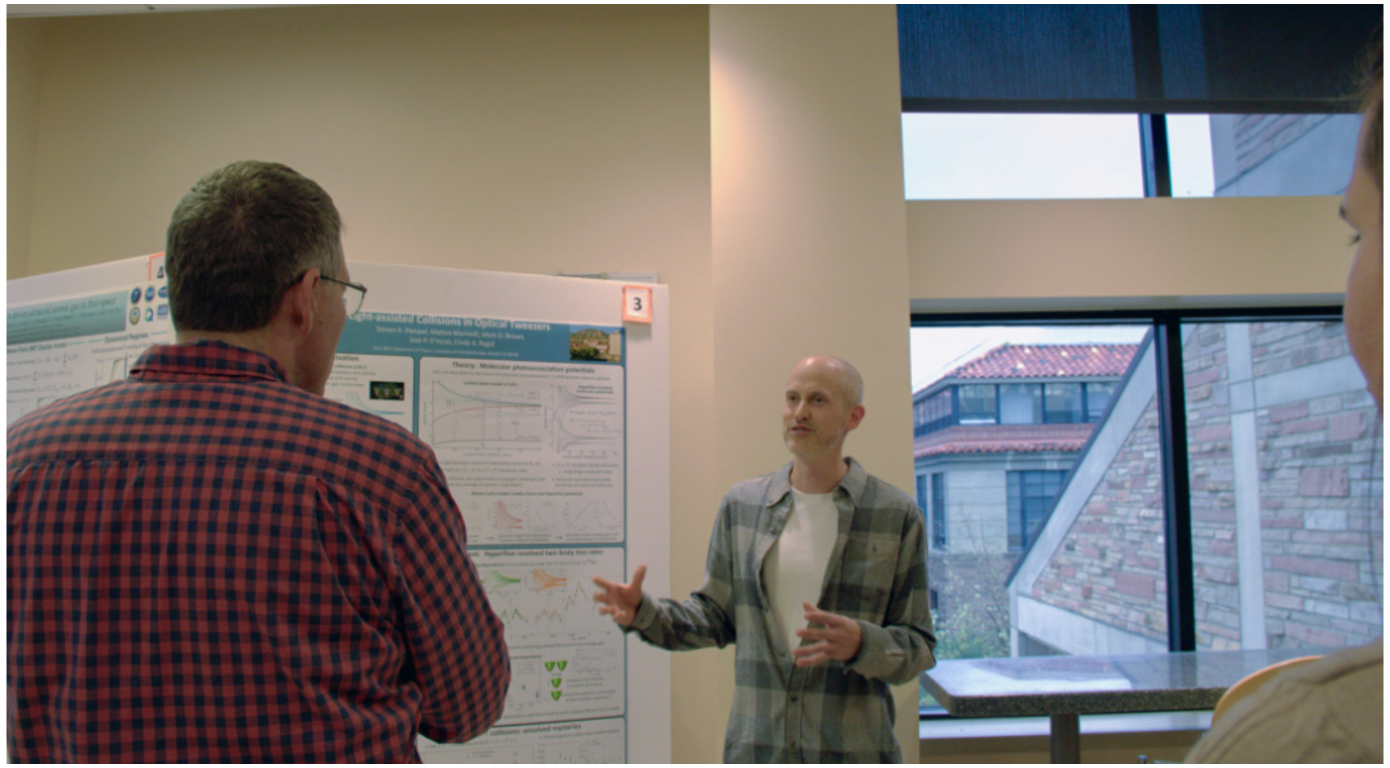
JILA Fellow Chair John Bohn listens as JILA graduate student Steven Pampel explains his research at the 8th JILA posterfest held in April 2024.
Credit: Kenna Hughes-Castleberry/JILA



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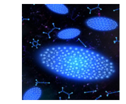
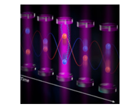
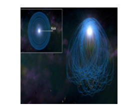
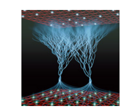








Feature Articles

Cold Coulomb Crystals, Cosmic Clues: Unraveling the Mysteries of Space Chemistry

While it may not look like it, the interstellar space between stars is far from empty. Atoms, ions, molecules, and more reside in this ethereal environment known as the Interstellar Medium (ISM). The ISM has fascinated scientists for decades, as at least 200 unique molecules form in its cold, low-pressure environment. It's a subject that ties together the fields of chemistry, physics, and astronomy, as scientists from each field work to determine what types of chemical reactions happen there.

Now, in the recently published cover article of the *Journal of Physical Chemistry A*, JILA Fellow and University of Colorado Boulder Physics Professor Heather Lewandowski and former JILA graduate student Olivia Krohn highlight their work to mimic ISM conditions by using Coulomb crystals, a cold pseudo-crystalline structure, to watch ions and neutral molecules interact with each other.

From their experiments, the researchers resolved chemical dynamics in ion-neutral reactions by using precise laser cooling and mass spectrometry to control quantum states, thereby allowing them to emulate ISM chemical reactions successfully. Their work brings scientists closer to answering some of the most profound questions about the chemical development of the cosmos.

Filtering Via Energy

"The field has long been thinking about which chemical reactions are going to be the most important to tell us about the makeup of the interstellar medium," explains Krohn, the paper's first author. "A really important group of those is the ion-neutral molecule reactions. That's exactly what this experimental apparatus in the Lewandowski group is suited for, to study not just ion-neutral chemical reactions but also at relatively cold temperatures."

To begin the experiment, Krohn and other members of the Lewandowski group loaded an ion trap in an ultra-high vacuum chamber with various ions. Neutral molecules were introduced separately. While they knew the reactants going into the ISM-type chemical experiment, the researchers weren't always certain what products would be created. Depending on their test, the researchers used different types of ions and neutral molecules similar to those in the ISM. This included CCl+ ions fragmented from tetrachloroethylene.

