

Fall 2017

dimensions

Department of Physics & Astronomy

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Four New Faculty Members Join the Department

A Glance at our Centers

Neutron Star Merger in the News

Northwestern University

On the cover:

This is a Higgs boson decaying to two photons in the CMS detector. The Higgs boson (or Higgs particle) is a particle in the Standard Model of physics. In the 1960s Peter Higgs was the first person to express the idea. On March 14, 2013, scientists at CERN tentatively confirm that they have found the particle. It is one of the 17 particles in the Standard Model.

Faculty News

Vicky Kalogera, CIERA Director and Daniel I. Linzer Distinguished University Professor, served as lead astrophysicist on the panel at the National Science Foundation's (NSF) press conference announcing the discovery of the first observation of neutron star mergers. **Shane Larson**, **Raffaella Margutti**, **Wen-fai Fong**, and their research groups also contributed to this historic discovery.

Michael Smutko was named for the ninth time to the 2017-2018 Associated Student Government Faculty and Administration Honor Roll. Every year, ASG asks Northwestern undergraduates to nominate faculty and administrators they feel have gone above and beyond to enrich our school's academic experience.

On October 13, 2017, **Bill Halperin** was elected as the chair of the C5 Commission on Low Temperature Physics of the International Union of Pure and Applied Physics (IUPAP), a group of 14 distinguished colleagues from around the world. He is also the representative for the United States on this commission which sponsors a number of international conferences, prizes, and awards. For the past three years he has been the commission secretary and will now serve as chair until October 2020.

Congratulations to Assistant Professor **Eric Dahl** on receiving the Henry Primakoff Award from the American Physical Society.

Professor Kalogera has been appointed as a Senior Fellow of the Canadian Institute for Advanced Research (CIFAR) program in Gravity and the Extreme Universe. CIFAR is a global research organization comprised of over 400 fellows, scholars, and advisors from more than 100 institutions in 17 countries which brings together "outstanding researchers to work in

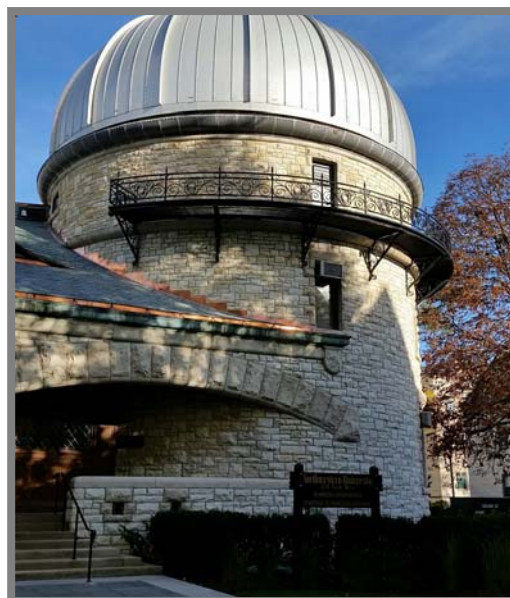
interdisciplinary, global networks to address the most important questions of our time."

CIERA Associate Director and Research Professor **Shane Larson** has been named to the NASA LISA Study Team. LISA, the "Laser Interferometer Space Antenna," is a space-based detector that will be jointly flown by NASA and the European Space Agency near the end of the next decade.

Mel Ulmer received the [Director's Innovation Initiative Grant](#).

Y. Yang, T. Nishikawa, and A.E. Motter, published their paper "Small vulnerable sets determine large network cascades in power grids" in [Science Magazine](#) and also created an animated summary of the paper you can [view here](#).

Claude-Andre Faucher-Giguere was recently a featured researcher in NUIT's newsletter, which highlighted the computational research done in their group [http://ciera.northwestern.edu/news/news_2016-2017.php#CAFGNUIT]



New Faculty Additions to the Department



Michelle Driscoll

Assistant Professor

Michelle Driscoll is an experimental soft condensed matter physicist. She grew up in Austin, TX, and while she dearly misses quality smoked brisket, she was happy to leave the terribly hot weather behind. Michelle has been taking apart and tinkering with all manner of things since she was a child, a passion encouraged by her father, a robotics repair technician. Today she looks at how things fall apart a little more carefully, studying how emergent patterns and structures can reveal underlying dynamics in a variety of unstable soft material and fluid systems.



