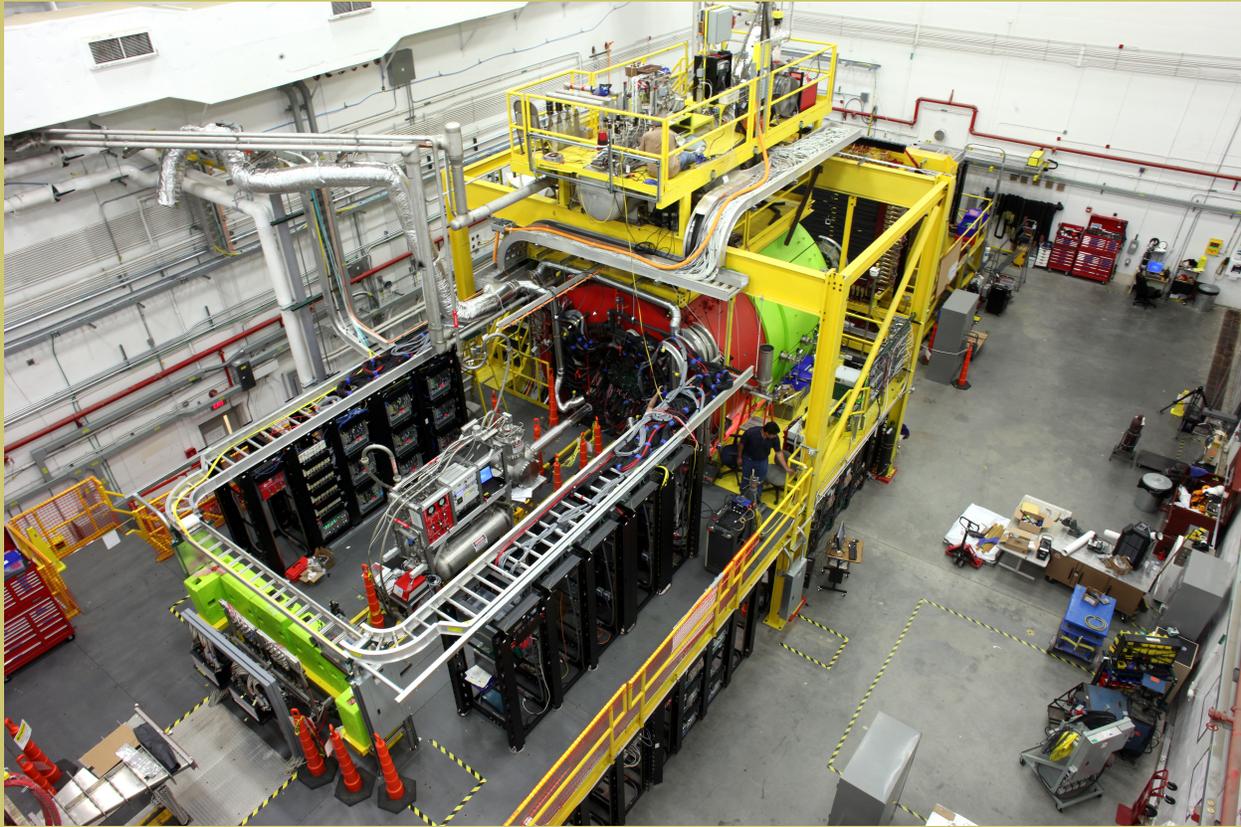


# *Dimensions*

Department of Physics & Astronomy



The GlueX experiment at Jefferson Lab, Newport News, VA

## IN THIS ISSUE:

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# Identifying an Exotic Meson

by Kamal Seth



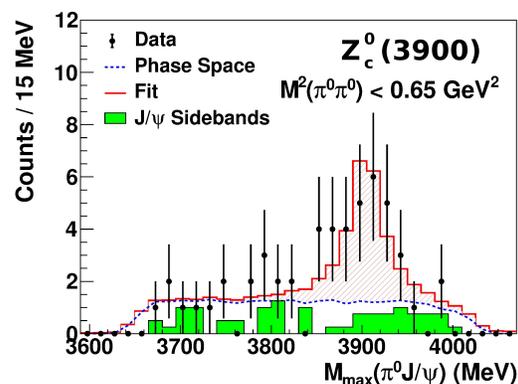
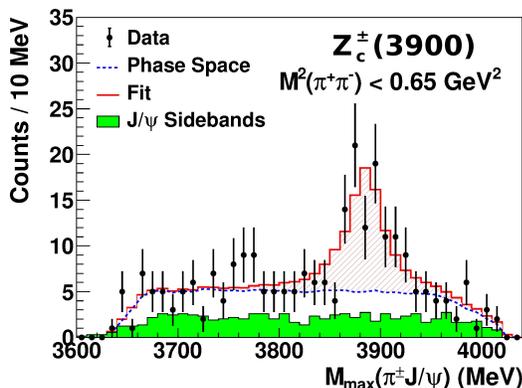
Until very recently only two types of hadrons, constructs of quarks and gluons, had been experimentally observed, quark-antiquark mesons, and 3-quark baryons, even though the accepted theory of strong interactions, Quantum ChromoDynamics (QCD) allows the existence of other constructs like 6-quark dibaryons, 2-quark/2 antiquark mesons, and mesons and baryons containing valence gluons. Numerous searches for these unusual hadrons, dubbed “exotic,” were made during the last 30 years, occasional claims for their observation were made, but none was confirmed. As more powerful and higher energy accelerators were built in China, Japan, U.S., and Europe, the search has received renewed attention. This is an account of one of these very recent successful searches in