"CCl^+ has been predicted to be in different regions of space. But nobody's been able to effectively test its reactivity with experiments on Earth because it's so difficult to make," Krohn adds. "You have to break it down from tetrachloroethylene using UV lasers. This creates all kinds of ion fragments, not just CCl^+, which can complicate things."

Whether using calcium or CCl^+ ions, the experimental setup allowed the researchers to filter out unwanted ions using resonant excitation, leaving the desired chemical reactants behind.

"You can shake the trap at a frequency resonant with a particular ion's mass-to-charge ratio, and this ejects them from the trap," says Krohn.

After filtering, the researchers cooled their ions using a process known as Doppler cooling. This technique uses laser light to reduce the motion of atoms or ions, effectively cooling them by exploiting the Doppler effect to preferentially slow particles moving toward the cooling laser. As the Doppler cooling lowered the particles' temperatures to millikelvin levels, the ions arranged themselves into a pseudo-crystalline structure, the Coulomb crystal, held in place by the electric fields within the vacuum chamber. The resulting Coulomb crystal was an ellipsoid shape with heavier molecules sitting in a shell outside the calcium ions, pushed out of the trap's center by the lighter particles due to the differences in their mass-to-charge ratios.

Thanks to the deep trap that contains the ions, the Coulomb crystals can remain trapped for hours, and Krohn and the team can image them in this trap. In analyzing the images, the researchers could identify and monitor the reaction in real time, seeing the ions organize themselves based on mass-to-charge ratios.

The team also determined the quantum-state dependence of the reaction of calcium ions with nitric oxide by fine-tuning the cooling lasers, which helped produce certain relative populations of quantum states of the trapped calcium ions.

"What's fun about that is it leverages one of these more specific atomic physics techniques to look at quantum resolved reactions, which is a little bit more, I think, of the physics essence of the three fields, chemistry, astronomy, and physics, even though all three are still involved," adds Krohn.

Timing is Everything

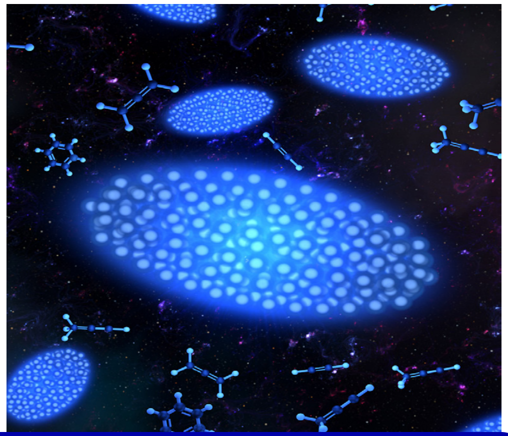
Besides trap filtration and Doppler cooling, the researchers' third experimental technique helped them emulate the ISM reactions: their time-of-flight mass spectrometry (TOF-MS) setup. In this part of the experiment, a high-voltage pulse accelerated the ions down a flight tube, where they collided with a microchannel plate detector. The researchers could determine which particles were present in the trap based on the time it took for the ions to hit the plate and their imaging techniques.

"Because of this, we've been able to do a couple of different studies where we can resolve neighboring masses of our reactant and product ions," adds Krohn.

This third arm of the ISM-chemistry experimental apparatus improved the resolution even further as the researchers now had multiple ways to determine which products were created in the ISM-type reactions and their respective masses.

Calculating the mass of the potential products was especially important as the team could then switch out their initial reactants with isotopologues with different masses and see what happened.

As Krohn elaborates, "That allows us to play cool tricks like substituting hydrogens with deuterium atoms or substituting different atoms with heavier isotopes. When



Coulomb crystals are surrounded by molecules used in the Lewandowski laboratory to study astrochemical reactions Credit: Steven Burrows/Olivia Krohn and the Lewandowski Group

we do that, we can see from the time-of-flight mass spectrometry how our products have changed, which gives us more confidence in our knowledge of how to assign what those products are."

As astrochemists have observed more deuterium-containing molecules in the ISM than is expected from the observed atomic deuterium-to-hydrogen ratio, swapping isotopes in experiments like this allows researchers to get one step closer to determining why this may be.

"I think, in this case, it allows us to have good detection of what we're seeing," Krohn says. "And that opens more doors."

Olivia A. Krohn and Heather J. Lewandowski. "Cold Ion–Molecule Reactions in the Extreme Environment of a Coulomb Crystal." Journal of Physical Chemistry A. 128(10), 1737–1752, 2024.

Written by Kenna Hughes-Castleberry

Twisting and Binding Matter Waves with Photons in a Cavity

Precisely measuring the energy states of individual atoms has been a historical challenge for physicists due to atomic recoil. When an atom interacts with a photon, the atom "recoils" in the opposite direction, making it difficult to measure the position and momentum of the atom precisely. This recoil can have big implications for quantum sensing, which detects minute changes in parameters, for example, using changes in gravitational waves to determine the shape of the Earth.

In a new paper published in the *Science*, JILA and NIST Fellows Ana Maria Rey and James Thompson, JILA Fellow Murray Holland, and their teams proposed a way to overcome this atomic recoil by demonstrating a new type of atomic interaction called momentum-exchange interaction, where atoms exchanged their momentums by exchanging corresponding photons.

Using a cavity—an enclosed space composed of mirrors—the researchers observed that the atomic recoil was dampened by atoms exchanging energy states within the confined space. This process created a collective absorption of energy and dispersed the recoil among the entire population of particles.