Alexander Tchekhovskoy

Assistant Professor

Sasha is a theoretical astrophysicist focusing on how black holes and neutron stars interact with their environment. They devour stars, eject relativistic jets, affect star formation and galaxy evolution, and enrich the Universe with heavy elements. To study these processes, he performs large-scale numerical simulations as well as algorithm and code development. The experiments that his 7th grade physics teacher showed in class got him excited about physics. Uncovering the physics in nature's most extreme laboratories has been his focus ever since. Sasha loves biking, roller skiing and furry animals.



Pallab Goswami

Assistant Professor

Pallab Goswami is a theoretical condensed matter physicist, but has a broad interest in different branches of theoretical physics. His parents were refugees and he grew up in abject poverty in the suburbs of Kolkata, India. He was introduced to physics and mathematics by his elder brother. He was fortunate to have many kind and passionate teachers, who inspired him to pursue physics at a professional level. Pallab is thrilled about the opportunity to share his passion for physics with the Northwestern community. He loves animals, history, movies, and a good sense of humor.



Andrew Geraci

Associate Professor

A native Chicagoan, Andy Geraci was born and raised on the north side, and is excited to be returning to the area to join the faculty at Northwestern! Most recently moving from Reno, Nevada, he is happy to be part of the new Center for Fundamental Physics at low energy where he plans to continue conducting tabletop experiments to search for physics beyond the standard model, gambling that a new discovery may be just around the corner. He lives with his wife, daughter, son, and two dogs in Wilmette, IL. His hobbies include playing guitar, hiking, swimming, and playing outdoors with his kids.

Selected Publications & Invited Lectures

Nate Stern [Valley-Polarized Exciton-Polaritons in a Monolayer Semiconductor](#), Yen-Jung Chen, Jeffrey D. Cain, Teodor K. Stanev, Vinayak P. Dravid, Nathaniel P. Stern *Nature Photonics* **11**, 431–435, (2017) [View-Only Online PDF](#) *Nature Photonics - News and Views: 2D materials: Valley Polaritons.*

“Three Cosmic Chirps and Counting” **Vicky Kalogera** [Sky & Telescope magazine](#), September 2017.

J. A. Sauls and Bill Halperin presented Plenary talks in the [London Prize Session](#) at the 28th International Conference on Low Temperature Physics (LT28), held in Gothenburg, Sweden:

- “The Left Hand of the Electron in Superfluid 3He” J.A. Sauls, August 11, 2017.
- “Superfluid Phases of Liquid 3He in Random Media and Confined Space” J.A. Sauls, August 15, 2017.
- “Superfluid 3He with Globally Anisotropic Quenched Disorder”, Bill Halperin, August 15, 2017.
- Bill Halperin gave the closing Plenary talk at the 28th International Conference on Low Temperature Physics (LT28): “Order Parameter Symmetry in the Topological Superfluids 3He and UPt₃”, Gothenburg, Sweden, August 16, 2017.

Jim and Bill were also invited to talk at the International Conference on Ultra-Low Temperature Physics (ULT2017), held in Heidelberg, Germany on August 18, 2017.

- “Spontaneous Symmetry Breaking and Topology of the Superfluid Phases of 3He” J.A. Sauls.
- “Superfluid 3He Order Parameter and Angular Momentum Direction in Anisotropic Aerogel” Bill Halperin.

“Hydrogen-rich supernovae beyond the neutrino-driven core-collapse paradigm” **Giacomo Terreran** et al.

Nature Astronomy **1**, 713–720 (2017)

<https://www.nature.com/articles/s41550-017-0228-8>



Y. Yang, T. Nishikawa, and A.E. Motter, Small vulnerable sets determine large network cascades in power grids, *Science* **358** (6365), eaan3184 (2017). <http://science.sciencemag.org/content/358/6365/eaan3184>

Anglés-Alcázar, D., Faucher-Giguère, C.-A., Keres, D., Hopkins, P. F., Quataert, E., & Murray, N. 2017, “The Cosmic Baryon Cycle and Galaxy Mass Assembly in the FIRE Simulations,” *MNRAS*, **470**, 4698. <https://academic.oup.com/mnras/article-lookup/doi/10.1093/mnras/stx1517>

Anglés-Alcázar, D., Faucher-Giguère, C.-A., Quataert, E., Hopkins, P. F., Feldmann, R., Torrey, P., Wetzell, A., & Keres, D., “Black Holes on FIRE: Stellar Feedback Limits Early Feeding of Galactic Nuclei,” *MNRAS Letters*, **472**, L109.