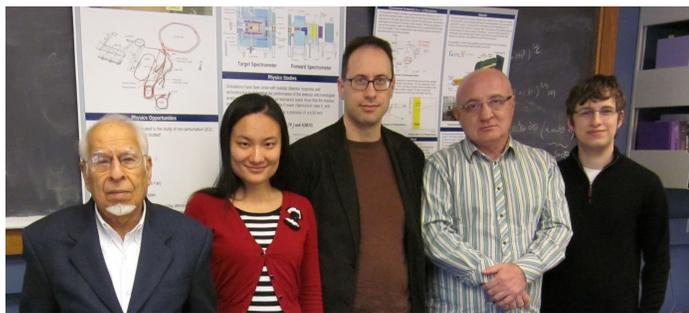
which the group of Professor Seth has played an important part.

Until recently, while a large number of conventional charged and neutral mesons containing ‘up’ and ‘down’ quarks and antiquarks had been observed, no charged mesons with masses larger than about 2500 MeV (two and half times the mass of a proton) had been observed. Only neutral heavier mesons containing ‘charm’ or ‘beauty’ quarks were known to exist in families called ‘charmonium’ and ‘bottomonium’. This changed recently. The B-meson factory in Japan recently claimed observing several charged exotic mesons, but their existence has remained controversial.

Last year the BES III group in Beijing and the Belle group in KEK, Japan claimed identical observations of an exotic charged hadron  $Z_c(3900)$  with mass of 3900 MeV which decayed into a charged pion (up/down quark/antiquark) and  $J/\psi$  (charm/anticharm quarks). Such a meson certainly deserves to be called ‘exotic’ because it must contain 4 quarks/antiquarks. However, there were two caveats associated with the observation. It was claimed that this meson was formed in the decay of a charmonium state  $X(4260)$  which is known to have very unusual properties itself. Further, if the observation is being interpreted correctly, there must be a neutral member associated with it to make the proper (isospin) triplet, which neither the BES or Belle groups observed. We decided to put both these caveats to test by analyzing our data from the CLEO/CESR electron-positron collider.

The first step was to try to form the charged  $Z_c(3900)$ , not from the unusual state  $X(4260)$ , as BES and Belle had done, but in the decay of a well known and understood state of charmonium,  $\psi(4170)$ , and then to search for the neutral  $Z_c(3900)$ . We succeeded in both efforts (see figure). We published the paper, entitled “Observation of the Charged Hadron  $Z_c^+(3900)$  and Evidence for the Neutral  $Z_c^0(3900)$  in  $e^+e^- \rightarrow \pi J/\psi$  at  $\sqrt{s} = 4170$  MeV”, with our graduate student, T. Xiao as the lead author, T. Xiao et al., Physics Letters B727, 366 (2013). The paper had received 137 citations in 6 months since its publication.





**Seth Group, from left to right- Professor Kam Seth, Ting Xiao, Sean Dobbs, Amiran Tomaradze, Luke Robinson**

## Faculty News

**William P. Halperin** has been elected to be the USA representative for the C5 Commission of the International Union of Pure and Applied Physics. He will be the secretary of the Commission for three years and then chair the Commission for the next three years.

**Vicky Kalogera** was elected as the astrophysics trustee of the NSF-funded Aspen Center for Physics on July 9. The ACP is a center for physicists that offers long-term workshops, conferences, and research opportunities for those invited to attend. ACP Trustees provide overall scientific, financial, and administrative guidance; typically, only one or at most two astrophysics positions open up every decade, and there are only nine trustees at any given time.

**John Ketterson** has published the second volume of his edited book, *Novel Superfluids*.

Read more:

<http://ukcatalogue.oup.com/product/9780199585915.do>

**David Meyer and Andy Rivers** have been named to the 2014 Faculty and Administration Honor Roll by the Associated Student Government (ASG).

