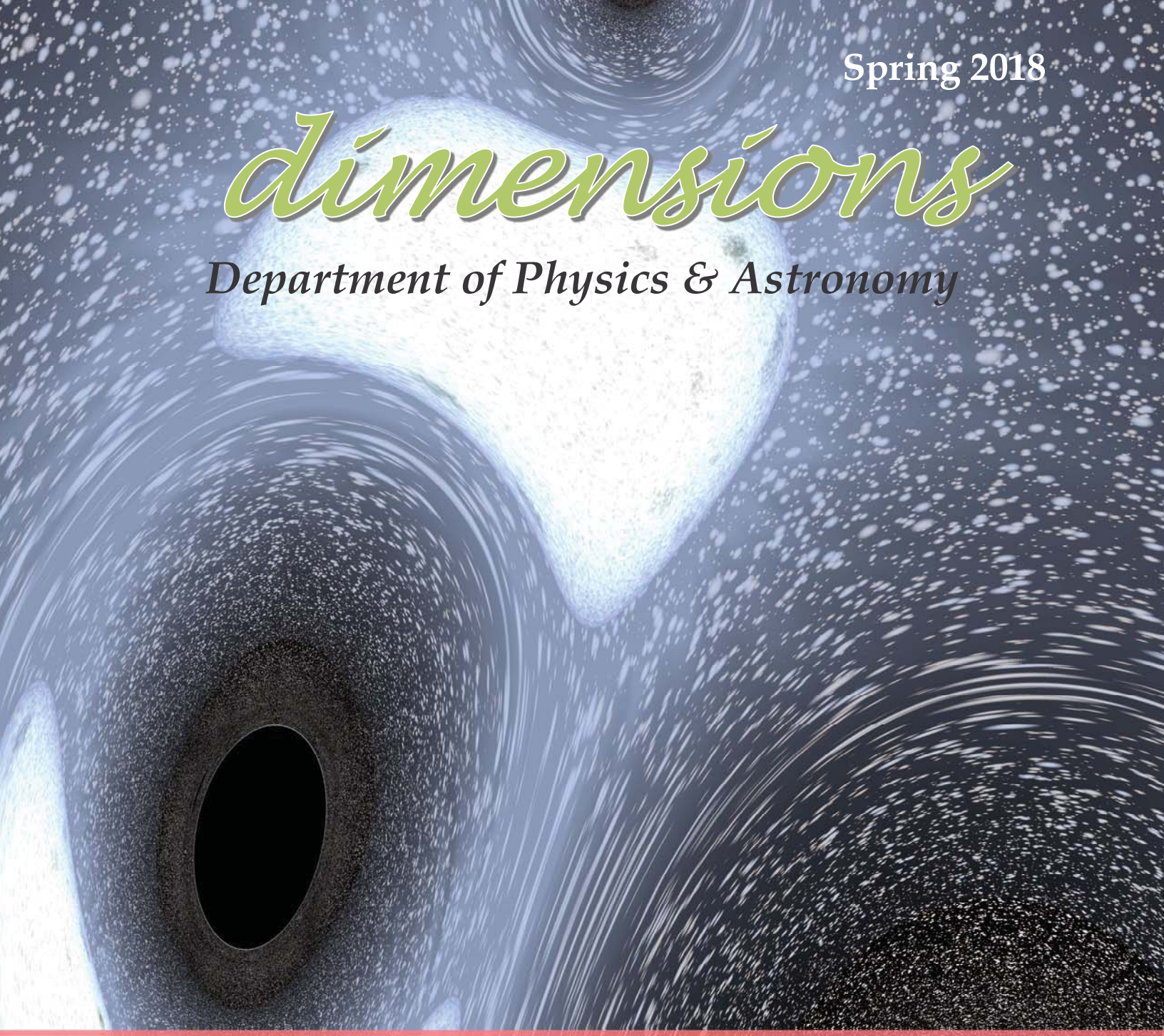


Spring 2018

dimensions

Department of Physics & Astronomy

In this issue:

Northwestern University

On the cover:

In late 2015, LIGO discovered gravitational waves emitted during the merger of two very distant black holes (BHs), confirming Einstein's century-old prediction. Astrophysicists are now debating: are such BHs more often born bound together, or do they find each other later in life? This image depicts the latter scenario, within a computer simulation. Three BHs and one normal star are engaged in a gravitational dance within the heart of a dense globular star cluster (which contains hundreds of BHs and nearly a million stars). The encounter will leave two of the BHs bound together, to later spiral in and merge, releasing gravitational waves. The very strong gravity near the BHs bends the (normally straight) paths taken by the starlight, a phenomenon called "gravitational lensing". Without the BHs, we would see a bright nearby blue-ish star straight ahead with a nearly uniform field of smaller, more distant, stars in all directions.