With these results, other researchers can design cavities to dampen recoil and other outside effects in a wide range of experiments, which can help physicists better understand complex systems or discover new aspects of quantum physics. An improved cavity design could also enable more precise simulations of superconductivity, such as in the case of the Bose-Einstein-Condensate–Bardeen-Cooper-Schrift (BEC-BCS) crossover or high-energy physical systems.

For the first time, the momentum-exchange interaction was observed to induce one-axis twisting (OAT) dynamics, an aspect of quantum entanglement, between atomic momentum states. OAT acts like a quantum braid for entangling different molecules, as each quantum state gets twisted and connected to another particle.

Previously, OAT was only seen in atomic internal states, but now, given these new results, it is thought that OAT induced by momentum exchange could help reduce quantum noise from multiple atoms. Being able to entangle momentum states could also lead to improvement in some physical measurements by quantum sensors, such as gravitational waves.

Add a Density Grating

Within this new study, inspired by previous research from Thompson and his team, the researchers examined the effects of quantum superposition, which allows particles like photons or electrons to exist in multiple quantum states simultaneously.

"In this [new] project, the atoms all share the same spin label; the only difference is that each atom is in a superposition between two momentum states," graduate student and first author Chengyi Luo explained.

The researchers found they could better control atomic recoil by forcing the atoms to exchange photons and their associated energies. Similar to a game of dodgeball, one atom may "throw" a "dodgeball" (a photon) and recoil in the opposite direction. That "dodgeball" may be caught by a second atom, which can cause the same amount of recoil for this second atom. This cancels out the two recoils experienced by both atoms and averages them for the entire cavity system.

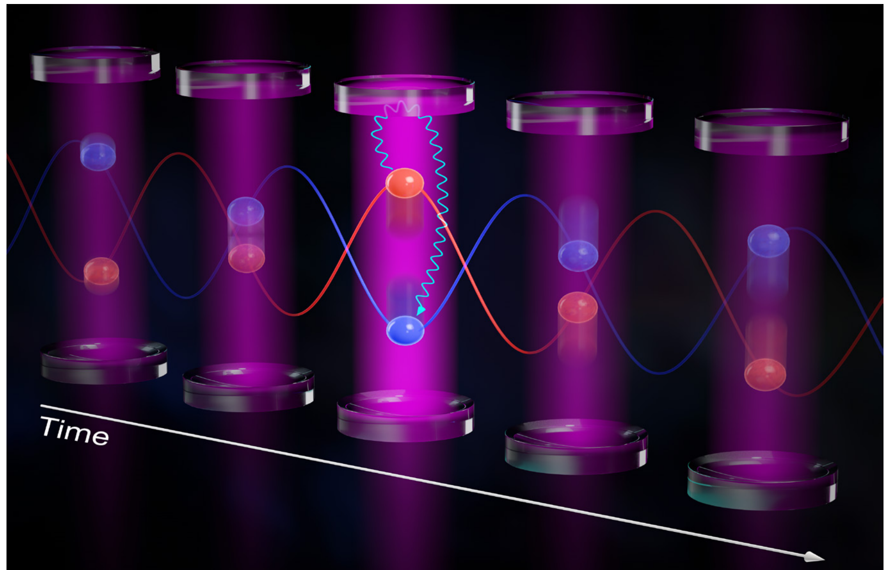
When two atoms exchange their different photon energies, the resulting wave packet (an atom's wave distribution) in superposition forms a momentum graph known as a density grating, which looks like a fine-toothed comb.

Luo added. "The formation of the density grating indicates two momentum states [within the atom] are 'coherent' with each other such that they could interfere [with each other]." The researchers found that the exchange of photons between atoms caused a binding of the two atoms' wave packets, so they were no longer separate measurements.

The researchers could induce momentum exchange by exploring the interplay between the density grating and the optical cavity. Because the atoms exchanged energy, any recoil from absorbing a photon was dispersed among the entire community of atoms instead of individual particles.

Dampening the Doppler Shift

Using this new control method, the researchers found that they could also use this recoil-dampening system to help mitigate a separate measurement problem: the Doppler shift.



Atoms inside of an optical cavity exchange their momentum states by "playing catch" with photons. As the atoms absorb photons from an applied laser, the whole cloud of atoms recoil rather than the individual atoms.
Credit: Steven Burrows/Holland, Rey, and Thompson Groups

The Doppler shift, a phenomenon in classical physics, explains why the sound of a siren or train horn changes pitch as it passes a listener or why certain stars appear red or blue in night sky images—it's the change in the frequency of the wave as the source and observer move toward (or away from) each other. In quantum physics, the Doppler shift describes a particle's energy change due to relative motion.

For researchers like Luo, the Doppler shift can be a challenge to overcome in getting a precise measurement. "When absorbing photons, the atomic recoil will lead to a Doppler shift of the frequency of the photon, which is a big problem when you talk about precision spectroscopy," he elaborated. By simulating their new method, the researchers found that it could overcome measurement skewing due to Doppler Shift.

The researchers also found that the momentum exchange between these atoms could be used as a type of quantum entanglement. As John Wilson, a graduate student in the Holland group, elaborated: "As an atom falls, its motion wiggles the cavity frequency. That, in turn, encourages other atoms to collectively feel that feedback mechanism and nudges them to correlate their motion through the shared wobbles."

