Fall 2013

DIMENSIONS

Department of Physics & Astronomy

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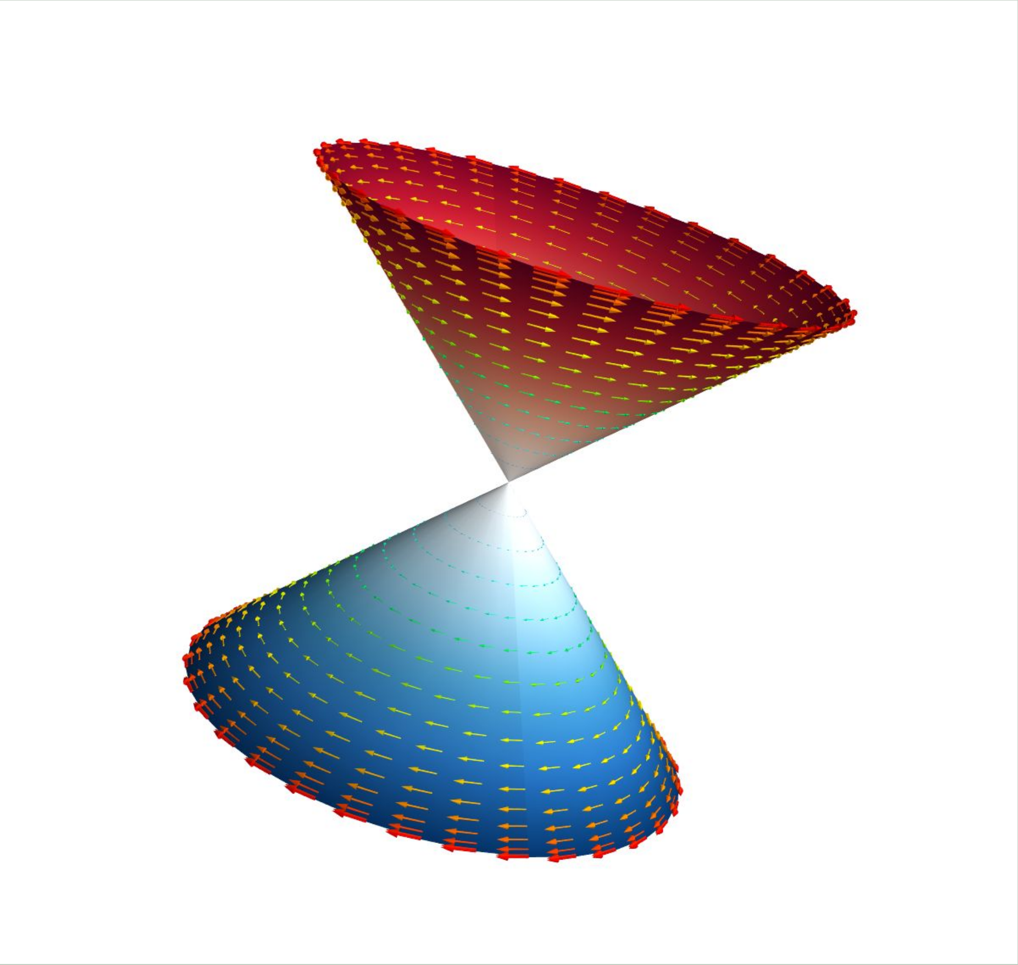


Helical Spin Structure of the Majorana Spectrum of Superfluid Helium-Three

Majorana fermions as quanta of a superfluid vacuum

by James A. Sauls

In a perspective article "Majorana returns" published in Nature Physics,[1] Frank Wilczek (Walter and Christine Heilborn Lecturer in 2004) wrote "In his short career, Ettore Majorana made several profound contributions. One of them, his concept of Majorana fermions - particles that are their own antiparticle - is finding ever wider relevance in modern physics." Majorana's idea, published in 1937, was born from Paul Dirac's relativistic quantum theory of the electron, the centerpiece being the *Dirac equation*, which not only accounted for electron spin of ½ (in units of Planck's quantum h-bar), but led directly to the prediction of the positron - the anti-particle of the electron with opposite electrical charge. Majorana found a new equation describing neutral, spin ½ particles that are their own anti-particle, and he speculated that the neutrino might be such a particle. Years later the discovery that the various flavors of neutrinos have mass, and can transform into one another, combined with theories for the spectrum of particles at energies near the Higgs mass, have fueled new generations of experiments designed to search for definitive signatures that neutrinos 'are' - or 'are not' - Majorana particles, as well as searches for hypothesized super-symmetric partners to the neutral gauge bosons of the standard model, all of which are Majorana fermions.