Faculty News

Vicky Kalogera Wins 2018 Dannie Heineman Prize administered by the American Institute of Physics (AIP) and the American Astronomical Society (AAS) for Astrophysics for her ground-breaking work studying compact objects, including black holes, neutron stars and white dwarfs in astrophysical systems.

Vicky Kalogera was awarded the Daniel I. Linzer Distinguished University Professor in Physics & Astronomy at the Weinberg Investiture Ceremony on January 31, 2018.

Congratulations to **Vicky Kalogera** on her election to the National Academy of Sciences.

Claude-André Faucher-Giguère and postdoctoral fellow Alexander Richings formu-late surprising new hypothesis for the origin on molecules in environments close to massive black holes.

Claude-Andre Faucher-Giguere, named 2018 Cottrell Scholar. Congratulations to Claude-Andre Faucher-Giguere for funding awarded to his proposal, "The Physics, Observational Signatures, and Consequences of Galactic Winds Driven by Active Galactic Nuclei."

The **Gabrielse, Geraci, Odom**, and **Stern** labs occupy 1 million square feet of new research space for their pioneering research.

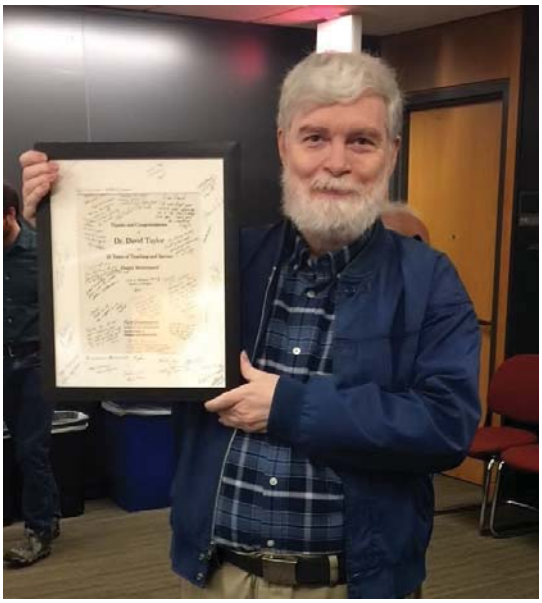
Gerald Gabrielse's research is featured in *"Nature, International Journal of Science"* which discusses how tabletop experiments could find evidence of new particles, offering a glimpse beyond the standard model.

Professor Gabrielse was also awarded the Board of Trustees Professor at the Weinberg Investiture Ceremony.

Enectali Figueroa-Feliciano was featured in the Northwestern Student Affairs blog as the Faculty in Residence at the Bobb-McCulloch-Goodrich residential community which has over 400 residents across its buildings.

Thank you Professor Taylor

After serving Northwestern University for 29 years, Professor David Taylor will be retiring at the end of August 2018. Professor Taylor received his PhD from the University of Maryland in 1983, and worked at the Physical Review as an Assistant Editor from 1984 to 1989, before coming to NU in October 1989. We all wish him the very best!



2018 Rapid Fire Research

Congratulations to the winners of this year's Rapid Fire Research. We thank everyone who participated in this event!

First Place

Cody Dirks - *"Carbon in the Interstellar Medium"*

Runners Up

Kyle Kremer— *"LISA Sources in Milky Way Globular Clusters"*

Dylaan Cornish (undergraduate) —*"The Host Galaxies of Short Gamma-ray Bursts"*

Special Thanks to our Donors

The Department of Physics and Astronomy would like to sincerely thank all of our donors who contribute greatly to our mission.

Our Department currently has 34 graduate faculty and 12 faculty at other ranks (instructional and research faculty). Our graduate program generally has about 100 graduate students and 30 full-time Postdoctoral Research Fellows associated with it, along with a varying number of Visiting Scholars and other distinguished guests. In most years, we have about 60 undergraduate majors in our department, many of them working in our research programs.

Selected Publications and Invited Lectures

"Sensitive Dependence on Network Structure: Analog of Chaos and Opportunity for Control" **Adilson E. Motter & Takashi Nishikawa**, SIAM News: Newsjournal of the Society for Industrial and Applied Mathematics, April 2, 2018.