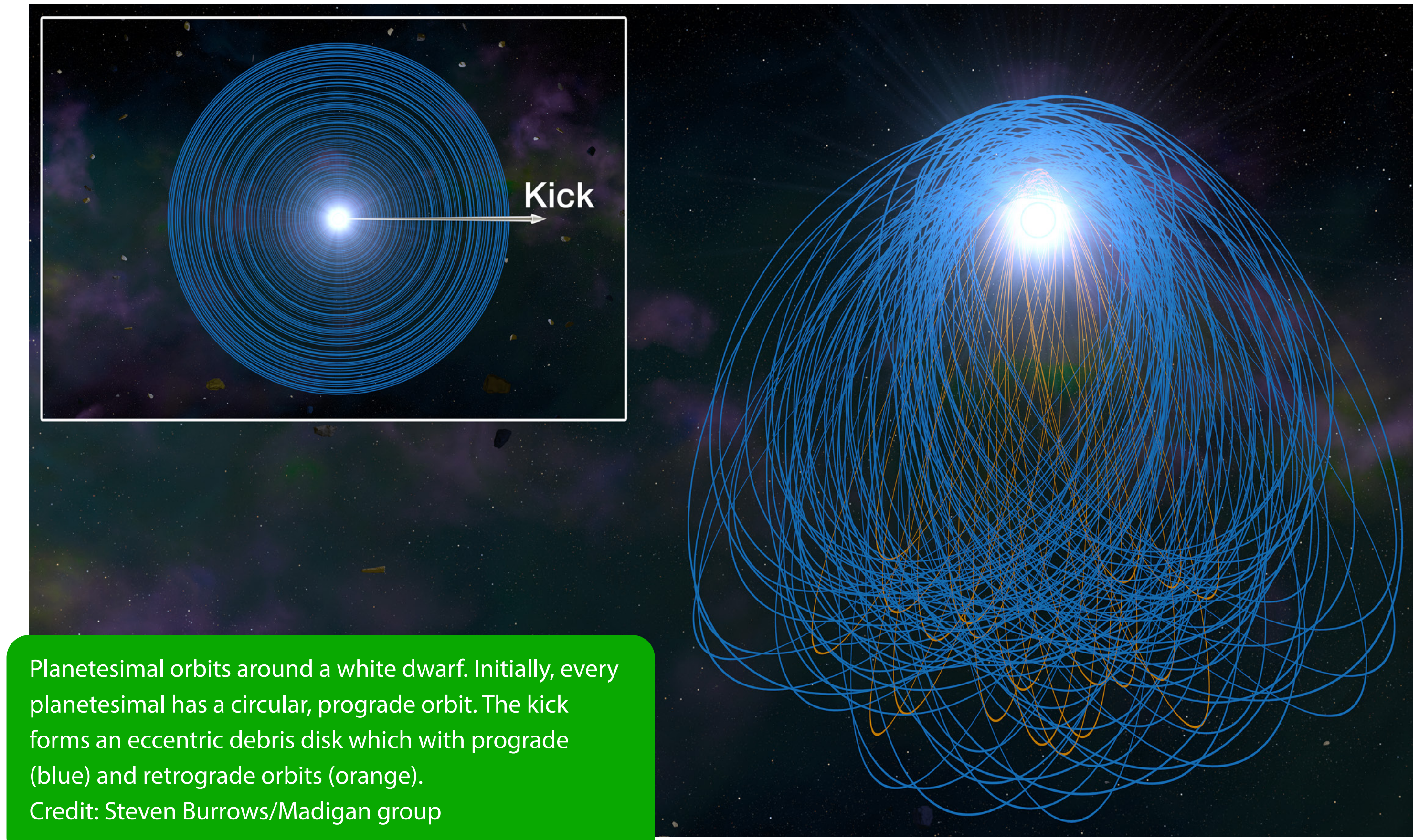
To test this "entanglement" even further, the researchers created a bigger separation between the momentum states of the atoms and then induced the momentum exchange. The researchers found that the atoms continued to behave as if they were connected. "This indicates that the two momentum states are really oscillating concerning each other as if being connected by a spring," added Luo.

Looking ahead, the researchers plan to probe this new form of quantum entanglement further, hoping to better understand how it can be used to improve various types of quantum devices.

Chengyi Luo, Haoqing Zhang, Vanessa P. Koh, John D. Wilson, Anjun Chu, Murray J. Holland, Ana Maria Rey, and James K. Thompson. "Momentum-exchange interactions in a Bragg atom interferometer suppress Doppler dephasing." Science, 384(6695), 551–556, 2024.

Written by Kenna Hughes-Castleberry,

Hungry, Hungry White Dwarfs: Solving the Puzzle of Stellar Metal Pollution



Planetesimal orbits around a white dwarf. Initially, every planetesimal has a circular, prograde orbit. The kick forms an eccentric debris disk which with prograde (blue) and retrograde orbits (orange).
Credit: Steven Burrows/Madigan group

Dead stars known as white dwarfs, have a mass like the Sun while being similar in size to Earth. They are common in our galaxy, as 97% of stars are white dwarfs. As stars reach the end of their lives, their cores collapse into the dense ball of a white dwarf, making our galaxy seem like an ethereal graveyard.

Despite their prevalence, the chemical makeup of these stellar remnants has been a conundrum for astronomers for years. The presence of heavy metal elements—like silicon, magnesium, and calcium—on the surface of many of these compact objects is a perplexing discovery that defies our expectations of stellar behavior.

"We know that if these heavy metals are present on the surface of the white dwarf, the white dwarf is dense enough that these heavy metals should very quickly sink toward the core," explains JILA graduate student Tatsuya Akiba. "So, you shouldn't see any metals on the surface of a white dwarf unless the white dwarf is actively eating something."

While white dwarfs can consume various nearby objects, such as comets or asteroids (known as planetesimals), the intricacies of this process have yet to be fully explored. However, this behavior could hold the key to unraveling the mystery of a white dwarf's metal composition, potentially leading to exciting revelations about white dwarf dynamics.