However, neutrino, LHC and dark matter experiments are not the only physics frontiers where Majorana's elusive particles have found renewed interest. The "ever wider relevance" that Wilczek refers to in his article are developments and discoveries in condensed matter where Majorana fermions *emerge* as quanta at ultra-low energies in a number of quantum liquid and solid phases of matter. Indeed since 2008 there has been an explosion of theoretical predictions and discovery of new materials - *insulators, superconductors and superfluids* - in which Majorana's idea has found relevance.

Among the physics frontiers in the search for Majorana fermions are the ultra-low temperature phases of the light isotope of Helium (^{3}He) - the B phase of superfluid ^{3}He to be specific. Not long after their discovery it was realized that the superfluid phases of ^{3}He provided a paradigm for one of the conceptual cornerstones of modern physics, namely the role of spontaneous symmetry breaking in quantum field theory and condensed matter physics.[2] The developments in this field lead to separate Nobel prizes for the discovery of the phases by Douglas Osheroff, Robert Richardson and David Lee in 1996, and for theoretical developments leading to the identification of these macroscopic quantum states of matter by Anthony J. Leggett in 2003.

But only since 2008 has it been widely appreciated that the ground state of this quantum liquid has remarkable properties connected with the mathematics of topology that imply that Majorana fermions exist as quanta. Everything we now believe we understand about superfluid ^{3}He tells us that Majorana fermions must emerge from the ground state of superfluid ^{3}He - what is aptly dubbed the "superfluid vacuum" - as low-energy quanta, confined on the surface or a boundary of superfluid ^{3}He.

So how might these exotic particles be detected? Several theoretical proposals focus on the spin of the Majorana fermions, or the *spin current* carried by Majorana particles. Detecting spin currents of Majorana fermions turns out to be complicated, sufficiently so that the elusive Majorana particles have so far remained just that.

A paper published this month in Physical Review suggests another route to detection.[3] The idea is based on the energy-momentum relation for the Majorana particles, $E = c|\mathbf{p}|$, where the "light speed" of the superfluid vacuum is $c \approx 5$ cm/sec. The superfluid vacuum offers a method for detecting these quanta at ultra-low temperatures utilizing the Doppler shift of the Majorana fermions if the superfluid vacuum is set in motion.

The fundamental property of a superfluid is that it supports a 'persistent current', i.e. mass flow without dissipation - the same phenomena responsible for superconductivity, i.e. the flow of electricity without Joule losses. For ^3He confined in a channel (Fig. 1), motion of the superfluid relative to the channel walls leads to a Doppler shift in the spectrum of Majorana particles confined on the walls, $E \rightarrow E' = c|\mathbf{p}| - \mathbf{p}\bullet\mathbf{v}_s$, where $\mathbf{v}_s$ is the velocity of the superfluid vacuum relative to the channel walls.

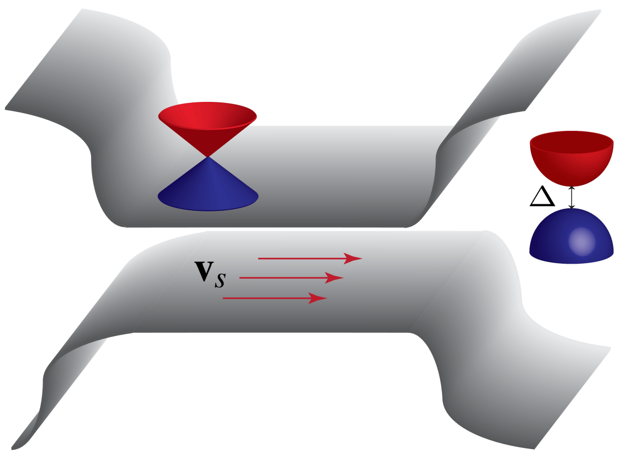


FIG. 1: Majorana Fermions confined on the boundary of ^3He have a massless dispersion, $E = c|\mathbf{p}|$, shown as the Majorana 'cone', while Dirac fermions with mass Δ, are the quanta in bulk ^3He. Relative motion of the superfluid vacuum ($\mathbf{v}_s$) leads to a Doppler shift in the energy of Majorana fermions.