A.E. Motter and M. Timme, Antagonistic phenomena in network dynamics, Annu. Rev. Condens. Matter Phys. 9, 463 (2018) [https://www.annualreviews.org/doi/10.1146/annurev-conmatphys-033117-054054]

Faucher-Giguère, C.-A. 2018, "Recent progress in simulating galaxy formation from the largest to the smallest scales," Nature Astronomy, DOI: 10.1038/s41550-018-0427-y [https://www.nature.com/articles/s41550-018-0427-y]

Richings, A. J. & Faucher-Giguère, C.-A. 2018, "The Origin of Fast Molecular Outflows in Quasars: Molecule Formation in AGN-driven Galactic Winds," MNRAS, 474, 3673 [https://doi.org/10.1093/mnras/stx3014]

Seth Group "Hyperon Form Factors and Di-quark Correlations" S. Dobbs , Kamal K. Seth, A. Tomaradze, T. Xiao, and G. Bonavicini, *Phys. Rev. D* 96, 092004 (2017).

Seth Group "Precision Measurement of the Hadronic Contribution to the Muon Anomalous Magnetic Moment" T. Xiao, S. Dobbs, A. Tomaradze, Kamal K. Seth, and G. Bonavicini, *Phys. Rev. D* 97, 03212 (2018).

Frederic Rasio's former PhD student Carl Rodriguez, now a Pappalardo Fellow in Physics at MIT, published his paper recently in Physical Review Letters and received strong recognition within the press [https://www.bostonglobe.com/metro/2018/04/11/black-holes-can-multiply-their-own-massive-star-clusters-mit-researchers-say/Ce9YTSURr7JT3TDDQIBZCL/story.html].

"ALMA Detection of Bipolar Outflows: Evidence for Low-mass Star Formation within 1 pc of Sgr A*" Farhad Yusef-Zadeh et al. The Astrophysical Journal Letters, Volume 850, Number 2 http://iopscience.iop.org/article/10.3847/2041-8213/aa96a2/meta

"Formation of precessing jets by tilted black hole discs in 3D general relativistic MHD simulations" Sasha Tchekhovskoy et al. Monthly Notices of the Royal Astronomical Society: Letters, Volume 474, Issue 1, 11 February 2018 [https://doi.org/10.1093/mnrasl/slx174]

Dearborn Observatory Visiting Schedule

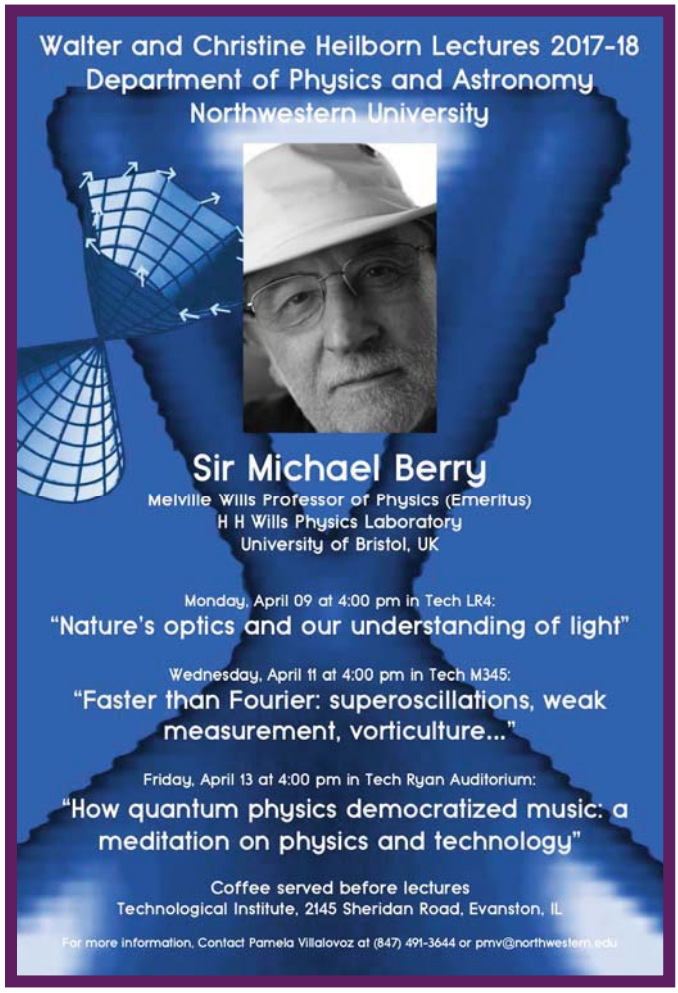
Spring/Summer Hours (April-September)

9-10 pm: One hour session by reservation only. Your group will be able to use the telescope for the full hour.

