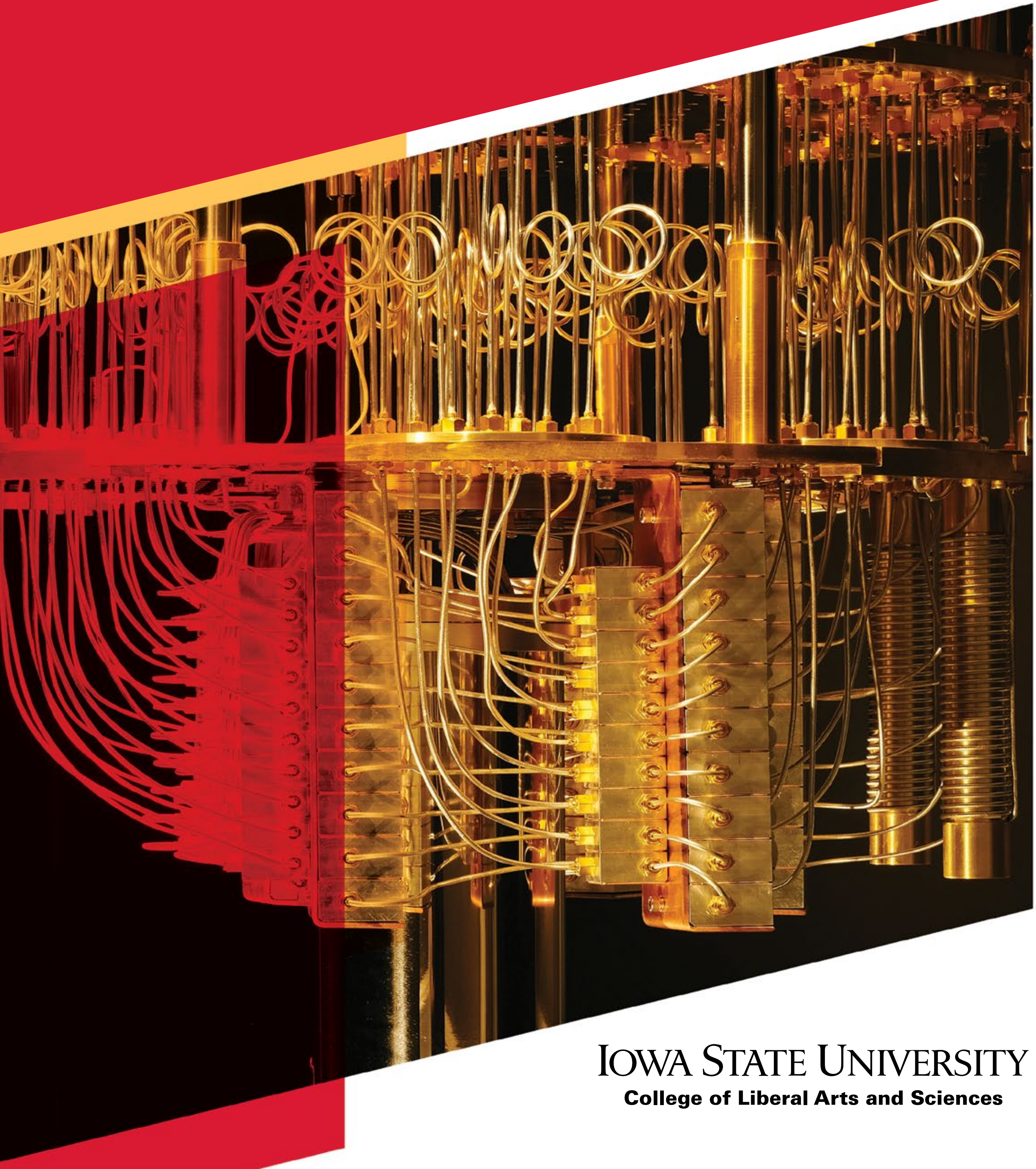
Quanta & Cosmos

Department of Physics and Astronomy | 2020 Newsletter



Iowa State University
College of Liberal Arts and Sciences

A Message from the Chair

The Public Research University across the United States has changed dramatically over the last few decades; its funding model, institutional priorities, business operations and the surrounding societal climate and expectations of higher education — all combined have led to significant headwinds in our pursuit of the core mission of teaching and research excellence. While as researchers, academics and teachers, we continuously drive change and strive for better ways of doing things, major decisions on organizational matters are made elsewhere — often outside the institution. The resilience, determination and commitment of our staff and faculty to Iowa State became more visible to me than at any other time in my memory (25 years) during the simultaneous implementation of new enterprise business software (Workday), and human resource system (Improved Services Delivery).

Our faculty have also proved their prowess for innovation and adaptation when faced with COVID-19 during spring break of 2020: within less than a week's time all of our courses were moved to online delivery. Comments from our students were overwhelmingly positive about their experiences taking their classes online for the remainder of the semester.

As a department of Physics and Astronomy, we are not insulated from other societal trends and perhaps the most impactful threat to our core mission was posed by the temporary recent Immigrations and Customs Enforcement order to revoke visas of international students should their education switch to online delivery only during the COVID-19 pandemic. Fortunately, this order was rescinded after significant pushback from business leaders and research university leadership across the US. However, significant damage is done; it may be difficult to overcome the perception that international students are less welcome in the United State than they were in the past. The combination of domestic and international students provide an environment that makes US higher education unique. Many of the international students build lives and start families in the US, become citizens, and form life-long friendships in our communities. Many of our domestic students make connections with research and business communities across the globe — forming important bonds with other nations to advance common interests and continue to contribute to leadership roles at the international level.

While some of you have experienced crises at the national and international level before, please be reminded that many of our students and postdocs are not only dealing with uncharted territory, but also are confronted with levels of uncertainty about their future not seen in several generations. While it may be difficult to form connections between our alumni across several generations, we will try to use technology to help make this connection: our next Physics and Astronomy Council Meeting will have a session open to all of our graduate students and postdocs.

Finally, in light of recent national events exposing social injustice and racial bias in the United States, I would like to reassure you that our values in the Department of Physics and Astronomy are in strong support of a diverse, equitable, ethical value driven and peaceful society — free of racial-bias. While we are only a small part of society as a whole, we can do our part in promoting these values through a firm and well-informed approach when encountering ignorant and incorrect statements about humans from other races, nations and/or sexual orientations.

My hope is that our department and Iowa State University will emerge from the current challenges as a strong research and educational institution. Inevitably this will require support for higher education at all levels of state and federal government. I would also like to thank you for your increased support especially in recent years!

Frank Krennrich

Frank Krennrich, Professor and Chair, Department of Physics and Astronomy
515-294-5442 | Krennrich@iastate.edu

COVER PHOTO
Quantum computers and accelerated discovery
https://www.flickr.com/photos/ibm_research_zurich/40645906341

Photo taken at 2018 ASCE (Credit: Graham Carlow)

OPPORTUNITIES TO GIVE

We hope that you would designate your contribution directly to the Department of Physics and Astronomy. Please feel free to call Frank Krennrich (515-294-5442), department chair, to discuss possibilities to donate or if you have questions about the different endowment funds.