The fraction of mass that can participate in the persistent current depends on the energy and momentum distribution of fermi particles present - in this case the Doppler shifted Majorana fermions - and the absolute temperature, T, which controls the number of thermally excited Majorana fermions. The Doppler effect leads to asymmetry in the thermal populations of Majorana excitations that are co-moving and counter-moving relative to the superfluid vacuum, and thus to a reduction in the persistent current. The linear dispersion of the Majorana particles, their Fermi statistics, combined with their confinement in two dimensions leads to a unique signature: a power law dependence for the reduction in the mass fraction of the persistent current with temperature, $\delta n/n$ proportional to $-(T/cp_f)^3$, where p_f is the Fermi momentum, c is the speed of the Majorana particles and $c\, p_f = \Delta$ is the mass gap for fermions in the bulk of the superfluid vacuum. Just as the radiation flux from matter in thermal equilibrium, proportional to T^4 , is a signature of the thermal distribution of photons, quanta of the electromagnetic vacuum, Majorana fermions reveal their presence as a mass flux, proportional to T^3, in response to the motion of the superfluid vacuum.

While we await the discovery of Majorana fermions, new experiments are being planned and theorists are exploring the "open range" of ramifications of matter in which Majorana particles naturally emerge. Whether or not all of the ideas spawned by Majorana's return to center stage will lead to deeper insight into quantum correlations, or to a new generation of quantum computers is far from being answered, but one thing is known. If Majorana fermions are *not* found in superfluid ^3He then of one of the most successful theories of twentieth century physics - the theory of quantum liquid phases of ^3He will need a pretty serious adjustment. I'm betting that Majorana's particles are zipping about the surface of ^3He, and that there is a remarkable two-dimensional quantum liquid waiting to reveal its secrets. And who knows, maybe we will find out that the larger universe we are embedded in is just as extraordinary as the superfluid vacuum!

1. Majorana Returns, Nature Physics 5, 614 - 618 (2009), Franck Wilczek.

2. The Universe in a Helium Droplet, Oxford University Press, 2009, Grigory E. Volovik.

3. Majorana excitations, spin and mass currents on the surface of topological superfluid ^3He-B, Phys. Rev. B 88, 184506 (2013), Hao Wu and J. A. Sauls.

Faculty News

Vicky Kalogera, working with a group of P&A faculty and CIERA postdocs, has secured an institutional membership for Northwestern in the Large Synoptic Survey Telescope (LSST) project: this decade's highest-priority ground-based astronomy program. Designed to survey the southern sky 1000 times over about ten years, the 8.4 meter LSST will help revolutionize astronomy by especially focusing on faint, transient and moving sources in the solar system, the Galaxy, and throughout the Universe. This institutional membership allows scientists throughout the University to help define the research program of the telescope and to join the LSST science groups, which are at the forefront of utilizing the telescope's data.

John Ketterson and Joe Sklenar, Seongjae Lee were featured on the cover of *Physics Review Letters* (Volume 111, Number 7). The team has recently studied the ferromagnetic resonant properties of a two-dimensional artificial quasicrystal with collaborators at the University of Kentucky, Lexington. The tiles used are Penrose P2 kites and darts that have boundaries defined by ferromagnetic permalloy bars of width 135 nm and lengths 500, and 810 nm.
Read the full article at
http://prl.aps.org/abstract/PRL/v111/i7/e077201

Adilson Motter has been elected to the Executive Committee of the APS Topical Group on Statistical and Nonlinear Physics (GSNP). Over each of the next three years he will be respectively vice-chair, chair elect, and chair of GSNP. Also, Professors Motter and David K. Campbell's *Physics Today* cover story on the 1963 seminar work of Edward Lorenz on the sensitive dependence on initial conditions has been translated to French by *Pour La Science*, and published in it's November 2013 issue.This work has been featured in *Physics World* and in the *APS journal Physics*.