10-11 pm: Walk-ins are welcome, but space in the dome is limited.

There is no charge for these tours; however, we do require a refundable deposit for groups of 10 or more. Additionally, the Observatory is available for private viewing events on other evenings. Reservations may be requested online at http://www.physics.northwestern.edu/about/dearborn-observatory/. For more information, please contact Yas Shemirani at 847-491-7650.

Heilborn Lectures April 2018



Since 2001, the Department of Physics & Astronomy has invited distinguished scientists to deliver lectures supported by the Walter and Christine Heilborn fund.

This year the lectures were held the week of April 09-13, 2018. Our guest lecturer was **Sir Michael Berry**, Melville Wills Professor of Physics (Emeritus) and Senior Research Fellow in HH Wills Physics Laboratory.

After graduating from Exeter and St Andrews, Michael Berry entered Bristol University, where he has been for more than twice as long he has not. He is a physicist, focusing on the physics of the mathematics...of the physics. Applications include the geometry of singularities (caustics on large scales, vortices on fine scales) in optics and other waves, connections between classical and quantum physics, and the physical asymptotics of divergent series.

Sir Berry delights in finding the arcane in the mundane–abstract and subtle concepts in familiar or dramatic phenomena: Singularities of smooth gradient maps in rainbows and tsunamis; the Laplace operator in oriental magic mirrors; elliptic integrals in the polarization pattern of the clear blue sky; geometry of twists and turns in quantum indistinguishability; matrix degeneracies in overhead-projector transparencies; Gauss sums in the light beyond a humble diffraction grating.

Sir Berry delivered lectures on April 9th, April 10th, April 11th, April 12th and April 13th entitled *"Nature's optics and our understanding of light,"* "*Variations on a theme of Aharonov and Bohm*," "*Faster than Fourier: superoscillations, weak measurement, vorticulture,"* "*Chasing the dragon: tidal bores in the UK and elsewhere; quantum and Hawking radiation analogies"* and *"How quantum physics democratized music: a meditation on physics and technology,"* respectively.

Department Events and News

Graduate Student Recruiting and Open House 2018

The Department reached new records for the number of PhD applicants (444) and for the number of acceptances (33). The Physics program had 284 applicants, while the Astronomy program had 160. We have 21 new Physics students and 12 Astronomy students joining us in Fall 2018. This will put us at over 100 PhD students enrolled in Fall 2018. Our graduate student Open House also reached new heights this year with 36 students attending, a remarkable 80% increase over last year's attendance. We're very excited to see where the new year takes us and to continue our success in attracting even more high-quality applicants.

CIERA Graduate Students Host Field Trip for Girls 4 Science

On Saturday, February 3, 2018, CIERA hosted a group from Girls 4 Science, a Chicago based nonprofit "dedicated to exposing girls, ages 10-18 years old, to (STEM) science, technology, engineering and math."

A total of 95 girls attended the event, where they were split into three groups for various structured activities. Graduate student **Aprajita Hajela** took groups on a tour of Dearborn Observatory, where they were able to learn about the different types of telescopes astronomers use for research. Graduate student **Eve Chase** lead a talk discussing celestial orbit, and facilitated a game where the girls could simulate solar systems composed of celestial bodies of varying mass and volume. Graduate student **Katie Breivik** gave informative talk about the LIGO discovery of gravitational waves, briefly discussing what gravitational waves are, Einstein's original theory, and the technology behind the discovery.

Computational Research Day 2018

Photo credit: Roger Anderson
Professor Shane Larson

Computational Research Day is an annual all-day symposium which brings together Northwestern students, faculty, and researchers across fields and disciplines to share and promote their experiences and efforts in digital research. Participation included CIERA faculty, students and staff where they shared their topics of research.

Research Staff and Graduate Student Achievements

Alexander Gurvich (Astronomy program) was awarded and accepted two prestigious fellowships: the Blue Waters fellowship for computational research, and an NSF Graduate Research Fellowship (Faucher-Giguère). In addition, Alex was among three winners of the Data Visualization Challenge during Computational Research Day 2018. He won for Best Animation with "Stellar Feedback vs. Galaxy Formation," a high resolution animation of a simulation of stellar feedback and resulting galaxy formation with three varied results side by side [https://youtu.be/noFAbbAF-xc].