Read more:

[http://issuu.com/annarennich5/docs/faculty\\_\\_\\_administration\\_honor\\_roll](http://issuu.com/annarennich5/docs/faculty___administration_honor_roll)



**David Meyer** has been in The Teaching Company's recent release of an 18-lecture video course entitled "A Visual Guide to the Universe." In this course, produced in partnership with the Smithsonian Institution, Professor Meyer discusses the scientific stories behind some of the most spectacular cosmic images obtained by NASA space probes and observatories over the past 20 years. The lecture topics range from Cassini's close-up view of Saturn's rings to Spitzer's infrared panorama of star formation in the Swan Nebula to Hubble's detailed view of the most peculiar galaxies.

Read more:

<http://www.thegreatcourses.com/courses/a-visual-guide-to-the-universe.html>

**Adilson Motter** and David Campbell's "Chaos at Fifty" paper has been selected to be part of the annual series "The Best Writing on Mathematics," published by The Princeton University Press.

**Giles Novak** has been appointed as the new faculty director of the Tech Instrument Shop. He began the three-year position in June 2014. As the faculty director, Professor Novak will directly oversee the shop, which is a full-service machining, fabrication and repair facility. He will also chair the faculty advisory committee, supervise staff and their professional development, lead fundraising efforts to expand the shop's capabilities and services, and partner with the Office for Research to make strategic decisions to ensure its financial stability.

**Frederic A. Rasio** has been appointed to the Advisory Board of the Kavli Institute for Theoretical Physics (KITP) at the University of California, Santa Barbara. On that advisory board, he joins a group of researchers who work in fields from quantum physics, chemistry, and biophysics to earth & planetary physics and astronomy. Together, they will help direct the scientific programs held at KITP, which is regarded as an international center for facilitating collaborations and advancing theory.

**David Schwab's** work on computer learning was recently featured in Quanta Magazine.

Read more:

<https://www.quantamagazine.org/20141204-a-common-logic-to-seeing-cats-and-cosmos/>

**Sara A. Solla** was elected an APS Fellow. Her citation is "For applications of statistical physics to problems concerning learning, adaptation, and information coding in neural systems."

Read more:

<http://www.aps.org/units/dbp/fellowship/index.cfm>

**Nathaniel Stern** received the 2014 Northwestern-Argonne Early Career Investigator Award for Energy Research for his proposal to investigate the use of monolayer semiconductor quantum dots to improve solar efficiency.

## Selected Publications

### Jens Koch

Perturbative approach to Markovian open quantum systems by Andy C. Y. Li, F. Petruccione, Jens Koch. **Sci. Rep.** **4**, 4887 (2014).

Once a quantum system interacts with environment degrees of freedom, it becomes an open quantum system whose evolution can often be cast into the language of a Lindblad master equation. Our article addresses the question how to set up a stationary perturbation theory at the level of this master equation in a controlled and systematic way. Results from this work may ultimately help to understand dissipative phase transitions in many-body quantum systems out of equilibrium.

<http://dx.doi.org/10.1038/srep04887>

### Yoram Lithwick

Theory and Simulations of Rotating Convection by Adrian J. Barker, Adam M. Dempsey, Yoram Lithwick. **Astrophysical Journal (ApJ)** **791:13**, 2014).

We study thermal convection in a rotating fluid in order to better understand the properties of convection zones in rotating stars and planets. We first derive a mixing-length theory for rapidly rotating convection, arriving at the results of Stevenson via simple physical arguments. The theory predicts the properties of convection as a function of the imposed heat flux and rotation rate, independent of microscopic diffusivities. In particular, it predicts the mean temperature gradient, the rms velocity and

temperature fluctuations, and the size of the eddies that dominate heat transport. We test all of these predictions with high resolution three-dimensional hydrodynamical simulations of Boussinesq convection in a Cartesian box. The results agree remarkably well with the theory across more than two orders of magnitude in rotation rate. For example, the temperature gradient is predicted to scale as the rotation rate to the four-fifths power at fixed flux, and the simulations yield  $0.75 \pm 0.06$ . We conclude that the mixing-length theory is a solid foundation for understanding the properties of convection zones in rotating stars and planets.

<http://arxiv.org/pdf/1403.7207.pdf>

### Brian Odom

Broadband optical cooling of molecular rotors from room temperature to the ground state by Chien-Yu Lien, Christopher M. Seck, Yen-Wei Lin, Jason H.V. Nguyen, David A. Tabor, Brian Odom. **Nature Communications** **5**, 4783 (2014).