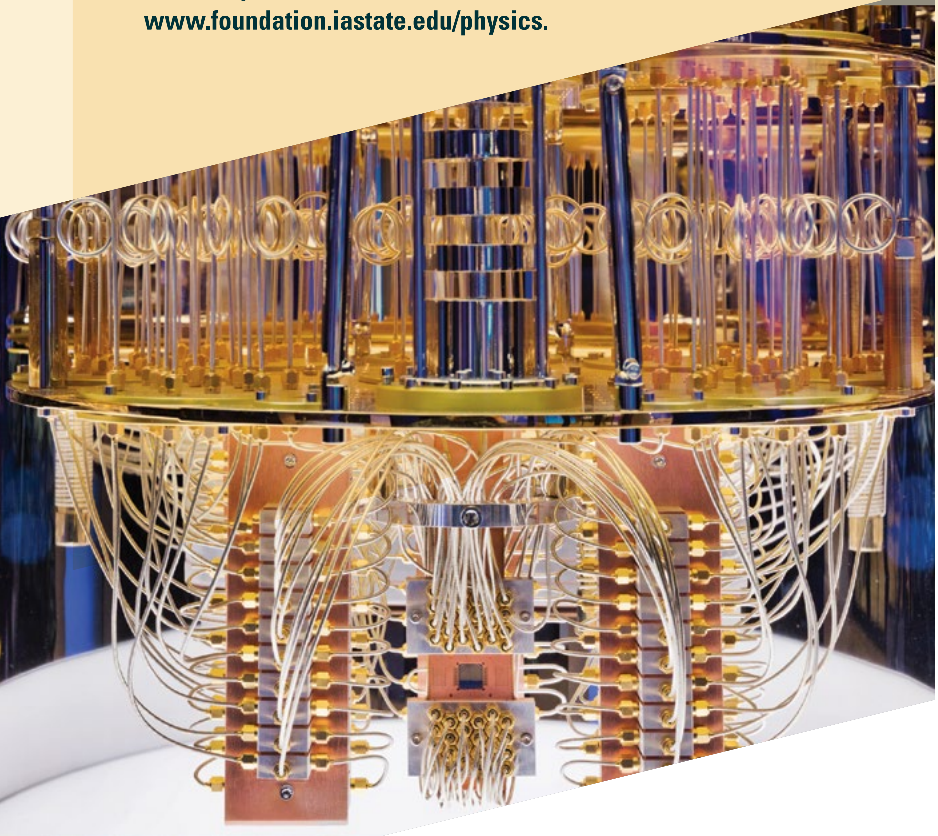
1) Contributions to the Physics and Astronomy Unrestricted Fund provide the department with the greatest flexibility to finance awards and projects (e.g., a theory coffee room).

2) Contributions to the Zaffarano Lectureship fund allow us to sustain the event over years to come.

3) Inaugural contributions to the Postdoctoral Prize Fellowship in Astronomy and Astrophysics will allow us to establish the fellowship fund.

If you are considering making a significant gift, you could establish a new endowed fund for a purpose that you designate—e.g., the Postdoctoral Prize Fellowship in Astronomy and Astrophysics. For details and guidance, please refer to Michael Gens, Executive Director of Development (call 515-294-0921 or email mgens@iastate.edu).

To donate online and designate your contribution directly to the Department of Physics and Astronomy, go to www.foundation.iastate.edu/physics.



The Electron-Ion Collider: A Nuclear Microscope *by John Lajoie*

Imagine for a moment if you could "image" the inside of an atomic nucleus in a way that was similar to getting an MRI or a CT scan at the doctor's office. That's exactly what a new machine, the Electron-Ion Collider (EIC), is being built to do – and it will revolutionize nuclear physics in the process.

The EIC, which is planned for construction at Brookhaven National Laboratory near the end of the next decade, will probe nuclei with beams of high-energy electrons. The energies will be so high that the electrons will interact electromagnetically with the inside the quantum fluctuations inside the neutrons and protons. These quantum fluctuations give the nucleon much of its character – they are key to determining its mass and spin, for example. This will allow nuclear physicists to probe hadronic matter - the "stuff" we and the world around us is predominantly made of – with unprecedented detail.

For example, we know that the mass of quarks only accounts for a small part of the mass of a proton or neutron. The small quark mass comes from the Higgs boson, a recently discovered particle at the Large Hadron Collider (LHC). While the Higgs boson is responsible for the mass of quarks, it cannot account for more than 90 percent of the mas of the visible matter in the universe. However, nucleons are much more than just quarks, they also contain gluons – *massless* particles that generate the force field that holds quarks together and are a dominant part of the quantum fluctuations in the nucleon. While gluons themselves are massless, they represent an energy density that we believe accounts for the remainder of the nucleon mass. The EIC will help nuclear physicists unlock how this works.