Summer undergraduate student **José Flores**, who participated in CIERA's REU program, also won a prestigious NSF Graduate Research Fellowship.

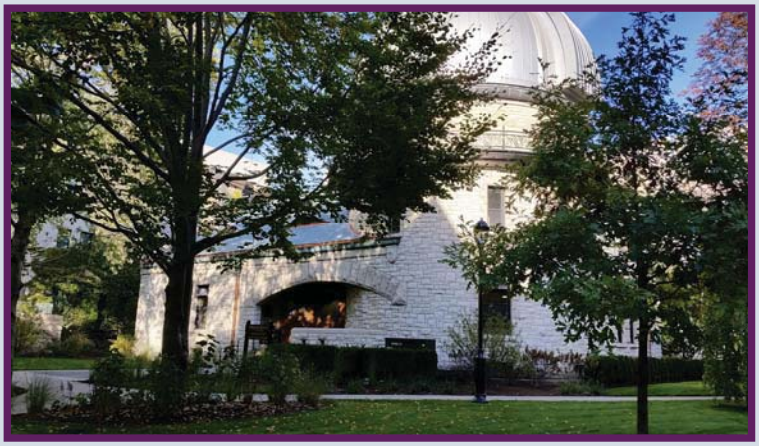
CIERA Postdoctoral Associate **Deanne Coppejans** hosted a regional workshop on radio astronomy.

Welcome to our new postdocs **Daniel Rey, Deniz Eroglu, Chiranjit Mitra, Chao Duan,** and **Pratyush Chakraborty** in the Motter Group.

At a press conference of the American Astronomical Society, CIERA Postdoctoral Fellow **Fabio Santos** presented new insights about the birth of stars & planets gained from study using the SOFIA airborne observatory [http://ciera.northwestern.edu/news/news_2017-2018.php#SantosResearch].

Graduate Student **Eve Chase** led the data analysis of a new gravitational wave detection.

Graduate student **Vesselin Velev** has received an Outstanding Graduate Teaching Award from Weinberg College of Arts & Sciences.



Staff News

In March, Faculty Support Assistant Tina Hoff left the department to pursue another opportunity in her hometown of Appleton, Wisconsin. In April, Cristian Pennington joined us and he will support those constituents that were once supported by Tina. In addition, CIERA hired Katherine Lamb as a Financial Assistant.

Cristian Pennington
Faculty Support Assistant

Cristian was raised in the Cincinnati, Ohio area and came to Illinois to study at the Moody Bible Institute in Chicago. In addition to his career in higher education he has worked in the culinary industry, including a period as an artisan baker.

Cristian is excited to be joining the Northwestern University community and exceptionally delighted to be invited into a vivacious department.

Katherine Lamb
Financial Assistant, CIERA

To help keep up with the continuous growth over the last several years, CIERA has recently hired a part-time Financial Assistant. In her new role, Katherine will support primarily the financial and payroll functions at CIERA, as well as the LSST Data Science Fellowship Program. Prior to this new position, Katherine had been an Editorial Assistant for the Astrophysical Journal Letters at Northwestern since 2012. She earned her Bachelor's degree of Fine Arts at New York University. Katherine is also the Founder and Producing Artistic Director of Dandelion Theatre in Chicago.

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Undergraduate News

Society of Physics Students (SPS) designed Dearborn Observatory shirts, sweaters and hats to sell to our local community to help support their student organization. Below are two of our undergraduates sporting their new gear.

Left to Right: Sophomore Andrew Bowen and Junior Theodore Baker.

2018 Sigma Pi Sigma Induction

Eric Chavez Anderson
Binghao Guo
Grace Lu
Julie Malewicz
Benjamin Thomas Moy
Doug (Harold) Pinckney
Ava Polzin
Eric Van Camp

Congratulations to Class of 2018 Physics and Astronomy Majors!