“Greatly Enhanced Merger Rates of Compact-object Binaries in Non-spherical Nuclear Star Clusters” **Fabio Antonini & Petrovich, Cristobal.** *The Astrophysical Journal*, Volume **846**, Issue **2**, article id. **146**, 22 pp. (2017). <http://adsabs.harvard.edu/abs/2017arXiv170505848P>

Sauls, J. A., and Takeshi Mizushima. “On the Nambu fermion-Boson Mass Relations for 3He.” *Physical Review B*, American Physical Society, 22 Mar. 2017, journals.aps.org/prb/abstract/10.1103/PhysRevB.95.094515. <https://journals.aps.org/prb/abstract/10.1103/PhysRevB.95.094515>

F. Yusef-Zadeh et al. “ALMA Detection of Bipolar Outflows: Evidence for Low-mass Star Formation within 1 pc of Sgr A*” *The Astrophysical Journal Letters*. The American Astronomical Society. 28 Nov 2017, <https://public.nrao.edu/news/2017-alma-lmstars/>

“The superluminous supernova SN 2017egm in the nearby galaxy NGC 3191: a metal-rich environment can support a typical SLSN evolution” **Raffaella Margutti** et al. *Astrophysical Journal Letters* arXiv:1706.08517 [astro-ph.HE] <http://lanl.arxiv.org/abs/1706.08517>

Sensitive dependence of optimal network dynamics on network structure, **Takashi Nishikawa, Jie Sun, and Adilson E. Motter**, *Phys. Rev. X* **7**, 041044 (2017). <https://journals.aps.org/prx/abstract/10.1103/PhysRevX.7.041044>

Tchekhovskoy, Alexander et al. “Formation of Precessing Jets by Tilted Black-Hole Discs in 3D General Relativistic MHD Simulations.” *Cornell University Library*. 1 Nov. 2017, <https://arxiv.org/abs/1707.06619>

Research Staff and Graduate Student Achievements

Josh Wiman presented his research at both LT28 and ULT2017 in poster sessions on "Superfluid ^3He Beyond Weak-Coupling".

Postdoctoral Fellow **Aaron Geller** Wins Scientific Images Contest (Figure 1) [http://ciera.northwestern.edu/news/news_2017-2018.php#GellerImages2017] which illustrates recent research in Rasio's Group (<http://adsabs.harvard.edu/abs/2017ApJ...836L..26C>).

Kamal Seth's research group has made the world's first measurements of the production of hyperon pairs by electron-positron annihilation. The paper describing our unique results has been accepted for publication in the Physical Review D.

Graduate Student **Fani Dosopoulou** Received [Holt Award](#)

Graduate Student **Eve Chase** Won [Best Poster Award at LSC-Virgo Meeting](#).

Graduate Student **Katie Breivik** Won [Blue Apple Prize](#) at Midwest Relativity Meeting.

Andrew Zimmerman gave an invited oral presentation at the 28th International Conference on Low Temperature Physics (LT28): "Superfluid ^3He Confined in Nanoscale Pores", Gothenburg, Sweden, August 12, 2017.

Man Nguyen gave a poster presentation at the 28th International Conference on Low Temperature Physics (LT28): "Anisotropy-Induced Transitions in Superfluid ^3He ", Gothenburg, Sweden, August 14, 2017

Ingrid Stolt gave a poster presentation at the 28th International Conference on Low Temperature Physics (LT28): "Observation of high-field vortex lattice structural transition in

$\text{HgBa}_2\text{CuO}_{4+\delta}$ with nuclear magnetic resonance", Gothenburg, Sweden, August 12, 2017

Graduate Student **Alex Gurvich** created image below (Figure 2). It is an image rendering of one of our galaxy simulations produced from simulations and using a visualization tool (Firefly) that we develop here at Northwestern.