Trapped molecules are widely recognized as holding promise for applications ranging from quantum information processing to searches for new physics beyond the Standard Model. However, the requisite internal state control and non-destructive state readout have proven challenging. Now, Brian Odom's group has developed a technique to use a single broadband laser to pump trapped molecules to their ground rotational-vibrational state, achieving cooling from room temperature to 4 Kelvins in a fraction of a second.

<http://www.nature.com/ncomms/2014/140902/ncomms5783/full/ncomms5783.html>



### Frederic A. Rasio

From Hot Jupiters to Super-Earths via Roche Lobe Overflow by Francesca Valsecchi, Frederic A. Rasio, Jason H. Steffen. **Astrophysical Journal Letters (ApJL 793:L3,2014)**.

Through tidal dissipation in a slowly spinning host star the orbits of many hot Jupiters may decay down to the Roche limit. We expect that in most cases the ensuing mass transfer will be stable. Using detailed numerical calculations we find that this evolution is quite rapid, potentially leading to complete removal of the gaseous envelope in a few Gyr, and leaving behind an exposed rocky core (“hot super-Earth”). Final orbital periods are quite sensitive to the details of the planet’s mass-radius relation, and to the effects of irradiation and photo-evaporation, but could be as short as a few hours, or as long as several days. Our scenario predicts the existence of planets with intermediate masses (“hot Neptunes”) that should be found precisely at their Roche limit and in the process of losing mass through Roche lobe overflow. The observed excess of small single-planet candidate systems observed by Kepler may also be the result of this process. If so, the properties of their host stars should track those of the hot Jupiters. Moreover, the number of systems that produced hot Jupiters could be 2-3 times larger than one would infer from contemporary observations.

[http:// rXiv.org/abs/1408.3635](http://rXiv.org/abs/1408.3635)

### Kamal K. Seth

First measurement of the electromagnetic form factor of the neutral kaon at a large momentum transfer and the effect of  $SU(3)$  breaking by Kamal K. Seth, S. Dobbs, A. Tomaradze, T. Xiao, G. Bonvicini. **Physics Letters B730 (2014) 332-335**.

<http://www.sciencedirect.com/science/article/pii/S03702>

First measurements of timelike form factors of the hyperons,  $\Lambda^0$ ,  $\Sigma^0$ ,  $\Sigma^+$ ,  $\Xi^0$ ,  $\Xi^-$ , and  $\Omega^-$ , and evidence of diquark correlations by S. Dobbs, A. Tomaradze, T. Xiao, Kamal K. Seth, G. Bonvicini. **Physics Letters B739 (2014) 90-94**.

<http://inspirehep.net/record/1325098/files/scoap3-fulltext.pdf>

**Fall 2014**

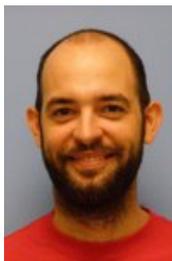
### Nathaniel Stern

Coherent optical non-reciprocity in axisymmetric resonators by Erik J. Lenferink, Guohua Wei, Nathaniel P. Stern. **Optics Express 22, pp. 16099-16111 (2014)**.

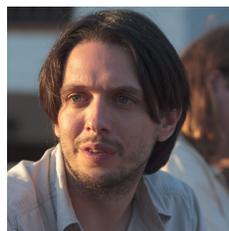
In recent years, there has been a significant interest in non-reciprocal optical behavior for both practical application as optical isolators and theoretical possibilities for quantum information in photonic networks. This manuscript combines the formalism of cavity QED and quantum optics with the broken symmetries of spin systems to reveal a new approach to non-reciprocal optical behavior in a coherent regime. The possibilities for experimental implementation are also investigated, and are currently being pursued in Stern's research lab.

<http://www.opticsinfobase.org/oe/abstract.cfm?URI=oe-22-13-16099>

## New Research Staff



**Daniel Angles-Alcazar** joined Assistant Professor Faucher-Giguère's group as a CIERA Postdoctoral Fellow. Daniel specializes in numerical simulations of galaxy formation and evolution, and he comes to us from the University of Arizona, where he received his PhD.



**Fabio Antonini** joined Northwestern in November; he was a postdoc at the Canadian Institute for Theoretical Astrophysics, and joins CIERA as a Postdoctoral Fellow.

Fabio will work with Professor Rasio's group as well as with Professor Kalogera's group.



**Sourav Chatterjee** joined Professor Rasio's group as a CIERA Postdoctoral Fellow; Sourav focuses on studying star clusters and exoplanet systems. He earned his Ph.D.

at Northwestern and was the Theoretical Astrophysics Postdoctoral Fellow at the University of Florida prior to returning to Northwestern.