Adilson Motter and **Frank Petriello** have been elected as APS Fellows. Prof. Motter's citation is, "For his contributions to the foundations of chaos and the study of nonlinear dynamics in complex networks, including the discovery of synthetic rescues and pioneering work on network synchronization phenomena, cascading failures, and the control of nonlinear network dynamics."
Prof. Petriello's citation is, "For pioneering new methods in the application of perturbative quantum chromodynamics to high-energy processes, and for computing high precision, fully exclusive production cross sections for electroweak vector bosons and Higgs bosons at hadron colliders."

Giles Novak, Andrew Rivers, and **Michael Smutko** have been included in the Associated Student Government's 2012-2013 Faculty Honor Roll.

Heidi Schellman was featured in Fermilab Today for her work with the DZero collaboration. With alumnus Sahal Yacoob, she has released new details on their method of measuring the mass of the W Boson.
Read the full article at
http://www.fnal.gov/pub/today/archive/archive_2013/today13-11-14.html

Michael Smutko addressed students on the effects of laptop use in class, which he has been researching at Northwestern since 2009. He found that using technology to multitask in the classroom leads to a marked decrease in performance. His advice to students: "It doesn't affect me. But it affects you."
Read more at the Daily Northwestern
http://dailynorthwestern.com/2013/11/10/campus/rcb-event-offers-northwestern-take-on-popular-ted-talks/

Mayda Velasco hosted the department's celebration of the award of the Nobel Prize to the theorists who originally proposed the existence of the Higgs Boson. Velasco's research, along with the work of fellow Northwestern physicists **Michael Schmitt** and **Kristian Hahn**, contributed to the discovery of the Higgs Boson.
Read the full article at
http://www.northwestern.edu/newscenter/stories/2013/10/scientists-toast-nobel-prize-for-higgs-discovery.html?utm_campaign=&utm_medium=email&utm_source=enews

Selected Publications

Michael J. Bedzyk

Crystalline polymorphism induced by charge regulation in ionic membranes by Cheuk-Yui Leung, Liam C. Palmer, Sumit Kewalramani, Bao Fu Qiao, Samuel I. Stupp, Monica Olvera de la Cruz, and Michael J. Bedzyk. **Proceedings of the National Academy of Sciences, 110, 16309-16314 (2013).**

The crystallization of molecules with polar and hydrophobic groups, such as ionic amphiphiles and proteins, is of paramount importance in biology and biotechnology. Research published in the Proceedings of National Academy of Sciences by a Northwestern University collaboration demonstrated how to combine X-ray scattering and theoretical to study how crystalline order within membranes formed by coassembled cationic and anionic amphiphiles can be controlled by varying pH and molecular tail length. Their work suggests how to design bilayer membranes with specific crystalline arrangements at ambient temperature and physiologically relevant pH environments by suitable choices of molecular headgroups and tails. Their work suggests how to design bilayer membranes with specific crystalline arrangements at ambient temperature and physiologically relevant pH environments by suitable choices of molecular headgroups and tails. Changes in crystallinity are likely to affect molecular diffusion rates across membranes and may enable control cover the encapsulation and release of molecules within the membrane. Moreover, pH-induced crystalline transformations are likely used by organisms to control metabolic flow in harsh environments.
http://www.pnas.org/content/early/2013/09/24/1316150110.abstract

Jens Koch

Dispersive regime of the Jaynes–Cummings and Rabi lattice by Guanyu Zhu, Sebastian Schmidt and Jens Koch. **New Journal of Physics 15, 115002 (2013).**

The interaction between two photons is typically extremely weak. Interaction of photons with matter, however, can induce an effective photon-photon interaction. This mediated interaction is harnessed in lattice systems of interacting photons, which can be implemented, for example, in the circuit QED architecture with coupled microwave resonators and superconducting qubits. Our recent work describes what happens in such a system when photons and qubits are strongly detuned: in this case, effective spin models and interacting boson models emerge, which may in the future be realized by circuit QED experiments.
http://iopscience.iop.org/1367-2630/15/11/115002/