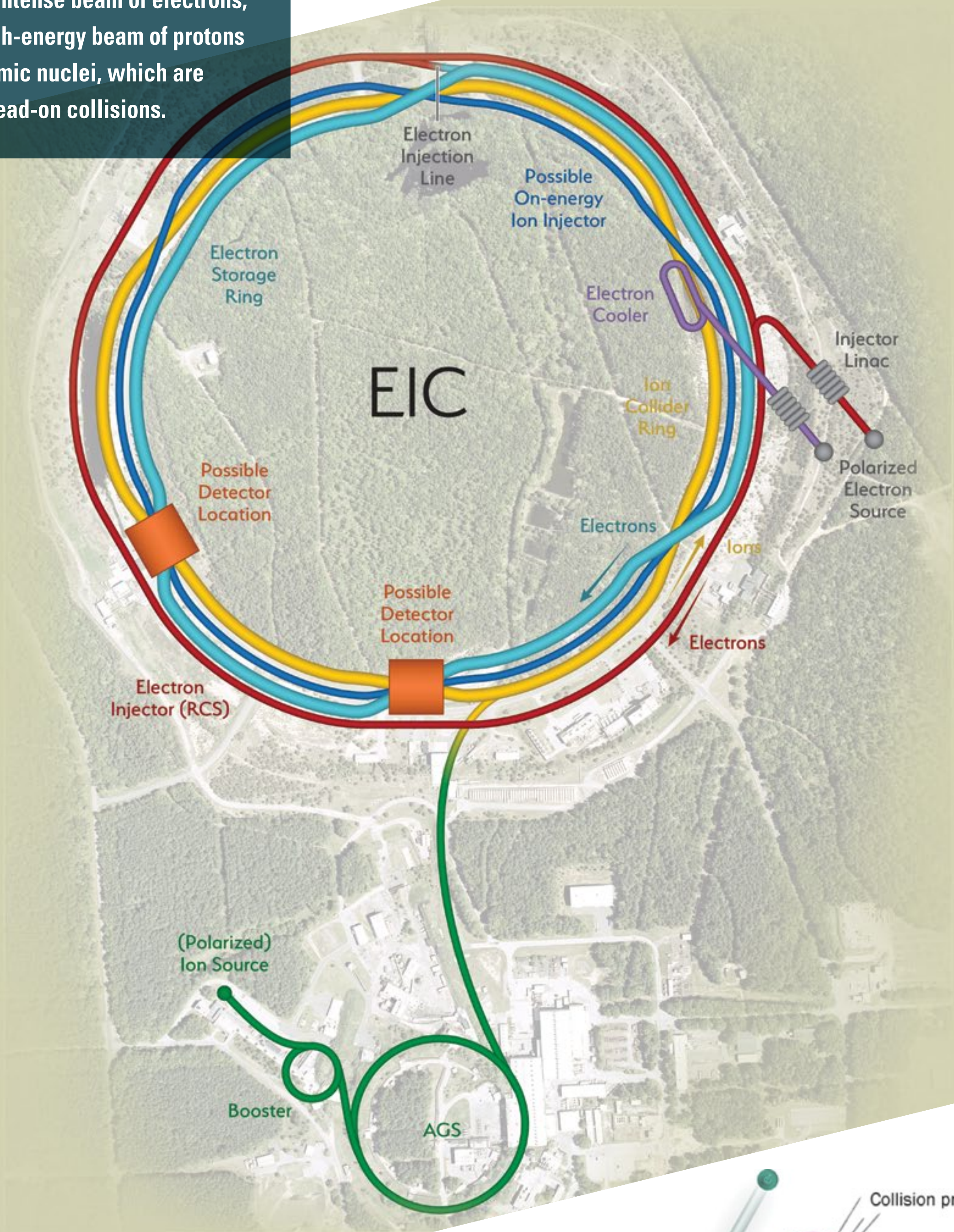
The collisions measured at the EIC will allow physicists to map the internal structure of nucleons and nuclei in many kinematic variables, creating multi-dimensional images of their structure. This unprecedented detail will allow physicists to study multi-particle correlations between quarks and gluons and their interplay with the vacuum of the strong nuclear force. For example, recent experiments at the Relativistic Heavy Ion Collider (RHIC, also located at BNL) suggest that the spin of the proton is carried by very small momentum gluons. A proton's spin is important in determining its optical, electrical and magnetic properties. Manipulating the spin of the proton with magnetic fields is how Magnetic Resonance Imaging (MRI) scans are done, yet we don't know how spin arises from a proton's complex internal structure. The EIC will provide the final pieces needed to understand this puzzle.

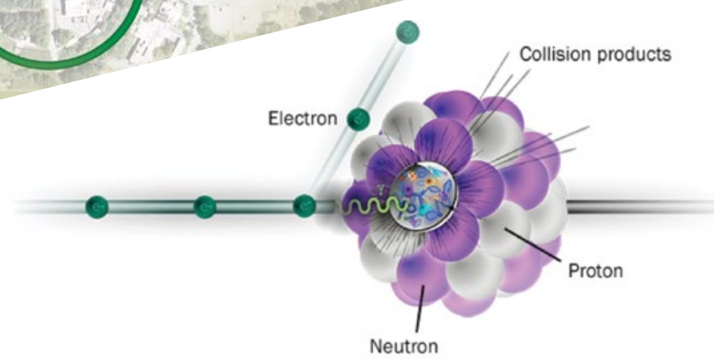
It's important to keep in mind that "big science" projects don't just benefit the scientists. The research and development of the technologies needed to realize the EIC have pushed the evolution of cryogenic magnets, radio-frequency cavities, and other detector components. These advances in technology will benefit high-tech industries from the manufacturing of computer chip the development of radioisotopes for medical diagnosis and treatment. Hundreds of students, engineers, and postdocs will be involved in the construction and operation of the EIC, gaining the technical skills to address out nation's greatest challenges.

The EIC project was given "Critical Decision 0", or CD-0 in Department of Energy (DOE) project-speak, late last year. This means that based on over a decade of studies and a National Academy of Sciences review the consensus of the Nuclear Physics community is that this new machine is necessary to make progress on these fundamental questions. When completed, it will be the only electron-nucleus collider operating in the world.

The Electron-Ion Collider will be a discovery machine for unlocking the secrets of the "glue" that binds the building blocks of visible matter in the universe. It will consist of two intersecting accelerators, one producing an intense beam of electrons, the other a high-energy beam of protons or heavier atomic nuclei, which are steered into head-on collisions.

Below: The Electron-Ion Collider will add an electron beam to the Realistic Heavy Ion Collider ring at Brookhaven National Laboratory in New York. The beam of electrons would scatter off a beam of atomic nuclei to extract the structure of the proton and neutrons within.





The low temperature and high pressure NMR laboratory *by Yuji Furukawa*

Nuclear magnetic resonance (NMR) technique discovered in 1946 is known as one of the important techniques to investigate the physical properties of materials from a microscopic point of view. The Department of Physics and Astronomy has a long history of utilizing NMR in condensed matter physics, with internationally prominent research groups led by Professors Richard Barnes (1956-1988) and Ferdinando Borsa (1989-2007). After joining the department in late-2008, Professor Yuji Furukawa has been conducting the NMR laboratory and has set up new four lab-built NMR spectrometers with 4 superconducting magnets (two 9 Tesla, 8.4 Tesla and 4.7 Tesla magnets), one electromagnet (1.5 Tesla), three ^{4}He cryostats, one ^{3}He-^{4}He dilution refrigerator, one lab-built high temperature cryostat and high pressure apparatus. This facility makes NMR measurements possible under multi-extreme conditions of the temperature range of T = 0.035 - 700 Kelvin, the pressure range of p = 0-25 kilo bar, and the magnetic field of H = 0 - 9 Tesla. This capability for NMR is only found in a few top-ranked NMR laboratories in the world. Utilizing the capability, we have carried out several research projects in internal collaborations with Professors David Johnston and Paul Canfield as well as international collaborations with many researchers from countries such as Japan, India, Italy, Russia and France. Here we describe a couple of interesting results obtained in the NMR lab.

(1) Ferromagnetic spin correlations in iron-based superconductors: After the discovery of high T_c superconductivity in iron pnictides in 2008, the interplay between spin fluctuations and the unconventional nature of superconductivity has been attracting much interest. From extensive experimental and theoretical works, stripe-type antiferromagnetic (AFM) spin fluctuations are believed to play an important role for the appearance of unconventional superconductivity. However, from our systematic ^{75}As NMR shift and spin-lattice relaxation rate measurements, we revealed for the first time the coexistence of stripe-type AFM and ferromagnetic spin correlations in both the hole- and electron-doped $BaFe_2As_2$ families of iron-pnictide superconductors and pointed out that the strong FM fluctuations compete with superconductivity. These results provided new avenues for future research for understanding the physical properties of iron-pnictide superconductors [1,2,3].