Eric Anderson
Hyuk Joon Park
Jack Baesman
Katie Barnhart
Scott Carmichael
Grace Lu
Slobodan Mentovic
Benjamin Moy
Doug Pinckney
Richard Puig
Nathaniel Speiser
Newlin Weatherford
Zhaoyuan Wu

Northwestern's Society of Physics Students (SPS)

President: Josh Pritz
Treasurer: Julie Malewicz
Secretary: Josemanuel Hernandez
Departmental Relations Chair: Orion Forowycz
Publicity Chair: Theo Baker
Historian: Andrew Bowen

Society of Physics Students Officers-Elect for 2018-2019
Left to Right: Josemanuel Hernandez, Julie Malewicz, Josh Pritz, Andrew Bowen, Orion Forowycz and advisor, Art Schmidt

Congratulations to our Undergraduate Awardees

Outstanding Undergraduate Thesis Research in Physics & Astronomy

Benjamin Moy

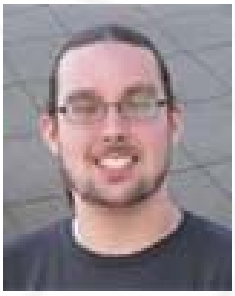
Outstanding Junior in Physics & Astronomy

Chandler Conn

Outstanding Sophomore in Physics & Astronomy

Joshua Pritz

Congratulations to our PhD and MSc Graduates

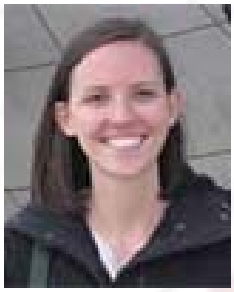


Dan Baxter (Dahl)

Eliminating Backgrounds in the Search for Dark Matter with the PICO-60 Bubble Chamber

Mecca Islam

Master of Science



Katelyn Breivik (Larson)

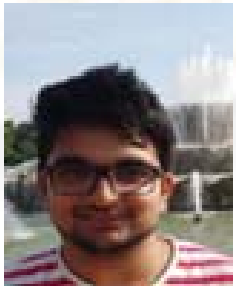
Simulating Binary Populations in the Milky Way

Kevin Kelly (De Gouvea)

New Neutrino Physics at Next-Generation Experiments

Fani Dosopoulou (Kalogera)

Dynamical Evolution of Eccentric Systems: From Stellar Binaries to Planetary Systems and Massive Black Hole Binaries



Aruj Mahajan

Master of Science

PhD and MSc Graduates (continued)

Bo Fu (Ratner)

Chemical Physics at the Molecule -Metal Interface

Mitchell Miller (Dutta)

Trivalent Ions Under Charged Langmuir Monolayers: Nano-scale Mechanisms for Charge Inversion and Liquid-Liquid Extraction

Boris Harutyunyan (Bedzyk)

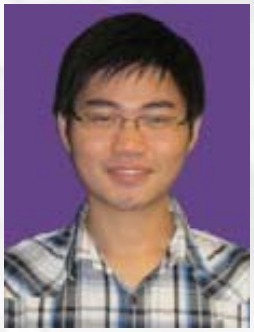
X-Ray Scattering Studies of Novel Photoactive Materials

Kevin Ostrowski

Master of Science

Young Pyo Hong (Jacobsen)

Improvements in X-ray Fluores-cence Tomography



Huanxin Wu (Luijten)

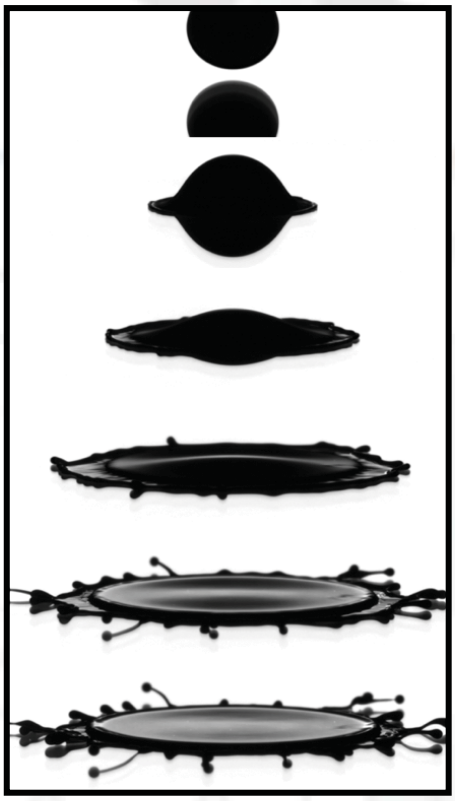
Efficient Simulation Techniques for Dielectrics and Their Effects on Electrolytes and Patch Colloids

Jason Hwang (Rasio)

Dynamics and Collisional Evolution of Closely Packed Planetary Systems

Faculty Spotlight: Professor Michelle Driscoll

Professor Driscoll is a soft condensed matter experimentalist, and her research lies at the interface between soft-matter physics and fluid dynamics. Her lab focuses on understanding how structure and patterns emerge in driven systems, and to how to use this structure formation as a new way to probe nonequillibrium systems. She studies emergent structures in a diverse array of driven systems, from the microscopic (driven colloidal suspensions) to the more table-top (fracturing meta-materials).