In results reported in a new paper in *The Astrophysical Journal Letters*, Akiba, along with JILA Fellow and University of Colorado Boulder Astrophysical and Planetary Sciences professor Ann-Marie Madigan and undergraduate student Selah McIntyre, believe they have found a reason why these stellar zombies eat their nearby planetesimals. Using computer simulations, the researchers simulated the white dwarf receiving a "natal kick" during its formation (which has been observed) caused by asymmetric mass loss, altering its motion and the dynamics of any surrounding material.

In 80% of their test runs, the researchers observed that, from the kick, the orbits of comets and asteroids within a range of 30 to 240 AU of the white dwarf (corresponding to the Sun–Neptune distance and beyond) became elongated and aligned. Furthermore, around 40% of subsequently eaten planetesimals come from counter-rotating (retrograde) orbits.

The researchers also extended their simulations to examine the white dwarf's dynamics after 100 million years. They found that the white dwarf's nearby planetesimals still had elongated orbits and moved as one coherent unit, a result never seen before.

"This is something I think is unique about our theory: we can explain why the accretion events are so long-lasting," states Madigan. "While other mechanisms may explain an original accretion event, our simulations with the kick show why it still happens hundreds of millions of years later."

These results explain why the heavy metals are found on the surface of a white dwarf, as that white dwarf continuously consumes smaller objects in its path.

It's all About Gravity

As Madigan's research group at JILA focuses on gravitational dynamics, looking at the gravity surrounding white dwarfs seemed like a natural focus of study.

"Simulations help us understand the dynamics of different astrophysical objects," Akiba says. "So, in this simulation, we throw a bunch of asteroids and comets around the white dwarf, which is significantly bigger, and see how the simulation evolves and which of these asteroids and comets the white dwarf eats."

The researchers hope to take their simulations to greater scales in future projects, looking at how white dwarfs interact with larger planets.

As Akiba elaborates, "Other studies have suggested that asteroids and comets, the small bodies, might not be the only source of metal pollution on the white dwarf's surface. So, the white dwarfs might eat something bigger, like a planet."

Discovering More About Solar System Formation

These new findings further reveal more about the formation of white dwarfs, which is important in understanding how solar systems change over millions of years. They also help shed light on the origins and future evolution of our solar system, revealing more about the chemistry involved.

"The vast majority of planets in the universe will end up orbiting a white dwarf," Madigan says. "It could be that 50% of these systems get eaten by their star, including our own solar system. Now, we have a mechanism to explain why this would happen."

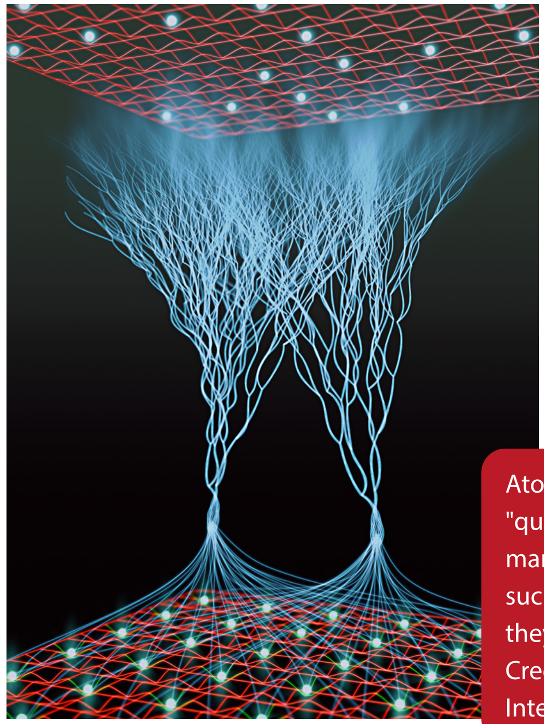
"Planetesimals can give us insight into other solar systems and planetary compositions beyond where we live in our solar region" McIntyre adds. "White dwarfs aren't just a lens into the past. They're also kind of a lens into the future."

Tatsuya Akiba Selah McIntrryre, and Ann-Marie Madigan. "Tidal Disruption of Planetesimals from an Eccentric Debris Disk Following a White Dwarf Natal Kick." The Astrophysical Journal Letters, 966(1), L4, 2024.

Written by Kenna Hughes-Castleberry,

The Interference of Many Atoms, and a New Approach to Boson Sampling

In daily life, when two objects are "indistinguishable," it's due to an imperfect state of knowledge. As a street magician scrambles the cups and balls, you could, in principle, keep track of which ball is which as they are passed between the cups. However, at the smallest scales in nature, even the magician cannot tell one ball from another. True indistinguishability of this type can fundamentally alter how the balls behave. For example, in a classic experiment by Hong, Ou, and Mandel, two identical photons (balls) striking opposite sides of a half-reflective mirror are always found to exit from the same side of the mirror (in the same cup). This results from a special kind of interference, not any interaction between the photons. With more photons, and more mirrors, this interference becomes enormously complicated.



Atoms in an optical lattice perform a "quantum walk" where they experience many different quantum phenomena, such as superposition or tunneling as they move around the lattice.
Credit: Alex Downham, Default Interactive and Steven Burrows/JILA

Measuring the pattern of photons that emerges from a given maze of mirrors is known as "boson sampling." Boson sampling is believed to be infeasible to simulate on a classical computer for more than a few tens of photons. As a result, there has been a significant effort to perform such experiments with actual photons and demonstrate that a quantum device is performing a specific computational task that cannot be performed classically. This effort has culminated in recent claims of quantum advantage using photons.

Now, in a recently published *Nature* paper, JILA Fellow and NIST Physicist and University of Colorado Boulder Physics Professor Adam Kaufman and his team, along with collaborators at NIST (the National Institute of Standards and Technology), have demonstrated a novel method of boson sampling using ultracold atoms (specifically, bosonic atoms) in a two-dimensional optical lattice of intersecting laser beams.