**Matt Dietrich** joined the Department as a research assistant professor in April, working with Brian Odom on rotational cooling of molecular ions. He worked previously on quantum computing with trapped ions at the University

of Washington, and then later at Argonne National Lab searching for the atomic electric dipole moment of ultracold radium atoms. Matt is interested ultimately in using cold atoms and molecules for precision tests of the standard model and nuclear structure.



**Aleksandar Haber** joined Professor Motter’s group as a post-doctoral fellow in September 2014. He was previously a graduate student at the Delft University of Technology in the Netherlands. His research is focused on optimization and control of complex networks.

he has led a group of scientists and programmers who have developed computer modeling tools that enable large-scale virtual prototyping of particle accelerators for physics and many other applications.

Read more:

[http://www.fnal.gov/pub/today/archive/archive\\_2014/day14-09-09.html](http://www.fnal.gov/pub/today/archive/archive_2014/day14-09-09.html)



**Jae Young Suh** has started a faculty position at Michigan Tech after working as a postdoc in the Stern Group. He is continuing his research in photonics, nanoplasmonics, and quantum optics in his own laboratory, building off of his research at

Northwestern with Professors Nathaniel Stern and Teri Odom in Chemistry.

## Alumni News



**Daryl Haggard**, CIERA Postdoctoral Fellow, had her research about the growth of supermassive black holes featured in the July 2014 issue of BBC’s Sky at Night Magazine. The piece,

filed under the “What I Really Want To Know Is…” section, features Daryl’s research on a small gas cloud approaching the supermassive black hole at the center of the galaxy and how the cloud will contribute mass to the black hole as it approaches.



**Panagiotis Spentzouris** has been named head of the Scientific Computing Division at Fermilab. Panagiotis got his doctorate working with Heidi Schellman in 1994, and after a postdoc at Columbia University, became a Research Associate at Fermilab. At Fermilab,

## Undergraduate Achievements

Undergraduate students Ben Sandeen (who works with Prof. Vicky Kalogera), Matt Hroma (working with Prof. Giles Novak), and Emily Ellinger (an advisee of Dr. Jason Steffen), were each awarded \$3,000 scholarships through the Illinois Space Grant Consortium. In addition, undergraduate student Daniela Deleon, (who works under Prof. Mel Ulmer), also received a \$2,000 scholarship.



**Matt Hroma**



**Emily Ellinger**

CIERA was host to a group of 27 talented high school and undergraduate researchers this summer. Among the students who worked in astronomy-related projects, nine were awarded funding from Weinberg College and NASA's Illinois Space Grant Consortium. Those students are listed below, with their projects:

**Leah Perri**, "Characterizing Astrophysical Parameter Estimation Capabilities of LIGO"

**Lauren Barmore**, "Visualizations of Planetary Formation and Dynamics"

**Shyam Bharadwaj**, "Feedback from Star Clusters in Cosmological Simulations of Galaxy Formation"

**Emily Ellinger**, "Modeling the Effects of Gaseous Disks on Planetary System Orbits"

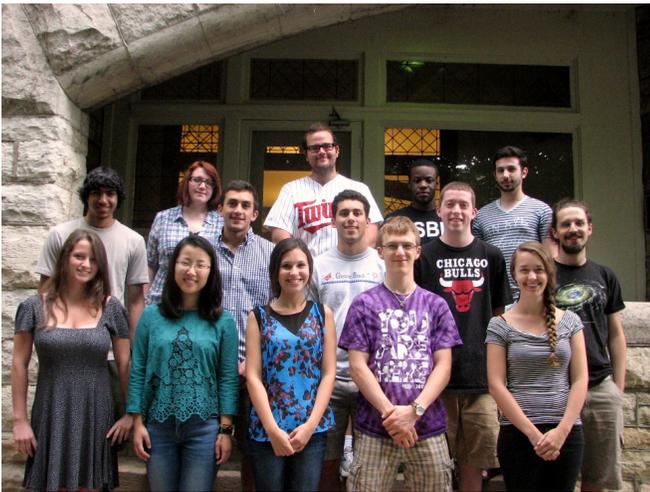
**Matthew Hroma**, "SHARP Instrument Upgrades, or Instrument Improvements to the SHARP Polarimeter"

**Tyler Karian and Shannon Grogans** are both working on "Next-Generation X-ray Optics"

**David Lee**, "Understanding the Orbital Properties of Exoplanets"

**Ben Sandeen**, "Gravitational Waves and Black Hole/Neutron Star Binary Systems"

Some of our summer students appear in this image:



3rd Row - Shannon Grogans, Scott Coughlin, Claudeson Azurin, Brandon Miller

2nd Row - Shyam Bharadwaj, Tyler Karian, Jeremy Vollen, Ben Lampert, Daniele Trifiro

1st Row - Amanda Newmark, Yifang Cao, Leah Perri, Ben Sandeen, Emily Ellinger

## Graduate Achievements



**Katie Breivik and Jason Hwang** were awarded The Illinois Space Grant Consortium Scholarship for the 2014-2015 school year. Katie Breivik, who studies under Prof. Shane Larson, and Jason Hwang, who studies under Prof. Fred Rasio, were each awarded \$10,000 by the ISGC.