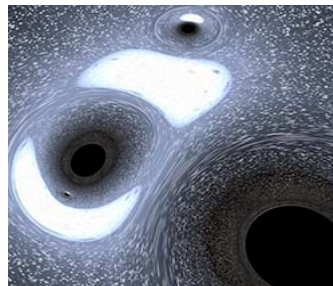


Figure 1

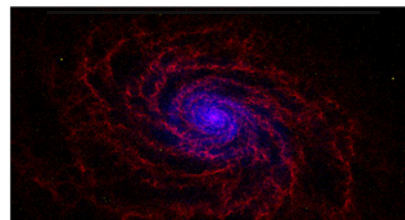


Figure 2

Undergraduate Achievements

CIERA REU summer Undergraduate student José Flores won a "best poster" award for the work he did in the Faucher-Giguere research group this summer [http://ciera.northwestern.edu/news/news_2017-2018.php#FloresSACNASPoster]

In the summer of 2017, 34 summer students worked closely with researchers at CIERA. 13 of these students received funding through CIERA's Research Experience for Undergraduate's (REU) program, 12 were funded through an educational grant awarded by NASA to Northwestern University through the Illinois Space Grant Consortium, and the remainder worked individually with CIERA faculty and postdocs.

http://ciera.northwestern.edu/news/news_2016-2017.php#summerresearchers2017

Meet Our New Staff Members



Julia Blend

Accounting Specialist

Julia grew up in Indiana and moved to Chicago to attend Ray College of Design. She started working at Northwestern University in Mail Services, so some of the staff and faculty at Tech may recognize her as a delivery driver. After 2 years, she transferred to NU's Accounts Payable department as a Customer Service representative. She recently took over for Vicki Eckstein as Accounting Specialist for the Physics and Astronomy department. In her spare time, she enjoys painting pop art portraits, collecting vinyl LPs, and watching horror movies. She also loves to cook, entertain, and play with her rescue pooch named Arrow.



Nga Du

Financial Assistant

Nga started at Northwestern as a Research Technologist at Feinberg School of Medicine studying stem cells and heart failure and most recently transitioned to become an Accounting Specialist at McCormick School of Engineering to work with students, particularly managing their accounts and payroll. She enjoyed working with the Engineering students and empowering them to make good decisions about their finances. Nga has a Bachelor's in Biology from DePaul University. In her spare time, she loves cooking, being outdoors, and spending time with her husband and two sons.



Scott La Tragna

Business Administrator, Center for Fundamental Physics

Scott began his career at Northwestern in 2007. He started on the loading dock for the Department of Chemistry, he was then promoted to accounting assistant in 2012. In 2014, Scott became the financial assistant, and was promoted again in 2015 to the financial coordinator in the chemistry department. Scott joined the CFP in 2017 as the Business Administrator. He coaches the Park Ridge Warriors baseball team, a 14-and-under league.



Laura Nevins

Program Assistant, Center for Fundamental Physics

Laura grew up in the Chicago suburbs and lived in northern California for several years, and has a Bachelor's degree in Art from the University of California, Davis. She came back to Chicago to get her Master's in Art History at the School of the Art Institute of Chicago, and decided to stay. She worked for the Psychology department as a Program Assistant for about three years before coming to Physics and Astronomy. In her spare time, she likes to draw and paint, knit, and do yoga.



Kari Frank
Director of Operations, CIERA

CIERA has a new Director of Operations, Dr. Kari Frank. Kari holds a PhD in Physics from Purdue, and is formerly a Research Associate at Penn State. Kari's focus is X-ray observations of galaxy clusters and supernova remnants. In addition to her research, Kari has devoted time at both Purdue and Penn State to help improve the careers of graduate students and postdocs. Kari is originally from Minnesota and in her spare time enjoys keeping a home aquarium and hiking.

The Department would like to congratulate our faculty support assistant, Pam Villalovoz on 20 years of service with Northwestern University!

2017 Incoming Graduate Students
PhD Students



Atallah, Dany



Hajela, Aprajita



Kimball, Charles



Krantz, Patrick



Lalakos, Aretaios



Lei, Weihua



Liu, Yihan



MacKenzie,
Michael



McDonough,
Nathan



Nahal, Geev



Nottet, Edouard



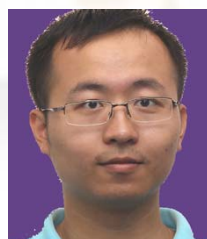
Ren, Runze



Weiss, Daniel



Wu, Qiming



Zeng, Hongfei

MSc Students



Gresl, John



Huh, Joon Suk



Khusro, Javad



Kim, Taeyoon



McCourt, Joseph



Ostrowski, Kevin



Zhou, Junfeng

Congratulations to our PhD and MSc Graduates (Summer/Fall 2017)