Using tools such as optical tweezers, specific patterns of identical atoms can be prepared. The atoms can be propagated through the lattice with minimal loss, and their positions detected with nearly perfect accuracy after their journey. The result is an implementation of boson sampling that is a significant leap beyond what has been achieved before, either in computer simulations or with photons.

"Optical tweezers have enabled ground-breaking experiments in many-body physics, often for studies of many-interacting atoms, where the atoms are pinned in space and interacting over long distances," says Kaufman. "However, a large class of foundational many-body problems—so-called 'Hubbard' systems—arise when particles can both interact and tunnel, quantum mechanically spreading out in space. Early on in building this experiment, we had the goal of applying this tweezer paradigm to large-scale Hubbard systems— this publication marks the first realization of that vision."

Techniques for Better Control

To achieve these results, the researchers used several cutting-edge techniques, including optical tweezers—highly focused lasers that can move individual atoms with exquisite precision—and advanced cooling methods that bring the atoms near absolute zero temperature, minimizing their movement and allowing for precise control and measurement.

Similar to how a magnifying glass creates a pinprick of light when focused, optical tweezers can hold individual atoms in powerful beams of light, allowing them to be moved with extreme precision. Using these tweezers, the researchers prepared specific patterns of up to 180 strontium atoms in a 1,000-site lattice, formed by intersecting laser beams that create a grid-like pattern of potential energy wells to trap the atoms. The researchers also used sophisticated laser cooling techniques to prepare the atoms, ensuring they remained in their lowest energy state, thereby reducing noise and decoherence—common challenges in quantum experiments.

NIST physicist Shawn Geller explained that the cooling and preparation ensured that the atoms were as identical as possible, removing any labels, such as individualized internal states or motional states, that could make a given atom different from the others. "Adding an additional label means the universe can tell which atom is which, even if you can't see the label as an experimenter," says first author and former JILA graduate student Aaron Young. "The presence of such a label would change this from an absurdly hard sampling problem to one that's completely trivial."

For the same reason that boson sampling is hard to simulate, directly verifying that the correct sampling task has been performed is not feasible for the experiments with 180 atoms. To overcome this issue, the researchers sampled their atoms at various scales.

According to Young, "We do tests with two atoms, where we understand very well what's happening. Then, at an intermediate scale where we can still simulate things, we can compare our measurements to simulations involving reasonable error models for our experiment. At large scale, we can continuously vary how hard the sampling task is by controlling how distinguishable the atoms are and confirm that nothing dramatic is going wrong."

Geller adds: "What we did was develop tests that use physics we know to explain what we think is happening."

Through this process, the researchers were able to confirm the high fidelity of the atom preparation and later evolution of the atoms' quantum states in comparison to previous boson sampling demonstrations. In particular, the very low loss of atoms compared to photons during the atoms' evolution precludes modern computational techniques that challenge previous quantum advantage demonstrations.

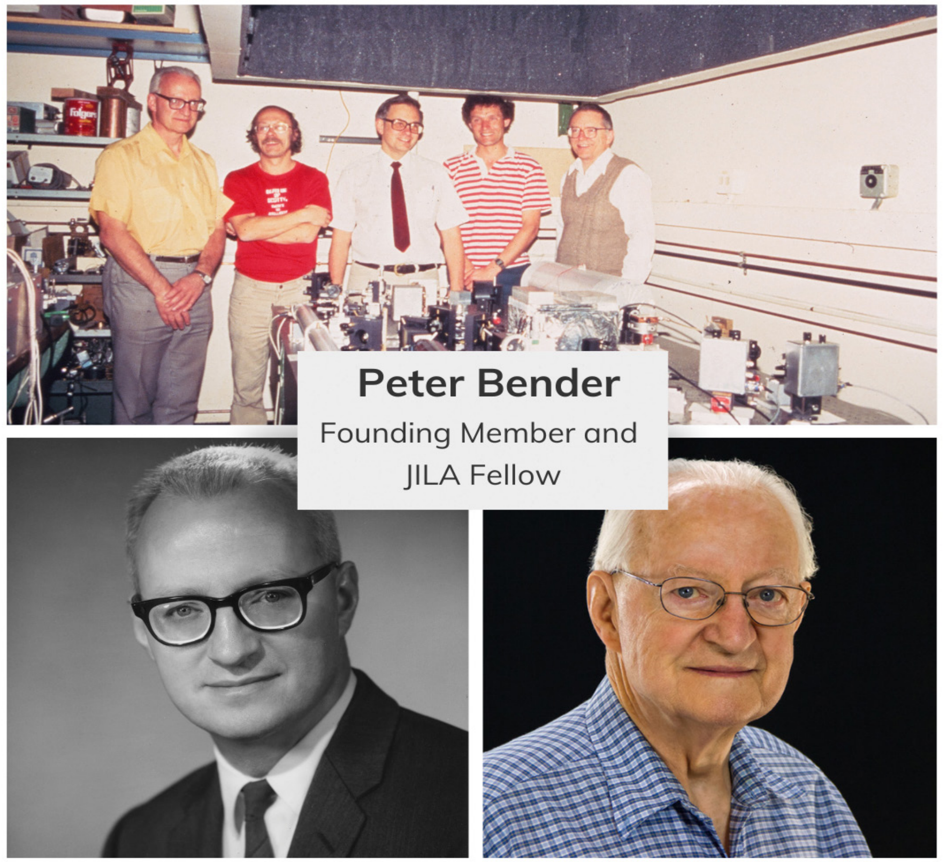
The high-quality and programmable preparation, evolution, and detection of atoms in a lattice demonstrated in this work can be applied in the situation where the atoms interact. This opens new approaches simulating and studying the behavior of real, and otherwise poorly understood, quantum materials.