(2) New magnetic structure in the iron-based superconductor $CaK(Fe,Ni)_4As_4$: Iron based superconducting materials provide also another interesting playground in studying magnetic structure. Although theoretical studies proposed three possible magnetic states (stripe-type spin density, spin-charge density and spin-vortex crystal states), only the first two magnetic states have been reported. In collaboration with Prof. Canfield's group, we discovered for the first time the new magnetic phase, called "hedge-hog" spin-vortex crystal state in Ni-substituted $CaKFe_4As_4$ [4,5]. In addition, using ^{75}As NMR measurements, we found that the parent compound $CaKFe_4As_4$ is located at a hedgehog spin-vortex crystal AFM quantum critical point, which is avoided due to superconductivity. This is the discovery of a new type of AFM quantum criticality [6].

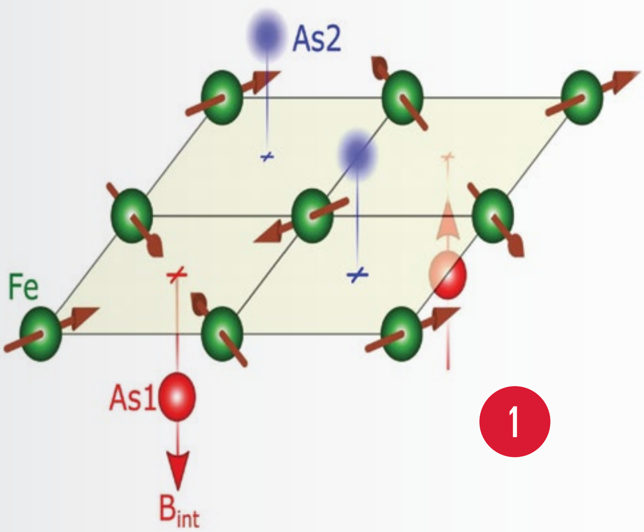
(3) Discovery of a new spin triplet superconductor UTe_2: We have carried out ultra-low temperature ^{125}Te NMR measurements down to 0.05 K on UTe_2 and we found no change of spin susceptibility in the superconducting state below T_c = 1.5 K. This provides strong evidence of spin-triple superconducting state in UTe_2. Our NMR data are the smoking gun for the discovery of the new spin-triplet superconductor [7].

Our group will continue to work on strongly correlated electron systems, especially focusing on unconventional superconductors and its related materials, and we also plan to develop NMR facility with magnetic fields greater than 9 T and a uniaxial strain apparatus.

[1] P. Wiecki et al., Phys. Rev. Lett. **115**, 137001 (2015).
[2] P. Wiecki, et al., Phys. Rev. B **91**, 220406(R) (2015).
[3] J. Cui, et al., Phys. Rev. B **94**, 174512 (2016).
[4] W. R. Meier, et al., njp Quantum Materials, **3**, 5 (2018).
[5] Q.-P. Ding, et al., Phys. Rev. B **96**, 220510(R) (2017).
[6] Q.-P. Ding, et al., Phys. Rev. Lett. **121**, 137204 (2018).
[7] S. Ran et al., Science **365**, 684 (2019).

Yuji Furukawa

Our group carries out NMR measurements to investigate the magnetic and electronic properties of materials, especially focusing on magnetism and superconductivity in strongly correlated electron systems, from a microscopic point of view.



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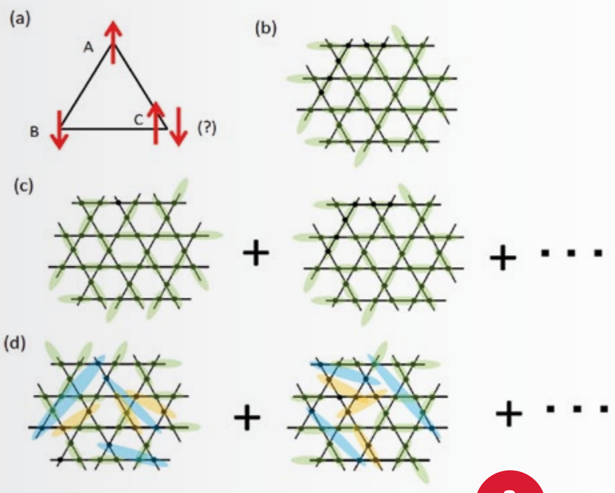

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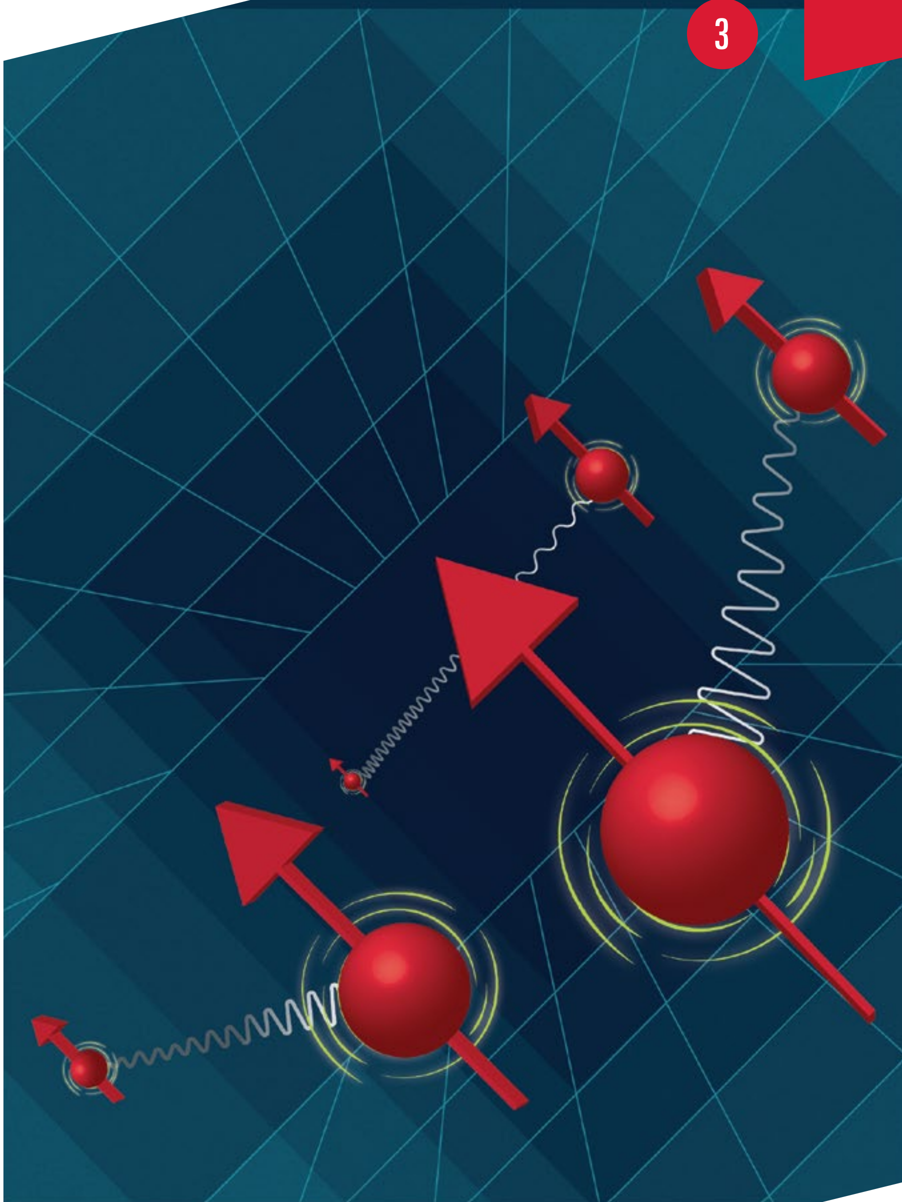
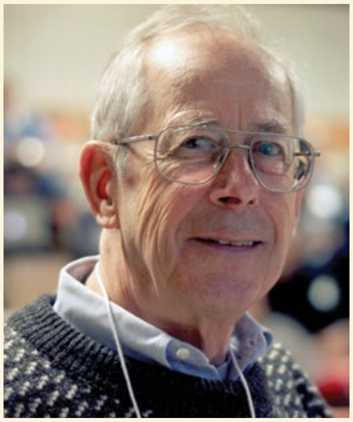