**Sean Cornelius** has received the 2014 Student Paper Prize from the Society for Industrial and Applied Mathematics (SIAM) for his approach to control nonlinear complex networks, published jointly

with his advisor in *Nature Communications*. Dr. Cornelius was a graduate student in Prof. Adilson E. Motter's group

<<http://dyn.phys.northwestern.edu/index.html>>.

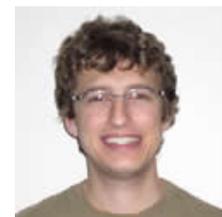
Read Cornelius' paper here:

<http://www.nature.com/ncomms/2013/130627/ncomms2939/full/ncomms2939.html>



**Andy Li** has been awarded a World Quantitative and Science Scholarship from the WorldQuant Foundation. Andy is a graduate student currently working with Prof. Jens Koch on quantum

of interacting many-body systems out of equilibrium.



**Luke Robison** has been awarded the prestigious and highly competitive Department of Energy Fellowship Award.



**Carl Rodriguez** recently produced a film entitled “Black Holes & Star Clusters” for the short film category at the Jackson Hole Science Media Film Festival. The film is about 5 minutes long, and focuses on explaining

globular clusters. The film contains videos produced by Matt McCrory and his team at Northwestern University’s Visualization Services. The film also features a CGI animation that was produced from an N-body simulation run by Carl. This is a biannual festival that took place September 17-19 2014 in Boston.



**Pam Villalovoz** was this year’s recipient of the Weinberg Community Excellence Award. This award is given to recognize a College staff member who positively represents their department or program by consistently displaying approachability and a welcoming demeanor to students, faculty and staff. This person contributes to a positive work environment and a feeling of community by demonstrating collegiality, energy and enthusiasm. Congratulations to Pam on well-deserved recognition!



**Niharika Sravan** volunteered at the City of Evanston’s Camp Kaleidoscope on July 18. She worked on a constellation project with a group of 3 to 5

year-olds designed to inspire their curiosity about the universe. Niharika helped the students create their own constellations from construction paper, and share their constellation myths with the class.

## Staff News



**Peter Anglada** joined CIERA in April 2014 as the new Financial Administrator. Peter earned a Master’s Degree in Business Administration from Kellogg, and most recently worked as a Financial Assistant in the

Life Sciences group. Peter enjoys tennis, reading, especially historical & classical novels.



**Early construction of the Dearborn Observatory dome, which was completed in 1875.**



**Liz Lwanga** started as the Undergraduate Secretary in September 2014. She lives in Evanston with her cat, Agnes, and is pursuing a dual master’s degree in divinity and social

work at Garrett Seminary. She enjoys traveling, sewing, reading, running, and spending time with friends and family.

# Northwestern's Society of Physics Students (SPS)

In Fall quarter 2014, the Society of Physics Students (SPS) held its first event of the year, The Magic of Physics. Professor Art Schmidt showed off a variety of magical and scientific demonstrations that showcased the magic of physics. The demonstrations included mirror illusions, static electricity levitation, and a column of flames! The attendees learned about the science behind these demos and how physics can be used to create magical illusions.

This quarter, SPS also hosted a lecture by Professor Adilson Motter titled "Complex Networks: When Not to Invoke Reductionism." The lecture focused on systems that exhibit collective behavior that cannot be predicted by the behavior of the individual parts, and how this applies to our understanding of the physical world.

SPS is looking forward to the coming year and has a lot of fun and interesting events planned for the future!



Students use static electricity for levitation.



Professor (and wizard) Art Schmidt at the Magic of Physics event.



Professor Art Schmidt demonstrates a column of flame.

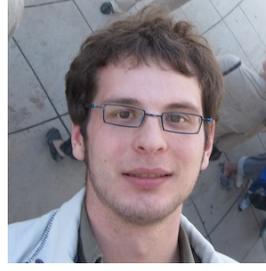
# Welcome to our 2014 Incoming Graduate Students!