Prem Kumar

Photonic Nonlinearities via Quantum Zeno Blockade by Yu-Zhu Sun, Yu-Ping Huang, and Prem Kumar. **Phys. Rev. Lett. 110, 223901 (2012).**

Realizing optical-nonlinear effects at a single-photon level is a highly desirable but also extremely challenging task, because of both fundamental and practical difficulties. We present an avenue to surmounting these difficulties by exploiting quantum Zeno blockade in nonlinear optical systems. Considering specifically a lithium-niobate microresonator, we find that a deterministic phase gate can be realized between single photons with near-unity fidelity. Supported by established techniques for fabricating and operating such devices, our approach can provide an enabling tool for all-optical applications in both classical and quantum domains.
http://prl.aps.org/abstract/PRL/v110/i22/e223901

Experimental Demonstration of Interaction-Free All-Optical Switching via the Quantum Zeno Effect by Kevin T. McCusker, Yu-Ping Huang, Abijith S. Kowligy, and Prem Kumar. **Phys. Rev. Lett. 110, 240403 (2013).**

We experimentally demonstrate all-optical interaction-free switching using the quantum Zeno effect, achieving a high contrast of 35:1. The experimental data match a zero-parameter theoretical model for several different regimes of operation, indicating a good understanding of the switch's characteristics. We also discuss extensions of this work that will allow for significantly improved performance, and the integration of this technology onto chip-scale devices, which can lead to ultra-low-power all-optical switching, a long-standing goal with applications to both classical and quantum information processing.
http://prl.aps.org/abstract/PRL/v110/i24/e240403

Adilson Motter

Doubly transient chaos: Generic form of chaos in autonomous dissipative systems by A.E. Motter, M. Gruiz, G. Karolyi, and T. Tel. **Phys. Rev. Lett. 111, 194101 (2013).**

Chaos is an inherently dynamical phenomenon traditionally studied for trajectories that are either permanently erratic or transiently influenced by permanently erratic ones lying on a set of measure zero. The latter gives rise to the final state sensitivity observed in connection with fractal basin boundaries in conservative scattering systems and driven dissipative systems. This study reveals a new type of chaos in the common prevalent case of undriven dissipative systems, whose transient dynamics fall outside the scope of previous studies. It is shown that such systems can exhibit positive finite-time Lyapunov exponents and fractal-like basin boundaries which nevertheless have codimension one. In sharp contrast to its driven and conservative counterparts, the settling rates grow exponentially in time, meaning that the fraction of trajectories away from the attractors decays superexponentially. While no invariant chaotic sets exist in such cases, the irregular behavior is governed by transient interactions with transient chaotic saddles, which act as effective, time-varying chaotic sets.
http://prl.aps.org/abstract/PRL/v111/i19/e194101

Jim Sauls

Chiral Phases of Superfluid ^{3}He in an Anisotropic Medium by J. A. Sauls. **Phys. Rev. B, 88, 214503 (2013).**

"Random fields coupled to an order parameter describing one or more broken continuous symmetries have been investigated since the early 1970's - from the destruction of long-range order of the Abrikosov vortex lattice in type II superconductor to ferromagnetism in a materials random magnetic disorder. I show that the quantum liquid phases of ^{3}He infused into silica aerogel provide a unique system for studying the struggle between order - in this case orbital order of a condensate of molecular pairs - and disorder characterized by random anisotropy of silica aerogel. This competition leads to remarkable new chiral superfluid phases exhibiting broken time-inversion symmetry, space parity, and as I argue, a novel phase that has finite range orientational order in two dimensions, but long range order in a third dimension. This phase is the realization of a biaxial-chiral phase with finite-range orientational correlations due to the random anisotropy field of the aerogel medium. These conclusions are supported by theoretical analysis of the phase diagram and NMR spectra of superfluid ^{3}He infused into anisotropic aerogel carried out in the ULT lab headed by W. P. Halperin at Northwestern."