Figure 1: A photo of one of lab-built NMR spectrometers at the NMR lab.
Figure 2: The new spin structure called “hedge-hog” spin vortex crystal discovered in Ni-substituted CaKFe4As4 [W. R. Meier, et al., njp Quantum Materials, 3, 5 (2018)].
Figure 3: The image of a spin triple superconducting state discovered in UTe2 [S. Ran, et al., Science 365, 684 (2019)].

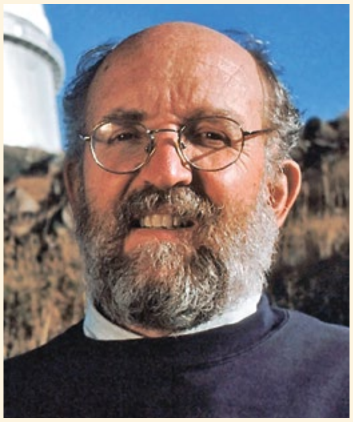
Nobel Prize 2019: the discovery of the universe

by Charles Kerton

The Nobel Prize in Physics for 2019 was shared by James Peebles, for his foundational work in theoretical cosmology, and the team of Michel Mayor and Didier Queloz, for their discovery of an exoplanet orbiting a solar-type star.



Jim Peebles
Photo by Juan Diego Soler



Michel Mayor
Photo by ESO (European Southern Observatory)

Didier Queloz
Photo by ESO (European Southern Observatory)

Many Nobel Prizes related to astrophysics have been given for particular discoveries, e.g., the discovery of the Cosmic Microwave Background (CMB) by Arno Penzias and Robert Wilson, or for the development of a new observational technique, e.g., the development of radio aperture synthesis by Martin Ryle. In contrast, Peebles' award was given for his lifetime work establishing the theoretical framework used in modern cosmology. In particular, much of his work explores the origin and growth of structure in our universe starting from temperature/density variations in the CMB to the formation and evolution of the cosmic web of galaxies (see Figure 1).

Peebles was co-author or lead author in the mid-1960s on some of the earliest articles describing the astrophysical implications of the newly discovered CMB. In the same volume of the Astrophysical Journal in which the CMB discovery is announced (v. 142 if you are curious), you can find his solo-authored paper describing the effect of this primordial radiation field on the formation of galaxies. From this beginning, he went on to publish hundreds of articles on various topics in cosmology.

Always a clear writer, Peebles is a great explainer of his field to both new students and to other physicists. Throughout his career, he has written numerous reviews of the field of cosmology, and his book, "Principles of Physical Cosmology", published in 1993, became the standard introduction to the field for many astronomers. It is on my bookshelf, and it is still worth reading!

The 1995 discovery of a planet around the sun-like star 51 Pegasi by Mayor and Queloz opened up an entirely new field of research: the detection and characterization of extrasolar planets. The Jupiter-like planet they discovered was detected by measuring the Doppler shift of spectral lines in the spectrum of 51 Pegasi as the star-planet system orbited around a common center of mass. This radial velocity technique is simple in principle, but, in practical terms, detection of extrasolar planets is extremely challenging. For example, a Jupiter-Sun system results in stellar motions of around 12 m/s, and this small signal is spread out over a multi-year period reflecting the orbital period of the planet. Because of these challenges, high-resolution astronomical spectrometers, such as the ELODIE instrument on the Observatoire de Haut-Provence 1.95-m telescope used by Mayor and Queloz, were fiber-fed echelle systems located in climate-controlled areas away from the main telescope.

To the surprise of Mayor and Queloz, and the astronomical community in general, the exoplanet they discovered had a radial velocity signature of over 50 m/s, and a period of just over four days, meaning the planet was extremely close to its parent star – about 8 times closer than Mercury is to our Sun. The presence of a Jupiter-like planet so close to a parent star was completely unexpected, but the planet 51 Pegasi b turned out to be only the first of many other so-called "Hot Jupiters" (see Figure 2).

The discovery of 51 Pegasi b opened the floodgates of exoplanet detection and characterization. It also increased interest in the study of how planets form within a circumstellar disk of material. Our view of exoplanets has changed tremendously from this starting point. We now know that planets are truly common, outnumbering stars, and that there is a tremendous diversity in solar system architectures. The radial velocity method remains a crucial observational technique as it is the only way to get planetary masses, and teams are developing even higher sensitivity spectrometers with the hope of detecting even Earth-mass planets.

The Nobel Prize in Physics 2019 was awarded for contributions to our understanding of the evolution of the universe and Earth's place in the cosmos.

Figure 1. WMAP image of the Cosmic Microwave Background showing temperature fluctuations of +/- 200 microKelvin. Peebles worked on the theory describing how these fluctuations relate to the formation of structure in our universe. Image credit: NASA/WMAP science team.

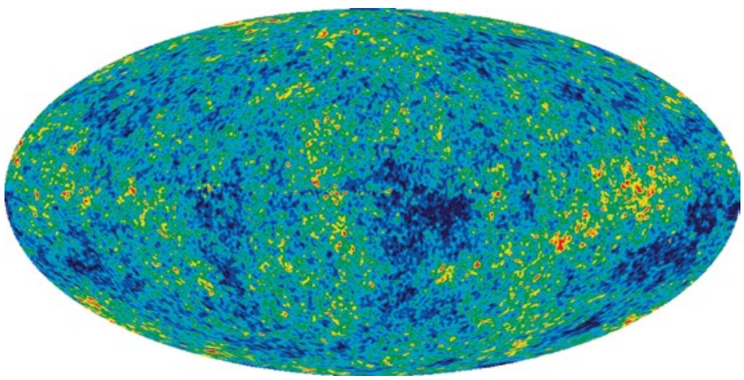


Figure 2. Artist's conception of the Jupiter-like exoplanet 51 Pegasi b, which was detected by Mayor and Queloz using the radial velocity technique. The proximity of the exoplanet to its parent star was completely unexpected. Image credit: NASA/JPL

Physics 551—Physics in the Era of High Performance Computing *by Jake Simon*

From running Monte Carlo simulations on desktops to launching multi-node jobs on campus supercomputers, using computers for scientific research is not only commonplace, it is necessary. The Department of Physics and Astronomy is no exception, as one of its primary goals is to train the next generation of students in the use of computational techniques.