Peter Ashton
(Giles Novak)

*Interstellar Dust Polarimetry with
BLASTPol and BLAST-TNG*

Constantijn van der Poel
(Andre De Gouvea)

*Neutrino Oscillations to Probe
Earth's Core*

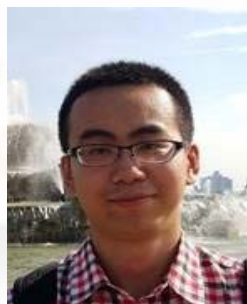


Samuel Hadden
(Yoram Lithwick)

*Characterizing Kepler's Multiplanet
Systems with Transit Timing
Variations*

Dominic Wilmes
(Shane Larson)

EMRI Spectroscopy with LISA



Hao Zhang
(Vicky Kalogera)

The Impact of Stellar Winds on He X-ray Binaries

Department Events

Neutron Star Merger

On October 16, 2017, scientists announced the first-ever observation of a binary neutron star inspiral and merger. This astronomical event will provide a powerful new way to understand the lives of stars and how they die and join the galactic graveyard.

Vicky Kalogera, CIERA Director and Daniel I. Linzer Distinguished University Professor in the Weinberg College of Arts and Sciences, served as lead astrophysicist on the panel at the National Science Foundation's (NSF) press conference announcing the discovery.

Anticipated by the Laser Interferometer Gravitational-Wave Observatory (LIGO) for more than 20 years, this merger represents the first joint detection of an astronomical event using two astronomical observing techniques: gravitational waves and electromagnetic radiation. Together these approaches are known as "multi-messenger astronomy". Gravitational waves were the subject of [2017's Nobel Prize in Physics](#), and multi-messenger astronomy was named one of the NSF's [10 Big Ideas](#) for future scientific investment. Northwestern is currently one of the few universities in the world with expertise on both sides of this cutting-edge field.

Additional Links on Gravitational Wave News:

- LIGO detected gravitational waves for the third time: http://ciera.northwestern.edu/news/news_2016-2017.php#LIGO3Wave
- LIGO and Virgo make first joint detection: http://ciera.northwestern.edu/news/news_2017-2018.php#LIGOTripleDetection
- 2017 Nobel Prize in Physics Awarded to Gravitational-wave Scientists Barish, Thorne, and Weiss: http://ciera.northwestern.edu/news/news_2017-2018.php#NobelPrize

On August 21, the total solar eclipse fascinated people across the country. Astronomers from CIERA travelled to Wyoming, Kansas, Idaho, Missouri, and southern Illinois to enjoy the event with friends and family along the path of totality. On the day of the eclipse, CIERA hosted an unadvertised pop-up viewing on the front courtyard

of the Technological Institute on Sheridan Road, attracting at least 650 people. Graduate students David Goldfinger, Kyle Kremer, and Shi Ye set up two telescopes specially outfitted with white light solar filters and eyepieces to make them safe. CIERA staff gave out safe viewing eclipse glasses and CIERA bookmarks. http://ciera.northwestern.edu/news/news_2016-2017.php#2017SolarEclipse

Top Telescope Access for CIERA Researchers

Northwestern is known for its strength in theoretical astrophysics, and now it is poised to lead in observational astronomy as well. CIERA recently signed contracts to secure institutional access to the Multiple Mirror Telescope (MMT) in Arizona, and the W. M. Keck Observatory in Hawaii. Both observatories have unique and complementary capabilities. MMT has the ability to target and refocus quickly, which is important for fast-changing celestial phenomena called transients. Keck, on the other hand, has a larger collecting area which allows researchers to explore older and fainter signals.

Prior to the new telescope contracts, NU astronomers did not have guaranteed access to the MMT, Keck, or any other research-grade observational facility. Now, Northwestern researchers are guaranteed an allotment of time per year to collect data. This is a significant commitment to and expansion of observational capabilities at Northwestern. CIERA will now have the ability to train students in observational astronomy with world-class facilities. Researchers will have more freedom with their projects because of the removal of the observatory time application process; guaranteed time allows researchers to take on more high-risk, high-reward projects.

With access to two of the leading telescopes in the world, the observational astronomers at CIERA have the ability to thrive and conduct research in exciting new areas, connecting theoretical research to observational data. Learn more about [telescope access at CIERA](#).