Emergent structures often have their genesis in unstable interfaces, such as the droplets that appear on the rim of a splashing drop or the long drips that emerge from a painted wall. Many driven fluid-fluid and fluid-suspension interfaces are unstable; the structures that emerge as they destabilize often reveal the dominant stresses acting on the system. The Driscoll lab looks at active and driven colloidal systems as well as fluid systems through the lens of structure generation. By developing a deeper understanding of the patterns and structures which emerge dynamically in a driven material, we can learn not only how these structures can be controlled, but also how to use them to connect macroscopic behavior to microscopic properties.

PhD, University of Chicago, 2014

Honors & Awards:

Yodh Prize, University of Chicago (2014)

Robert A. Millikan Fellowship (2010 - 2013)

Another component of Prof. Driscoll's research is understanding material failure via emergent structures. She probes how soft solids fall apart, and what kinds of patterns and structures are generated as these materials fail. When a rigid solid, like window glass, fails, it often does so rapidly and catastrophically. In a special class of marginally rigid materials (very small shear modulus), the failure behavior is very different. As the rigidity transition is approached, failure due to the application of uniaxial stress evolves from brittle cracking to system-spanning diffuse breaking; thus the spatial extent of the failure zone can be used as a direct probe for material rigidity. The Driscoll lab use these sorts of model experimental systems to understand connections between material failure and microstructure, as well as to develop new ways to probe the rigidity of a broad class of soft materials.

Noteworthy Events

Investiture Ceremonies of Professor Gerald Gabrielse, Board of Trustees Professorship
and
Vicky Kalogera, Daniel I. Linzer Distinguished University Professorship

Photo credit: Rob Hart

Dean Adrian Randolph, Gerald Gabrielse, and Michael Schmitt

Photo credit: Rob Hart

Photo credit: Genie Lemieux

Photo credit: Genie Lemieux

Dean Adrian Randolph, Vicky Kalogera and Michael Schmitt

Alumni Focus

Laszlo Frazer was a postdoc for a year in Prof. Eric Borguet's group at the Energy Frontier Research Center for the Computational Design of Layered Materials, at Temple University, in Philadelphia. Then he moved to Sydney, where he was a postdoc in Prof. Timothy Schmidt's group at UNSW. This is where he got involved in the new ARC Center of Excellence in Exciton Science, and where he published a press release that can be viewed here.

Lauren Barmore graduated in June 2017 with a B.A. in physics and a minor in German, and currently a PhD student at Washington State University in Pullman, WA. Lauren is also working at the Institute for Shock Physics, where they study materials at extreme conditions using dynamic compression.

Xu Du graduated from Northwestern University with a Ph.D degree in Physics in 2003. Now he is a senior scientist at ABB Inc. in San Jose, California.

Barbara Kegerreis Lunde received her BA in Physics in 1957 and an MS in Physics in 1959 from Northwestern University. She was awarded Distinguished Science and Technology Professional Award from the Minnesota Federation of Engineering, Science and Technology Societies, 2015 & awarded Duke of Distinction from York High School, Elmhurst, IL, 2016. Currently, she is babysitting her grandchildren, 2 and 4 years old, working at H&R Block and as an usher lead at the new Minneapolis stadium, on the boards of the Minnesota Renewable Energy Society, her neighborhood, and the Twin Cities Northwestern Alumni.

Peter Maksym earned his PhD from NU in 2012, and then started his first postdoc at the University of Alabama in Tuscaloosa, working with Jimmy Irwin and Bill Keel. Peter is currently a postdoc at the Harvard-Smithsonian Center for Astrophysics, working primarily with Pepi Fabbiano and Martin Elvis, and actively involved in a wide variety of projects. These include spatially resolved studies of AGN feedback, time domain UV and X-ray spectroscopy of stellar tidal disruption events and "voorwerpjes".