**Erik Binter**



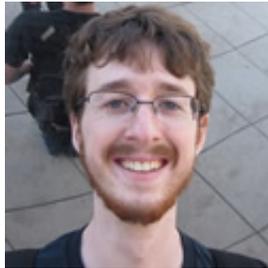
**Sebastian Fuchs**



**Joshua Fixelle**



**Mahshid Ghaffari**



**Zachary Hafen**

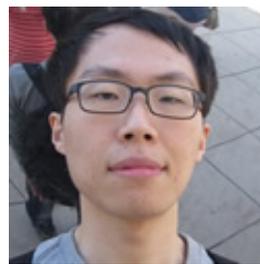


**Mecca Islam**



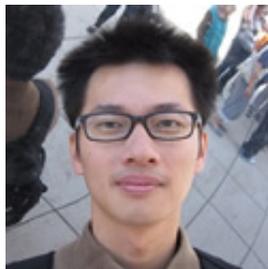
**Golam Kashef**

**Anirudh Krovi**

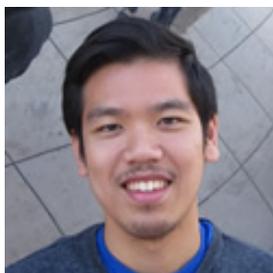


**Jinho Lim**

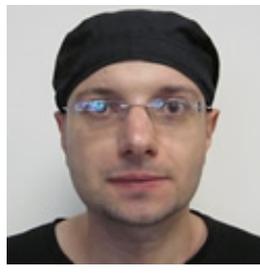
**Wei-Ting Lin**



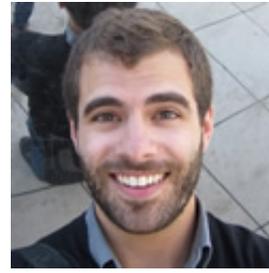
**Michael Medina**



**Man Nguyen**



**Mehdi Zahedi**

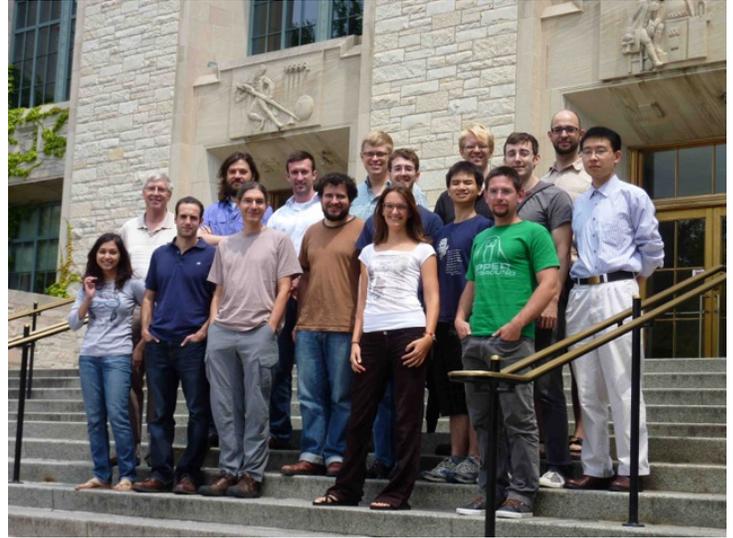


**Michael Zevin**

## Department Events

### CIERA Hosts Galaxy Formation Workshop

On July 24-26, CIERA hosted a workshop for the FIRE (Feedback In Realistic Environments) galaxy formation simulation project. This workshop, organized by Prof. Claude-André Faucher-Giguère, brought together sixteen galaxy formation experts to Northwestern from leading institutions in the US, Canada, and Europe and catalyzed a number of new projects within the FIRE collaboration. The FIRE project produces simulations that are currently being used to study the origin of heavy elements in the Universe, the effects of stellar processes on dark matter and gas in and around galaxies, and galaxy/black-hole co-evolution.



### Experts on X-Ray Optics Meet at Northwestern, Discuss Next-Generation Space Telescopes



On Friday, August 22nd, CIERA hosted a meeting of some of the country's leading experts in fabricating X-ray mirrors for space-based X-ray telescopes. Organized by Professor Mel Ulmer, thirteen attendees from Goddard Space Flight Center, Harvard/CfA, Lawrence Livermore National Laboratory, Marshall Space Flight Center, MIT, NASA Headquarters, and Northwestern University met to give summaries of each group's methods for producing high-resolution, lightweight X-ray optics, and to also talk about each lab's biggest challenges. Finally, they discussed the next steps forward for organizing their efforts, and working towards the next X-ray telescope mission.