Centers Associated with the Department

CAPST— *Center for Applied Physics and Superconducting Technologies* ***Opened September, 2017***

Northwestern University and Fermi National Accelerator Laboratory have established a research center that will support collaborative research between Northwestern and Fermilab scientists in the broad field of superconducting materials, devices and technology development. The new center will provide new opportunities for graduate research and postdoctoral fellows. The breadth of research at CAPST will further investigations into the upper limit of performance of superconductors for next-generation particle accelerators, help develop superconducting devices for quantum information science and technology, and expand the frontier in superconducting materials. “The center is a marriage of basic science, applied research, and technology development,” says CAPST codirector James Sauls, Physics and Astronomy, and an expert in theoretical physics. “This effort provides cross-institutional access to state-of-the-art research equipment, facilities, and expertise in the field of superconductivity and materials physics. An immediate goal of the research center is to develop a fundamental understanding of the physics that sets the ultimate limit to the performance of superconducting radio-frequency (SRF) cavities for particle acceleration.” Anna Grassellino, CAPST codirector and a Fermilab physicist, is working to develop SRF cavities with improved performance at lower operational costs. “It is fascinating how particle accelerators can be very large and complex installations, but their ultimate performance depends strongly on the physics of superconducting materials at the nanometer scale,” Grassellino says.

The collaboration is already paying dividends, with Northwestern having been awarded a research grant for CAPST from the Physics Division of the National Science Foundation (NSF). “This new award will allow the CAPST research team to develop a detailed understanding for the physical processes that limit the accelerating field and quality factor of SRF cavities, and with that knowledge to push the performance level toward theoretical limits,” says Sauls. “The grant from NSF will also help bring a greater presence of accelerator science to the University and provide new research opportunities for graduate students, both at Northwestern and Fermilab.” Northwestern faculty Venkat Chandrasekhar, William Halperin, John Ketterson, Jens Koch, and Nate Stern, all Physics and Astronomy, as well as David Seidman, Materials Science, will lead various research efforts within the center. Eight Fermilab staff members, including Anna Grassellino and Alexander Romanenko, who hold adjunct faculty appointments in Physics and Astronomy at the University, are part of CAPST.

COFI—*Colegio De Fisica Fundamental E Interdisciplinaria de las Americas*

The COFI center is composed of physicists, cosmologists and astronomers from the USA, Latin American and Europe. The emphasis of our research is on areas of common interest between these fields. The institute is based in Old San Juan, Puerto Rico and is managed as a non-profit organization registered under the name of “Colegio de Fisica Fundamental e Interdisciplinaria de las Américas” (COFI). Funds granted so far come from private individuals, the federal government (national and international laboratories) and institutions like Northwestern University. COFI is an independent group fully devoted to scientific research in theoretical, computational and experimental areas.

The main mission is to focus on fundamental and applied physics, but it also supports education via specialized summer school for PhD students and postdocs, research opportunities for undergraduates, and public lectures.

CFP—Center for Fundamental Physics

Opened September, 2017

The Center for Fundamental Physics at Low Energy (CFP for short) is a long-term initiative of the Northwestern Department of Physics and Astronomy. The faculty members, graduate students and undergraduates associated with the CFP, along with CFP fellows, specialize in small-scale, low-energy experiments to investigate the particles, interactions, and symmetries of the universe - to test and help develop our most fundamental theoretical descriptions. A weekly CFP colloquium features the most exciting international developments in relevant atomic, molecular, and optical physics, along with related developments in high energy physics, astrophysics, and new detector technologies. Associates of the CFP, researchers from Northwestern and neighboring institutions who broaden the CFP community by their participation in the CFP colloquium, help select colloquium topics and speakers. The CFP also encourages interdisciplinary activities that reflect upon, illuminate and reveal the assumptions, implications and methods of fundamental physics.

Northwestern University is an eager and ideal host for this unique center of excellence. As part of its active engagement in increasing the stature and visibility of the Department of Physics and Astronomy, and in improving the intellectual opportunities for its students and faculty, Northwestern launched the CFP with new faculty lines for a founding director and core research group leaders. The university provided freshly renovated, adjacent laboratories in the Mudd building, and a suite of offices in the heart of the Department of Physics and Astronomy. The university is also committed to providing the crucial support services that CFP researchers (and many others at the university) need to fabricate intricate apparatus for cutting-edge laboratory measurements. Included are maintaining a well-equipped and staffed professional machine shop, a student machine shop within which students are mentored as they safely use up-to-date machine tools, an electronics design shop whose engineer is able to design electronics for precise measurements, and pursuing a sustainable and affordable source of liquid helium.