Professor Saul's presented the results of this work as an Invited Talk at the International conference on Statistical Physics of Disordered Systems, held at the The Courant Institute, New York, NY, August 22-23, 2013.
http://prb.aps.org/abstract/PRB/v88/i21/e214503

Hao Wu and J. A. Sauls

Majorana excitations, spin and mass currents on the surface of topological superfluid ^{3}He-B by Hao Wu and J. A. Sauls. **Phys. Rev. B, 88, 184506 (2013).**

The B-phase of superfluid ^{3}He is a 3D time-reversal-invariant topological superfluid with an isotropic energy gap, Δ, separating the ground state and bulk continuum states. We report calculations of surface spectrum and spin and mass current densities originating from the Andreev surface states for confined ^{3}He-B. The surface states of ^{3}He B phase has a helical spin structure, this gives rise to a spontaneous ground state spin current. Also, the surface states are linearly dispersed, thus thermal excitation leads to power law suppression of both spin and mass current, providing a direct signature of the Majorana branches of surface excitations in the fully gapped 3D topological superfluid.
http://prb.aps.org/abstract/PRB/v88/i18/e184506

Joshua Wiman and J. A. Sauls

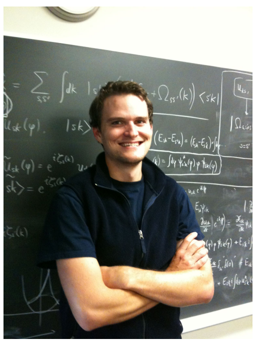
Superfluid phases of ^{3}He in a periodic confined geometry by J.J. Wiman and J. A. Sauls. **J. Low. Temp. Phys., 174:1-14 (2013). DOI: 10.1007/s10909-013-0924-4.**

Impurities and boundaries can dramatically alter the phase diagram of superfluid ^{3}He relative to the bulk, where at ambient pressure only the B phase is stable. We consider superfluid ^{3}He confined in a two dimensional lattice of square, sub-micron-scale boundaries ("posts") with rough (maximally pair-breaking) boundaries. We report theoretical and numerical results for the phase diagram at ambient pressure as a function of temperature T, lattice spacing

L, and post edge dimension d. For all L and d at which a superfluid transition occurs, we find a first transition from the normal state to an inhomogeneous, periodic "polar" phase. For fixed L there is a critical post dimension d_c above which only the polar phase is stable. For $d < d_c$ there is also a second transition to a low temperature, periodic "B-like" phase. http://link.springer.com/article/10.1007%2Fs10909-013-0924-4#

Alumni News

Yoonseok Lee graduated in 1997 from NU with a Ph.D. in Physics under the supervision of W. P. Halperin. He was recently elected Fellow of the American Physical Society in recognition of his contributions in low temperature physics (Division of Condensed Matter Physics), "For high-precision ultrasound measurements in quantum liquids, and discovery of the acoustic Faraday effect and broken spin-orbit symmetry in superfluid 3He-B". He is currently Professor of Physics at University of Florida.



David Ferguson worked as a post-doc with Professors Jens Koch and Jim Sauls. He is now working for Northrop Grumman in Maryland as their staff theorist doing research on superconducting quantum circuits.

Tristan Matthews graduated in August 2013 from NU with a Ph.D. His thesis was entitled "2010 BLASTPol Observations of Magnetic Fields in Lupus." In October he accepted a position as Data Scientist with Bay Sensors in Palo Alto, CA.

The pictured: Tristan (top) working on gondola integration in Palestine, Texas, Summer 2010.

Lindheimer Astronomical Research Center 1967-1995

Staff News

Congratulations to **Marsha Coffey**, who has been with the Department of Physics & Astronomy for 15 years! She is the department's Business Administrator.

Congratulations to **Bob Tilden**, who has been with Northwestern for 40 years! He is a computer software developer with our particle physics group. Bob's special interests are photography, and his favorite spots to photograph are the streets of Chicago and the Chicago Botanic Garden. Also, he enjoys working with electronics, reading, travel, and occasional kayaking & biking.

Please visit the Physics and Astronomy website for a complete list of upcoming events:
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".