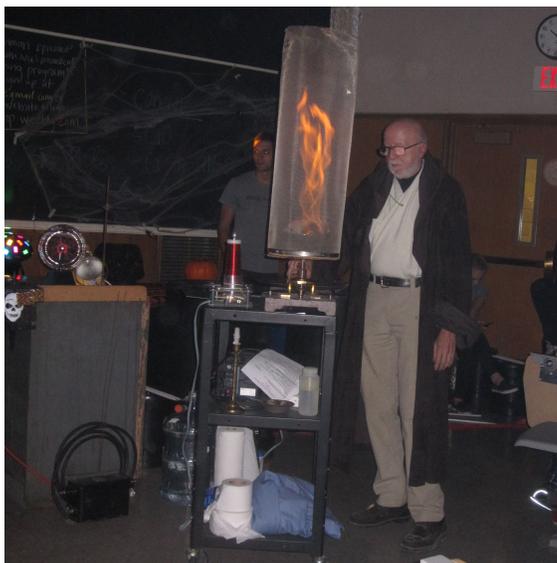
### Graduate Students met with over 100 Second Grade Students

On May 28th, graduate students Meagan Morscher and Joel Schwartz met with a group of over 100 2nd grade students from Rowe Elementary School in Chicago, who were visiting the NU campus. Meagan and Joel talked to the kids about what a scientist is, shared examples of some of the cool things that scientists work on, and did a couple of fun demos. They also addressed the negative stereotype of a scientist as a socially awkward person in a lab coat who cares only about science, by starting the presentation wearing lab coats, safety glasses and gloves (although neither of them actually works in a lab coat!).



They explained to the kids that not all scientists even work in a traditional lab (off came the lab coats!), and that scientists are real people who also like to do some of the same things that they do, like hang out with friends, play sports, listen to music, enjoy the outdoors, and even play video games!

## Chemistry Halloween Show with Professor Art Schmidt



Pillar of Fire- rotating tube of mesh creates a tornado of fire from small alcohol flame.



Professor Schmidt as Obi Wan Kenobi with R2D2 mini me



Blowing up the earth using a leaf blower

On Halloween 2014, Eberhardt Zwergel, the Chemistry Department Lecturer Demonstrator put on his traditional Chemistry Halloween Extravaganza where for each of the four Gen. Chemistry classes on Halloween he does an hours worth of explosive chemistry reactions. For the last 20 or so years he has invited Art Schmidt to participate with cameos of his more spectacular Physics Demonstrations. This year dressed as Obi Wan Kenobi Art lit up a full size fluorescent light in his hand ala light saber using a Tesla Coil. He and Eberhardt have vied in a friendly competition to see who could create the most impressive pillar of fire. This year Eberhardt's was higher but Art pulled even with creativity, by roasting marshmallows over his tower of flame. Art blew up the world floating a globe beach ball on the air stream from a leaf blower. For the finale Art lit Eberhardt's propane torch with a Horn gap or Jacob's Ladder arc, which Eberhardt used to ignite balloons filled with hydrogen and oxygen hydrogen mixtures. The Technological Institute rocked with shocks from the explosions.

# Inauguration of the Institute of Cosmology and Physics



Congratulations to Professor Mayda Velasco, Director of the new Institute of Cosmology and Physics (COFI), on the institute's successful inauguration! The event began on November 2<sup>nd</sup> with a dinner and address by Nobel Laureate, Adam Riess. About 100 people attended the dinner, with 40% of the attendees traveling from abroad. The inauguration continued the next day with a public lecture by Riess at the University of Puerto Rico, attended by over 1000 people.

# Farewell Party for Professor and Chair Heidi Schellman



After 24 years in the Department, Prof. Heidi Schellman is moving to accept a position as Professor and Chair of the Department of Physics at Oregon State University. Prof. Schellman has chaired our Department since 2010. The Department and friends bid a fond farewell to her at a party on November 19.



# Physics & Astronomy Department Holiday Party 2014!



Our 2014 Holiday Party was lots of fun. Plenty of good food, and holiday joy enjoyed by everyone!



**Dimensions was compiled by Monica Brown**

Please visit the Physics and Astronomy website for a complete list of upcoming events:  
[www.physics.northwestern.edu/events](http://www.physics.northwestern.edu/events)  
Be sure to check out our Facebook Fan page and our LinkedIn Group Page.  
Type in "Department of Physics and Astronomy, Northwestern University".

# Alumni News

Name: \_\_\_\_\_

Degree: \_\_\_\_\_

Graduation Year: \_\_\_\_\_

e-mail Address: \_\_\_\_\_

Phone Number: \_\_\_\_\_

News: \_\_\_\_\_

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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 Monica Brown [monica.brown@northwestern.edu](mailto:monica.brown@northwestern.edu).

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