This was the mindset that went into the redesign of Physics 551, the graduate level computational physics course taught this Spring 2020 semester. Newly hired Assistant Professor Jake Simon led the effort in redeveloping this course, and in doing so, had several key objectives in mind.

First, it was his primary goal to train students to use computational tools ranging from laptops to 100,000 core supercomputers at national facilities to tackle complex problems in physics. Ultimately, he developed the course with a practical approach in mind, moving away from pure lecture format and designing many in-class activities for students to work on during class. Often included with these assignments were descriptions of how what they were learning could be applied in actual research projects.

But beyond just the training aspect, Prof. Simon also aimed to teach the students exactly how the tools he presented were designed in the first place. For example, it is very useful to know how to run a Monte Carlo integration, but to actually know how it works at its core is even more powerful. Despite the prevalence of many pre-developed tools at our disposal these days, it is still very important to know how those tools work in order to trust the result they give you.

Finally, along similar lines, Simon has continually emphasized the importance of testing code and learning how to characterize errors. Nearly all numerical techniques are approximate in some way, and knowing how to interpret the potential pitfalls associated with such approximation is a must-have skill for any scientist using computational techniques.

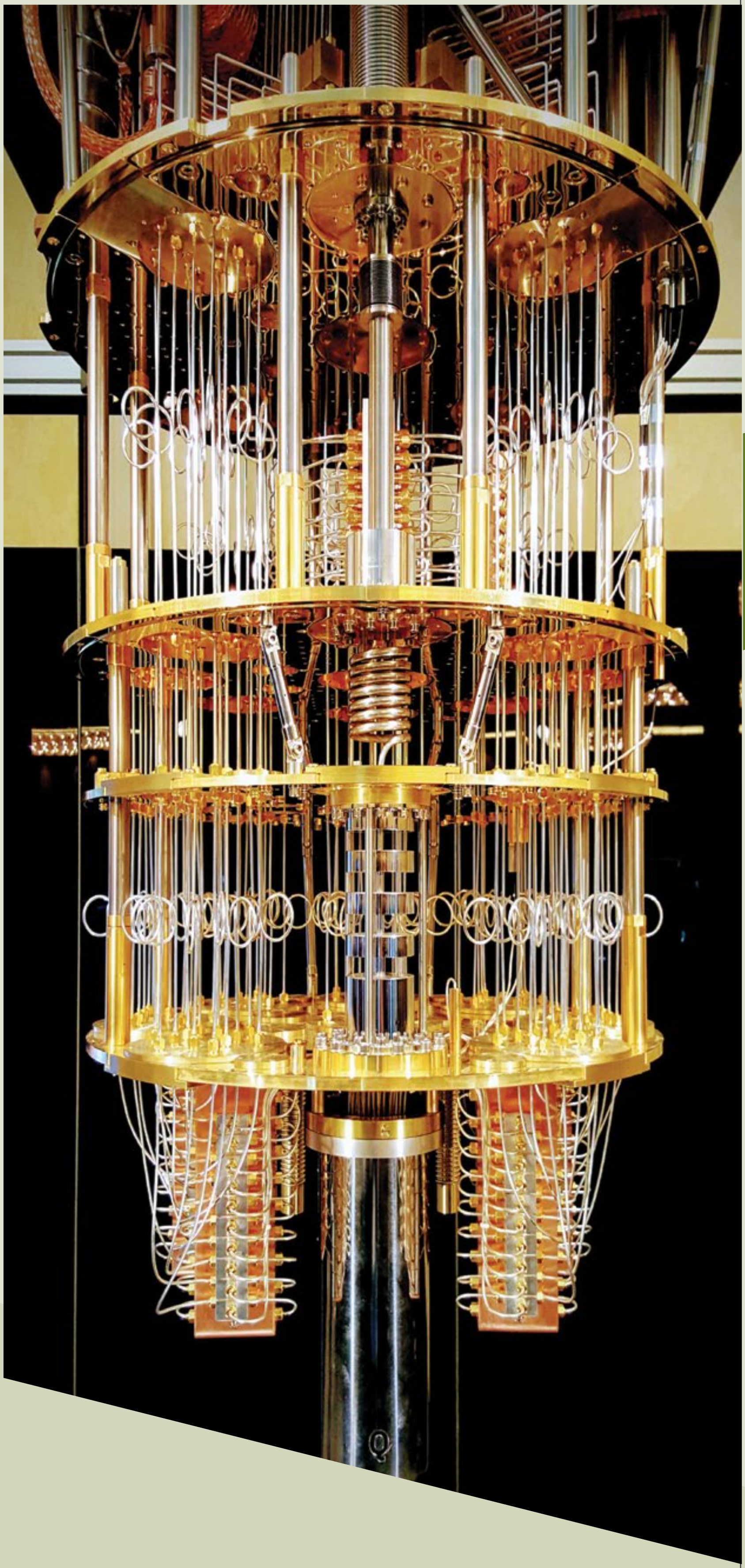
Simon hopes to continue to build on this course the next time he teaches it, as it is slated to expand from a 2-credit course to a 3-credit course in Spring 2021. Ultimately, the hope is to make this an integral class for anyone using computational techniques as part of their research, if even to create a simple python script to calculate an integral.

New Course on Quantum Computing Debuts in Spring 2021 *by Thomas Iadecola*

The Department of Physics and Astronomy is excited to introduce a new course, "PHYS 422X/ 522X: Foundations of Quantum Computing," in the spring semester of 2021. This course comes at an opportune time when interest in quantum computing is expanding rapidly. The number of jobs in quantum technology has been growing steadily, and there is a market for both hardware and software development. This growth has been driven both by large corporations—including Google, Microsoft, IBM, and Honeywell—expanding into this new domain, and by numerous startups, including Rigetti and IonQ, that bridge academia and industry. More fundamentally, quantum information theory provides a modern perspective on cutting-edge problems in quantum physics across disciplines, from condensed matter and solid state physics to high energy physics and cosmology.
This course thus provides a unique way to meet the academic needs of our students, whether they plan to pursue careers within or outside academia.

The course is aimed at advanced undergraduate and beginning graduate students, with the goal of understanding how quantum mechanics can be applied to solve hard computational problems. The course material is inherently interdisciplinary; it will include a primer on quantum mechanics designed to be accessible to students from other departments with the appropriate mathematical background, as well as exposition on the theory of classical computation that is not included in the standard physics curriculum. The course will synthesize these topics in an introduction to quantum algorithms, while also touching on physical realizations of quantum computers. A final project will engage students with frontier topics in the field that are tailored to their interests and academic background, laying the foundation for them to apply their new knowledge in a variety of future endeavors.