CIERA—Center for Interdisciplinary Exploration and Research in Astrophysics

CIERA, the *Center for Interdisciplinary Exploration and Research in Astrophysics*, was founded in 2007 with the goal of establishing Northwestern as a world leader in astronomy research. The mission of CIERA is to envision, develop, and pursue a top research and education program in astronomy and astrophysics that is internationally recognized for its competitive innovation and scientific advances, building upon our unique interdisciplinary culture and approach. CIERA activities include supporting postdoctoral fellows who develop independent research programs, advancing graduate and undergraduate research, and hosting various seminar series and a long-term visitors program. Special emphasis is given to interdisciplinary research connections with applied math, biology, chemistry, computer science, electrical engineering, materials science, mechanical engineering, planetary science, and statistics. CIERA is a University-level Research Center, reporting to the Vice President for Research, which bridges research and education across departments and schools.

Faculty Spotlight: André de Gouvêa

The ultimate goal of Particle Physics is to understand the fundamental laws that govern all natural phenomena. While we are very far from achieving such a lofty goal, we adhere to the premise that, at very small distances, the world is best described as if everything was made out of fundamental, point-like particles. Particle physicists concentrate their research efforts on identifying what all the different particles are, determining their properties, and understanding how they interact with one another.

By the first decade of the twenty-first century, it was clear that our best, most successful model for the physics of particles was at least incomplete. Different probes, at very different distance scales, of the energy and matter content of the universe revealed that most of the energy density of the universe today is not made up of the known particles—photons, electrons, quarks, neutrinos. The new forms of energy were dubbed ‘dark energy’ and ‘dark matter.’ Dark matter appears to be made of a new type of fundamental particle whose properties are virtually unknown (dark energy is a weirder problem about which we understand even less!). On a very different front, a variety of experiments aimed at understanding the properties of neutrinos—the most elusive and least understood of the fundamental particles—revealed that neutrinos behave in a way that contradicted theoretical expectations. In a nutshell, we discovered neutrino oscillations which translated into the fact that neutrino masses were not zero and that the different lepton-families mixed. Understanding why neutrino masses are not zero implies the existence of new fundamental particles whose properties are only poorly constrained. Our group concentrates most of its research efforts attempting to piece both the dark matter puzzle and the neutrino mass puzzle, concentrating a little more heavily on the latter.

We work on what is referred to as particle physics phenomenology. We construct simple models for what the new physics responsible for, say, nonzero neutrino masses could be and compute the consequences of this new physics for current and future experimental particle physics probes. These potential new phenomena take on many forms and can reveal themselves in a plethora of different particle physics and astrophysics experiments. For this reason, we also dedicate a lot of our research effort to understanding how different particle physics experiments work and what sorts of measurements they can perform. We often work together with experimental particle physicists and interact with and contribute to different particle physics experiments. Right now, we are official members of three current and future particle physics experiments, all hosted by Fermilab: the new $g - 2$ experiment, which aims at measuring with unprecedented precision the magnetic moment of the muon—muons are “cousins” of the neutrinos and the origin for nonzero neutrino masses can leave a quantitative imprint in the properties of the muon; the *Mu2e*-experiment, which aims to look for new interactions capable of transforming muons into electrons; and the Deep Underground Neutrino Experiment (DUNE), the most ambitious long-baseline neutrino experiment, which hopes to study the properties of neutrinos by shooting them over 1200 km from Fermilab to a gigantic liquid-argon detector located deep inside a mine in Lead, South Dakota.