"Using non-interacting particles allowed us to take this specific problem of boson sampling to a new regime," says Kaufman. "Yet, many of the most physically interesting and computationally challenging problems arise with systems of many interacting particles. Going forward, we expect that applying these new tools to such systems will open the door to many exciting experiments."

Aaron W. Young, Shawn Geller, William J. Eckner, Nathan Schine, Scott Glancy, Emanuel Knill, and Adam M. Kaufman. " An atomic boson sampler" Nature, 629(8011), 311–316, 2024.

Written by Aaron Young and Kenna Hughes-Castleberry

Remembering JILA Fellow and Founding Member, Astrophysicist Dr. Peter Bender



Left: A collage containing the many faces of astrophysicist Peter Bender.
Credit, Kenna Hughes-Castleberry/JILA

Right: A photo of Peter Bender in his younger years.
Credit: Optica

Dr. Peter L. Bender, an esteemed experimental physicist and a foundational member of JILA (formerly the Joint Institute for Laboratory Astrophysics) at the University of Colorado Boulder, passed away recently, leaving behind a legacy marked by significant contributions to the fields of geophysics, astrophysics, and precision measurement.

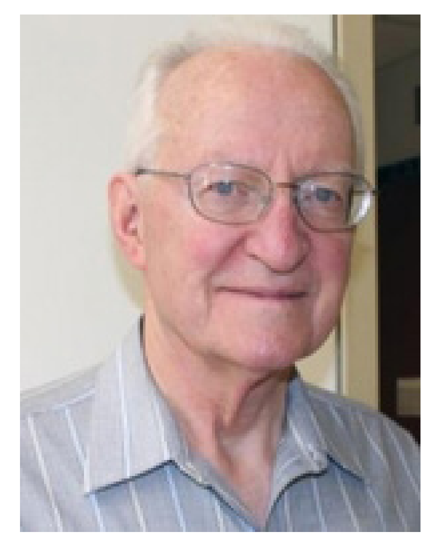
As a JILA Fellow from 1963 to 1995, and later a Fellow Adjoint, Bender was deeply and actively involved in pioneering research that has shaped our understanding of the universe.

Born in New York, Bender's early passion for math and physics propelled him to pursue an undergraduate degree at Rutgers University, followed by graduate degrees at Princeton, where he was influenced by the notable physicist Robert Dicke. Bender's dissertation on the optical pumping of sodium vapor laid the groundwork for a career that would blend rigorous experimental physics with theoretical insights, always aimed at pushing the boundaries of what we understand about physical measurements and astrophysical phenomena.

Bender's tenure at JILA began in the 1960s, after a productive period at the National Bureau of Standards (now NIST), where he focused on precision measurements and magnetic fields. His work at JILA quickly pivoted towards the astrophysical, culminating in a significant role in the Apollo missions' Lunar Laser Ranging Experiment. This collaboration included scientist Dr. James Faller, another early member and Fellow of JILA. This experiment involved placing retroreflectors on the moon, which are still used to measure the distance between the Earth and the moon with extraordinary precision.

Beyond his lunar research, Bender's contributions extended into other areas of astrophysics and geophysics. Over four decades, he developed the conceptual design and scientific justification for the LISA (Laser Interferometer Space Antenna) project, a space mission for detecting gravitational waves, a key prediction of Einstein's theory of general relativity. His work and stewardship helped pave the way for this field's future explorations and have impacted how we perceive phenomena in deep space.

In geophysics, Bender applied his expertise in precision measurement to study the Earth's gravitational field, contributing to gravity mapping missions like GRACE (Gravity Recovery and Climate Experiment) and its successors. These missions monitor variations in Earth's gravity, which have implications for studying water reserves, sea level rise, and climate change.



Throughout his career, Bender was not just a mentor but a true collaborator to many in the scientific community. He was known for his quiet yet profound ability to question and refine existing theories and experiments, pushing scientific inquiry further with each project. His advisory roles for NASA, the National Academy of Sciences, and the National Research Council underscored his commitment to science and its advancement.

Bender's legacy is not only marked by his scientific achievements but also by his deep philosophical engagement with the implications of science for society. He believed strongly in the power of scientific inquiry to contribute positively to the world. Still, he remained acutely aware of the broader social and economic contexts in which scientific work is embedded.

As we remember Peter Bender, we reflect on a career that epitomized the pursuit of knowledge and the application of that knowledge to solve real-world problems. His work continues to inspire a new generation of scientists at JILA and beyond, ensuring that his contributions to astrophysics and precision measurement will endure in the scientific community for decades.

Life After JILA: Tanya Ramond

While industry and academia tend to be the two main job trajectories after graduating with a Ph.D. or postdoctoral degree, some individuals combine aspects of these careers, like Tanya Ramond has in her role as Founder and CEO of Sapienne Consulting.

"As an independent consultant, I am driven by a deep passion for commercialization and product strategy in deep tech areas," Ramond explains. "These areas of technology are particularly challenging, often hardware-based, and heavily reliant on intellectual property. My expertise and enthusiasm extend to fields like quantum physics, optics, aerospace, and clean tech, inspiring those around me to push the boundaries of what is possible."

Ramond's journey towards Sapienne Consulting began when she graduated with her Ph.D. from JILA and the University of Colorado Boulder, studying with the late JILA Fellow Carl Lineberger. Ramond then transitioned to doing a postdoctoral degree at NIST. "I stayed in academia," Ramond remarks about that time. "But then decided that wasn't for me in the long term. So I then went into aerospace and worked at Ball Aerospace for ten years."