As the birthplace of the (classical) digital computer, the Department of Physics and Astronomy is deeply intertwined with the history of computing itself. It is thus fitting that the department will host Iowa State's first course offering on this new paradigm for computation.



NI NI

Ni Ni got her Ph. D. degree from Iowa State University in 2009 with a major in Physics and a minor in Material Science and Engineering. She received her training in Paul. C. Canfield's group at ISU on single crystal growth and characterization. Before she joined the faculty at University of California, Los Angeles in 2013, she worked as a postdoctoral researcher at Princeton University from 2009 to 2012 and then a Marie-Curie distinguished postdoctoral fellow at Los Alamos National Laboratory.

Ni Ni is currently an associate professor of the Department of Physics and Astronomy at UCLA. She is a recipient of the Early Career Research Award from the U.S. Department of Energy. She leads a diverse research program including the characterization of physical properties and structures of materials through thermodynamic, transport, X-ray and neutron measurements, with an emphasis on the design, synthesis and crystal growth of new materials. Recently, the research of her group focuses on the discovery and investigation of new topological, magnetic and superconducting materials.

Besides work and taking care of two energetic kids, she enjoys reading, sewing and sci-fi/disaster movies. She is really grateful for the wonderful, collaborative and productive time she spent at ISU.

JOHN WEAVER

Professor Weaver received his BS degree in physics from the University of Missouri in 1967 and his Ph.D. in solid state physics from Iowa State University with David Lynch in 1972. He was on the staff of the Synchrotron Radiation Center at the University of Wisconsin-Madison until 1982 when he moved to the University of Minnesota. He joined the faculty of the University of Illinois in 2000, and served as head of the Department of Materials Science and Engineering. He was named the Donald B. Willett Professor at the University of Illinois in 2003. He became Professor Emeritus in 2014. He and his wife Mary reside near Burlington, Vermont, close to family.

Weaver is a Fellow of the APS, the AVS, and the AAAS. In 1994-95 he held the Amundson Professorship at Minnesota and an Alexander von Humboldt Senior Distinguished U.S. Scientist Award to work at the Fritz-Haber-Institut in Berlin. He was also a University Professor at Tohoku University. In 1995 he was awarded the Royal Society Kan Tong Po Professorship at the University of Hong Kong. Research & Development Magazine named him their Scientist of the Year in 1997, and Iowa State University recognized him with its Distinguished Achievement Citation in 1998. In 1999, he was Chief Judge for Singapore's National Science Talent Search, and he received the Medard W. Welch Award of the American Vacuum Society ["for his seminal contributions to the atomic-level understanding of thin-film growth, interfacial interactions, and etching"]. He gave the Peter Winchell Lecture at Purdue University in 2000 and the Kodak Distinguished Lecture at Rensselaer Polytechnic Institute in 2003.

Weaver's research activities focused on the physics and chemistry of surfaces, interfaces, and nanostructures. He is the author of ~490 refereed papers, including 21 chapters and monographs on valence state photoemission, metal/semiconductor interfaces, high temperature superconductors, fullerenes, semiconductor etching, nanostructured materials, and buffer-layer-assisted growth.

Daniel Zaffarano Lectureship

The next Daniel Zaffarano Lectureship will be held at Iowa State University in 2021. This lecture series was established in 2015 and was made possible by the generosity of our alumni. The purpose of the lectureship is to bring an outstanding scholar to central Iowa and Iowa State University each year to speak on a topic in the physical sciences and discuss relevant technical applications, philosophical implications, and relation to broader human affairs.

The tradition of bringing prominent scientists to Iowa State University dates back to the John Franklin Carlson Lectures (1955–1969), which were inaugurated (see picture) by J. Robert Oppenheimer (1955), followed by Niels Bohr (1957), Percy W. Bridgman (1957), and others. The Zaffarano Lectureship is an effort by the Department of Physics and Astronomy to revive this fine tradition.

The inaugural Zaffarano Lecture was given by Sir John Pendry from Imperial College London on the topic of metamaterials, the physics of invisibility, and practical applications such as an "invisibility cloak." The following year Professor Roger Blandford from Stanford University discussed the progress on detecting black hole mergers with gravity waves and their relation to gamma ray astronomy and relativistic astrophysics. More information about the past events can be found at *http://www.physastro.iastate.edu/events/zaffarano-lecture*.

2021 ZAFFARANO LECTURE

Wendy L. Freedman

TBD *(see department website for details)*

The next Zaffarano Lecture will be given by Professor Wendy L. Freedman. She is the John & Marion Sullivan University Professor of Astronomy and Astrophysics at The University of Chicago, and will be giving the next Zaffarano Lecture on the subject of observational cosmology. Prof. Freedman is well known for her work on the Hubble constant and her tenure as director of the Carnegie Observatories in Pasadena and the Las Campanas in Chile. She is a member of the National Academy of Sciences, she received the Dannie Heineman Prize for Astrophysics and she is a co-recipient of the Gruber Cosmology Prize. Her work and leadership has resulted in great improvements of the accuracy of the cosmic distance scale, essential for constraining fundamental cosmological parameters.

WENDY LAUREL FREEDMAN

Wendy Laurel Freedman (born July 17, 1957) is a Canadian-American astronomer, best known for her measurement of the Hubble constant, and as director of the Carnegie Observatories in Pasadena, California, and Las Campanas, Chile.

John & Marion Sullivan University Professor of Astronomy and Astrophysics at The University of Chicago

Her principal research interests are in observational cosmology, focusing on measuring both the current and past expansion rates of the universe, and on characterizing the nature of dark energy.

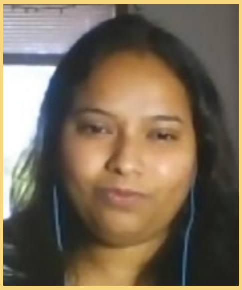
Freedman has been elected a member of the US National Academy of Sciences,[8] the American Philosophical Society, a Fellow of the American Academy of Arts and Sciences, and a Fellow of the American Physical Society.[1]In 2009 Freedman was one of three co-recipients of the Gruber Cosmology Prize.[11] She received the 2016 Dannie Heineman Prize for Astrophysics,[12] awarded jointly by the American Institute of Physics and the American Astronomical Society, "for her outstanding contributions and leadership role in using optical and infrared space- and ground-based observations of Cepheid stars, together with innovative analysis techniques, to greatly improve the accuracy of the cosmic distance scale and thereby constrain fundamental cosmological parameters."