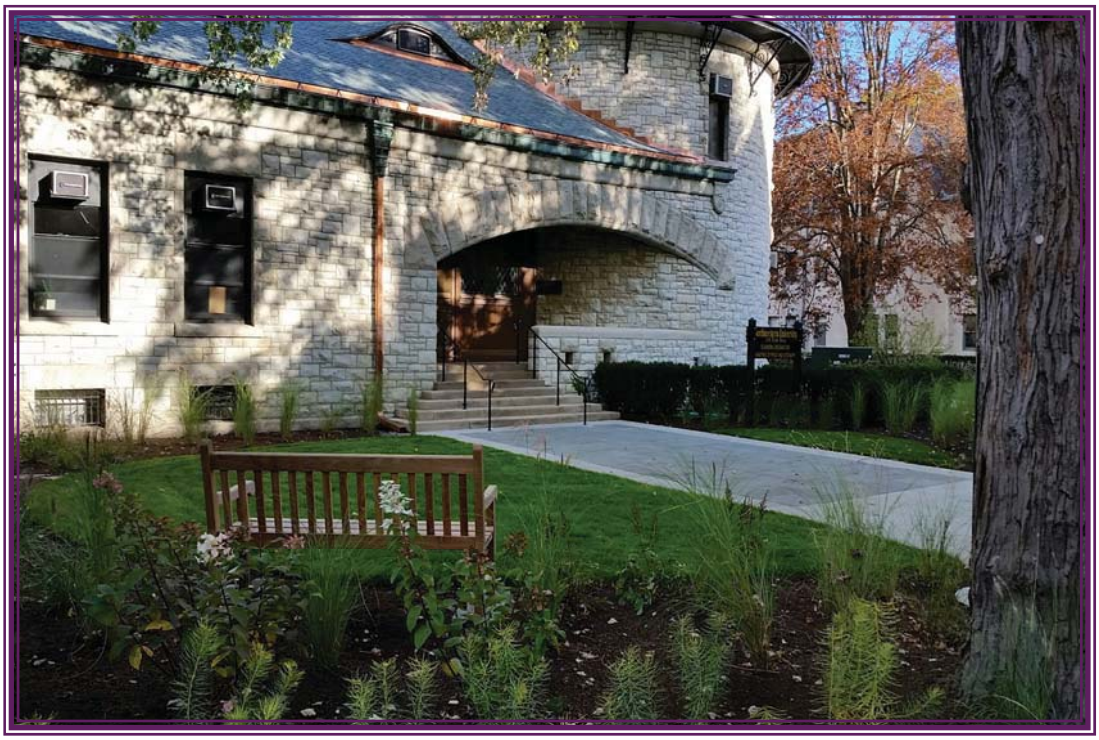
Michael Steinitz received his PhD from the department of Materials Science, where he began doing neutron scattering with Professor Lyle Schwartz. His thesis work was done in the lab of his mentor, Professor Jules Marcus, of the Department of Physics, who got his PhD at Yale from Lars Onsager. Michael's research career was successful, with lots of work in neutron scattering at Chalk River and dilatometry in my lab at StFX. Several inventions and innovations in dilatometry, particularly at high temperatures, were made in his lab in collaboration with his long-time collaborator, Professor Jan Genossar of the Technion in Haifa, Israel.

Michael retired in 2016 but is still active as editor of the Canadian Journal of Physics and a member of Commission 13 of IUPAP, on Physics for Development. In the course of his career he was president of the Canadian Association of Physicists and received the Kirkby Medal for service to the physics community.

May Kim received her physics PhD from Northwestern working for Professor Selim Shahriar in 2015. She is still at her first postdoc job at Purdue University working on realizing long range interaction

between ultracold atoms trapped above a nanophotonic waveguide under the supervision of Professor Chen-Lung Hung.

Bruce Harmon was the first NU student of Art Freeman's and obtained his PhD in 1973 working on the electronic structure of Gadolinium. Being a Chicago native, he was a bit shocked to land in Iowa for a postdoc, but the Ames Laboratory was/is the world center for rare earth research and it was not long before he became the Assistant to Full Professor stages at Iowa State University, while maintaining 50% of his appointment with the Ames Lab, where he eventually became Deputy Director. Bruce retired recently, but still comes into the office and engages in research. He has traveled all over the world and treasures collaborations with scientists from many countries. Bruce's h-index is 62, with a total of ~14,000 citations.



The department newsletter is a means of reaching out to the alumni to keep them abreast of current research and developments in the Department of Physics and Astronomy. It is also a forum for alumni to keep the department informed of their accomplishments; the department welcomes submissions from alumni of newsworthy items for publication in the newsletter. Please feel free to send in items using this form (just fold and staple the page), or to email your news to

***Yas Shemirani** at yassaman.shemirani@northwestern.edu*

Please take the time to join our LinkedIn page for our alumni.

Follow us on Facebook!

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