Tanya Ramond, CEO and Founder of Sapienne Consulting
Credit: Tanya Ramond

After her time at Ball, Ramond spent several years working at smaller companies and start-ups, learning more about the business development side of the tech industry. Ramond explains "Up to that point, I've been very much in more engineering, technical roles. But the pain point I saw was more around getting technologies into the market correctly, in ways that actually address problems, and where people will buy them."

Observing these issues inspired Ramond to use her scientific background, MBA, and more recently acquired business skills to encourage small companies and start-ups to develop effective use cases for their products.

Ramond's passions and ideas culminated in Sapienne Consulting in 2015, which offers innovation and commercialization services to small companies and start-ups. While a lot of Ramond's consulting is business-focused, she does find herself leaning on the skills she learned during her time at JILA.

"The level of scientific excellence that you are exposed to at JILA establishes a high bar for your career expectations and doing a postdoc at NIST was no different," Ramond elaborates. "It set the stage for an ability to spot amazing technology and amazing scientific talent. I carried this through to my current mission that world-class technology deserves to make a world-class impact in the marketplace and in society, and I want to make that happen for a range of customers across industries from aerospace to renewable energy."

Ramond's interest in the Colorado tech start-up industry has inspired her to advise various companies, including Aphelion Aerospace and other startups she mentors through the University of Colorado Research to Market program or TechStars accelerators. She also works as a consultant for the Boulder Small Business Development Center and is the Treasurer of the Colorado Photonics Industry Association.

"When I was at JILA, 'quantum' was not spelled with an upper-case 'Q' like it is now," Ramond states. "Today, the word is starting to spread about the world-class Quantum ecosystem we have here in Colorado—and have always had here in Colorado—and that also applies to other Colorado deep tech prowess such as aerospace and cleantech. It is exciting to start seeing the momentum finally build."

News and Awards

News

JILA and The University of Colorado Boulder Physics Department is Set to Host 2025 Conference for Undergraduate Women and Gender Minorities in Physics. The conference will bring approximately 150 students from the Midwest region to Boulder. The three-day regional conferences are sponsored by the American Physical Society (APS) and held annually at select institutions around the country.

JILA Hosts First Posterfest Since the COVID-19 Pandemic. JILA hosted its 8th annual Posterfest, marking a vibrant return to its traditional format after disruptions due to the COVID-19 pandemic. Held on April 18, this community event provided a platform for graduate students to showcase their research to the wider JILA community. Structured around three 30-minute presentation intervals, the event was designed to facilitate a broad range of discussions and allowed presenters and attendees to network, explore other projects, and enjoy refreshments together.

JILA Fellow Dana Anderson Speaks on Quantum Computing at the 2024 Conference of World Affairs. Anderson discussed the tangible applications of quantum technology that already impact our world, such as the atomic clock. He explained that these clocks can help with navigation but can also be used to measure Earth's gravity, which can help better monitor the effects of climate change, such as the melting of polar ice.

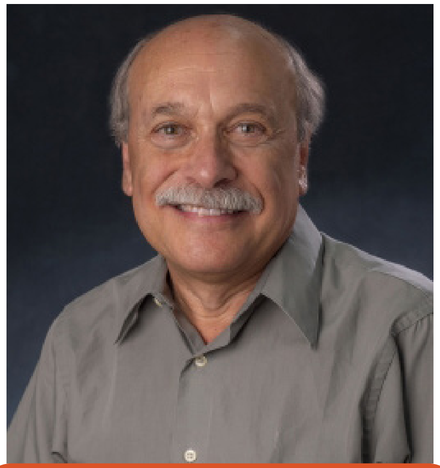
New "Humans of JILA" podcast episodes: PISEC part 1 and 2. These episodes highlight the Partnerships for Informal Science Education in the Community (PISEC) program. PISEC is an educational outreach program supported by JILA's Physics Frontier Center (PFC) and the University of Colorado Boulder. Its mission revolves around connecting university volunteers with local K–12 students.

Awards

JILA Undergraduate Research Assistant Aaron Barrios is Awarded a 2024 Jacob Van Ek Scholarship. This year, Barrios is among twenty-three distinguished students to receive one of the college's highest honors, reflecting his outstanding contributions and academic excellence in the fields of Physics, Astronomy, and Mathematics.

JILA Undergraduate Research Assistant Luke Coffman Awarded Prestigious Goldwater Scholarship. This award places Coffman among a select group of 438 students nationwide recognized for their significant achievements and potential in science, technology, engineering, and mathematics research.

JILA Fellow and Astrophysical and Planetary Sciences Professor Mitch Begelman is Elected to the National Academy of Sciences. This prestigious honor is bestowed in recognition of his distinguished and ongoing contributions to original research in astrophysics.



JILA Fellow and Astrophysicist Mitch Begelman has been elected to the National Academy of Sciences (NAS).
Credit: Glenn Asakawa

JILA Fellow and University of Colorado Boulder Physics professor John Bohn and JILA and NIST Fellow and University of Colorado Boulder Physics Professor Eric Cornell are awarded 2024 Physics Department Teaching Awards. These awards recognize their exceptional dedication to teaching and their profound impact on students at different levels of their academic journey.

University of Colorado Boulder

NIST National Institute of Standards and Technology
U.S. Department of Commerce

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 two John D. and Catherine T. MacArthur Fellows, Margaret Murnane and Ana Maria Rey. JILA's CU members hold faculty appointments in the Departments of Physics; Astrophysical & Planetary Science; Chemistry; Biochemistry; and Molecular, Cellular, and Developmental Biology, as well as in the School of Engineering.

The wide-ranging interests of our scientists have made JILA one of the nation's leading research institutes in the physical sciences. They 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 Science & Technology.

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