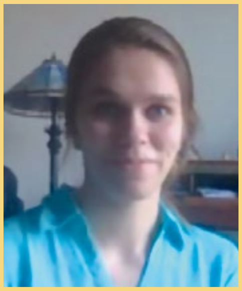
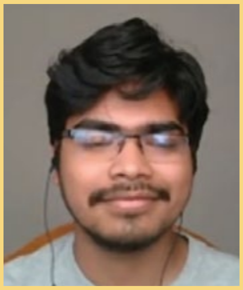
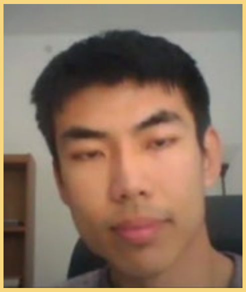
Departmental Awards 2020

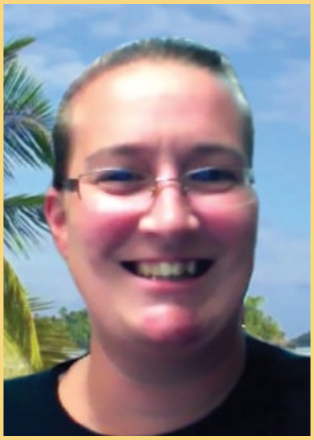
GRADUATE COLLEGE TEACHING EXCELLENCE AWARD

Scholarship award of $150 and the book entitled *What is Real? The Unfinished Quest for the Meaning of Quantum Physics* by Adam Becker.

From left to right: Atreyee Das, Farhan Islam, Elizabeth Krenkel , Suvadip Mandal, and Jian Wu.
Not shown: Noah Applegate, Lars Sivertsen



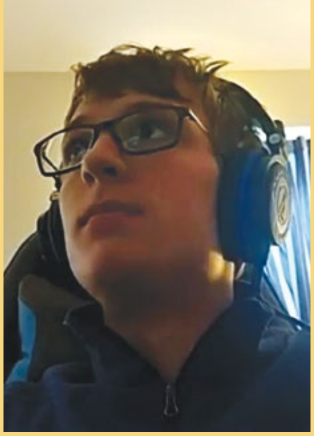


DEPARTMENT OF PHYSICS AND ASTRONOMY SUPERIOR SERVICE AWARD

Presented on behalf of the faculty of the Department of Physics and Astronomy to recognize superior service by the scientific and support staff of the department. This recognition is a monetary award of $200 and engraved plaque. This year's recipients are Theresa Birch *(shown above)* and Roy McKay.

JUN YE AND HUIQUING WANG AWARD

The Jun Ye and Huiquing Wang Award in Physics is given to the junior physics majors that have the highest cumulative grade point average. This year's recipients will each receive the $2,000 award and are John Mobley *(shown above)* and Joshua Slagle.



LEGVOLD AWARD

The Sam Legvold Award was set up in memory of a former faculty member, Dr. Sam Legvold. It is presented each year to a junior physics major to recognize outstanding academic performance and to provide funds for the senior year. Each award consists of a scholarship award in the amount of $1,000. This year's recipients are Aaron Bendickson and Evan McKinney *(shown above).*

They are recognized by the Department of Physics and Astronomy as an outstanding junior among our physics majors.

WILLIAM W. LANG SCHOLARSHIP

This award is established to support students majoring in Physics in the Department of Physics and Astronomy, demonstrating financial need as determined by the Office of Student Financial Aid, and having a high academic merit based on academic achievement. Preference is given to students who are residents of the State of Iowa as permitted by federal and state law, and University policy. A scholarship in the amount of $1,000 is awarded to Lillian Uhl *(shown above)* and Charles Howell.

DEAN'S LIST

- Donia Mansoor A. Alzayer
- Ethan Patrick Beacom
- Emmit Tyler Benitez
- Jacqueline R. Blaum
- Christopher Thomas Bramel
- John Michael Bunney
- Benjamin G. Burdick
- Daniel Patrick Buser
- Andrew Marshall Chatman
- Sean Michael Donnelly
- Cody James Durbin
- Kiley Ann Fridley
- Alexander Matthew Gale
- William B. Huynh
- Elisa Carolin John
- Keaton Jacob Kline
- Noah C. Kutz
- Zachary Tyler Lang
- Paige Rae Leeseberg
- Liam Gregory McDermott
- Sam C. Minier
- John Mobley
- Matthew Elton Neller
- Michael Robert O'Brien
- Wyatt S. Peterson
- Jensen Petros
- Matthew T. Pham
- Emily G. Pottebaum
- Samuel Scott Roberts
- Tyler Jesse Rodriguez
- Till S. Schaeffeler
- John Louis Schmidt IV
- Nicholas Timothy Schmidt
- Patrick James Stanley
- Kenneth Reid Stratton
- Sadie G. Welter

QIMING LI AND XIAOSHA GRADUATE SCHOLARSHIP FOR EXCELLENT RESEARCH IN PHYSICS

Qiming Li and Xiaosha Graduate Scholarship for Excellent Research in Physics is a new award at the Department of Physics and Astronomy. It is given to a graduate student for outstanding research performed at ISU as evidenced by the nominations of at least three faculty members and strong publication record among other requirements. The first recipient of this award is Chirag Viswani who is conducting his research under the supervision of Prof. Jigang Wang. Chirag's main research interest is in topology-enabled quantum logic and information science. He works on establishing topological control principles driven by quantum coherence. Chirag's most important result is a paper on "Hybrid Higgs Modes by Light-Controlled Interband Quantum Entanglement" published in Nature. Chirag has already acquired international reputation for breaking new grounds in driven quantum systems in topological matter, superconductor and semiconductors.

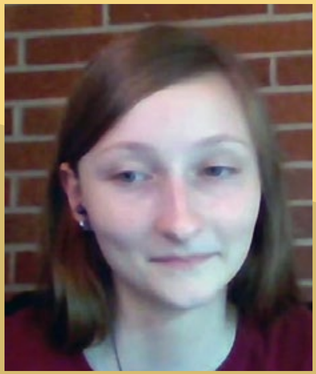
MOST VALUABLE INSTRUCTOR AWARD

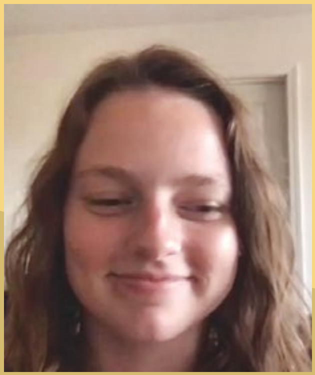
This year's recipient is Rebecca Flint.

Award was presented on behalf of the graduate students by Grad Student Representative John Wilde.

GENE RUBY SCHOLARSHIP

This award is established in memory of Gene Ruby, twin brother of Dean Graham Ruby. Dean attended Iowa State College in 1950-1953 and received his B.S. in 1953, majoring in Physics. The recipient of this award is a junior or senior enrolled in the Department of Physics and Astronomy, based on academic achievement. A scholarship in the amount of $2000 per is awarded to each of the following students: Aaron Bendickson, William Huynh, Linsey Kitt *(below left)*, Gwendolyn Koop, Wyatt Peterson, Tyler Rodriguez, Sadie Welter *(below right)*, and Jakob Williams.





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