Ph.D. UC Berkeley, 1999

Awards and Honors

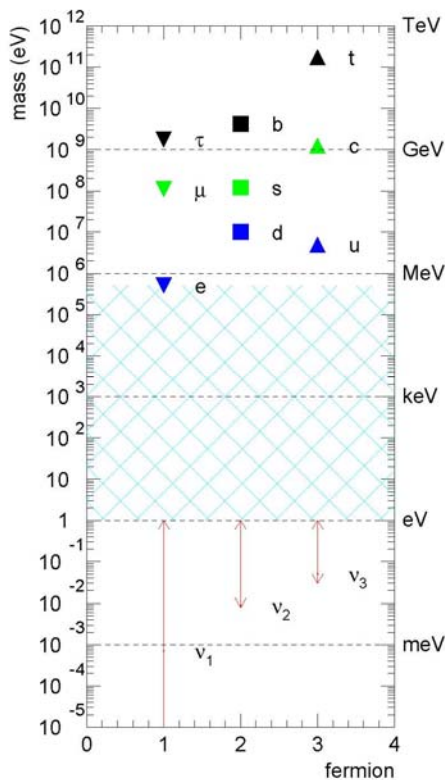
Fellow of the American Physical Society

Member of the Editorial Board for Physical Review Letters

Member of the Fermilab Physics Advisory Committee

Faculty Spotlight (continued)

More recently, we have been exploring the possibility that nonzero neutrino masses and dark matter are a consequences of the same new particles and interactions. It is possible that the dark matter and the neutrinos are close relatives. This hypothesis may be tested by cosmic ray experiments, direct searches for dark matter, observations of supernova explosions, or even high-energy colliders, like the Large Hadron Collider at CERN. These are very exciting times for particle physics. We have identified phenomena we can't properly describe theoretically and need more experimental information before we can figure out what these recent discoveries mean and how they will impact our understanding of fundamental physics. We expect the current and next generation of experiments to reveal a new world of fundamental particles and hope our theoretical research efforts will help us move towards a more satisfying understanding of how nature works.



The masses of all the known fermions span at least 13 orders of magnitude. Two of the three neutrino masses are known to be non-zero. Neutrino masses are much smaller than those of all other fermions.

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 37 graduate faculty and 12 faculty at other ranks (instructional and research faculty). Our graduate program generally has about 100 graduate students and 37 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.



Alumni Focus

David Joffe alumnus of the department (Ph.D. 2004 - supervisor K. Seth) recently received tenure and promotion to Associate Professor in the Department of Physics at Kennesaw State University.

Jerry Novotny earned a BS in Physics from the University of Notre Dame (class of 1972) and then attended and graduated from the Kellogg School of Management in Evanston (Class of 1974). While not using my physics degree in my professional career, I continue to have interest in science in general and manufacturing specifically.

Ahmet Uysal is currently working at Argonne National Laboratory in Argonne, IL as a staff scientist. He moved to Buffalo Grove, IL and is very happy with his newborn baby boy: Ekrem Uysal. Ekrem was born on May 6th and he is their second child. Big sister Asel was born a few months before Ahmet graduated.

Stephen A. Becker earned his BA degree from Northwestern University in 1972, and an MS degree from Case Western University in 1974 before going on for his PhD in astronomy from the University of Illinois, Urbana (1979). In 1978, as a graduate student at the University of Illinois, he first visited Los Alamos to give a presentation for Art Cox in T-6 and while a Postdoc at Cal Tech (1980-1982), he returned to LANL many times as a visiting scientist in X and T Divisions. He became staff member in group X-2 in 1983, and was mentored by Michael Newman, Steve Howe, and Merri Wood-Shultz during his first two years. Steve's work in nuclear weapons has included active participation with six nuclear tests — four as the principle secondary designer. He was also the appointed design physicist for two unfielded nuclear tests. He served for many years as the Point of Contact (POC) for the W85, W80 and W78 weapon systems. As a result of his astrophysical training it was noticed that there was a connection between the astrophysical r-process and the heavy-element production done by LLNL and LANL in special nuclear tests where new elements and isotopes were discovered, and a comprehensive review paper was written. An unclassified presentation of this study was presented to the Russian design lab at RFNC-VNIIRF in March 2005. Steve is still committed to his initial scientific interest in astronomy, serving as president of the Pajarito Astronomy Club. He is also a member of the American Astronomical Society and the International Astronomical Union. In non-scientific activities, he is a private pilot, he relishes flying aerobatic planes in Santa Fe, and in 1995, he made it to the interview stage of the astronaut selection process.



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Contact Us

Department of Physics & Astronomy

2145 Sheridan Road
Evanston, IL 60208

Phone:
(847) 491-3685

Fax:
(847) 467-6857

physics-astronomy@northwestern.edu

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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

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**Department of Physics & Astronomy
Northwestern University
2145 Sheridan Road
Room F 165
Evanston, IL 60208-3112**