New Research Staff

Claude-André Faucher-Giguère joined the Department of Physics & Astronomy and CIERA as a NASA Einstein Fellow in September 2013. He obtained his Ph.D from Harvard University in 2010, where he received the Eric R. Keto Prize in Theoretical Astrophysics for his thesis, and was a Miller Research Fellow at UC Berkeley from 2010-2013. Next year he will officially join the Physics & Astronomy faculty at NU, where he is starting a new research group in galaxy formation. The galaxy formation group at NU focuses on understanding the multi-scale physical processes that govern galaxy formation in the cosmological context, including star formation, galaxy-black hole co-evolution, galactic dynamics, and connections with the intergalactic medium and cosmology. To address these problems, Dr. Faucher-Giguère and his group combine the strengths of large-scale numerical simulations, analytic modeling, and comparison with observational data.

Laura Fissel began a CIERA Fellowship at Northwestern in October 2013, working with Giles Novak and his research group. Laura obtained her Ph.D. from the University of Toronto where she worked on BLASTPol: the Balloon-borne Large Aperture Telescope for Polarimetry, which uses polarized emission from dust grains to map magnetic fields in star forming regions. Laura also was awarded an NSERC Postdoctoral Fellowship. At Northwestern she will work on analyzing data from BLASTPol's two Antarctic science campaigns along with other complementary data in order to investigate how star formation is regulated. Laura will also work on the design and construction of a "next generation" BLASTPol experiment.

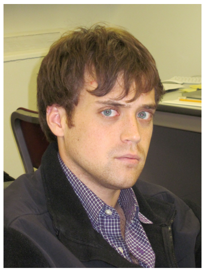
Aaron Geller, a Lindheimer Postdoctoral Fellow, is studying the evolution of star clusters, the birthplaces of most stars and planets in our Galaxy. As part of his NSF AAPF fellowship, he is currently working with collaborators at Northwestern, The University of Chicago, the Netherlands, and Australia, to develop new software to accurately simulate the evolution of planetary systems, including those like our Solar System, within star clusters. With this new tool he will investigate how close encounters between planetary systems and other stars born together in star clusters can modify and possibly even destroy young planetary systems, and thereby shape the orbits of the growing number of exoplanets that are observed today in our Galaxy.

Daryl Haggard (CIERA Postdoctoral Fellow) Talia Weiss, and Taylor Sims (Evanston Township High School students), were selected as regional finalists for the Siemens Talent Competition and presented their work at the University of Notre Dame in November 2013. Their project is titled, "Environment and Variability of High Redshift X-ray Bright Optically Normal Galaxies." In addition, Erin Roth (Carleton College), NU NASA Space Grant summer student working with Haggard, was invited to represent Illinois at the National Meeting. Her poster presentation was titled, "Swift Monitoring of the Galactic Center: From Supermassive Black Holes to Magnetic Neutron Stars."
For more information see:
http://ciera.northwestern.edu/news/news 2013-2014.php#Roth

Fabio P. Santos joined CIERA in October 2013 as a visiting postdoctoral fellow, working with Giles Novak's research group. Fabio obtained his doctoral degree in physics from the Federal University of Minas Gerais (UFMG) in Brazil, and was subsequently awarded a Science without Borders Fellowship from the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES). Santos' main research interests are the interstellar medium and star formation, focusing on magnetic fields and optical/near-infrared polarimetry.

Laura Trouille, a CIERA Postdoctoral Fellow, worked with high-school students to challenge ideas about our galaxy. One of the most exciting research questions in astrophysics today is: “How many stars in our Galaxy have planets like the Earth, which might have life on them?” In October, astronomers from Berkeley and Hawaii published an updated answer to this question, estimating that 22% of Sun-like stars have Earth-sized habitable planets circling them. Two high-school students, working with Dr. Trouille in her Computational Astrophysics course, challenged this result: they estimate that only 10% of Sun-like stars have habitable, Earth-like planets.

Graduate Achievements



Sean Cornelius and his Ph.D. advisor, Professor Adilson Motter, have developed NECO: an algorithm for NEtwork COntrol. The algorithm allows reprogramming networks or rescuing them from the verge of failure. It applies to networks underlying various processes, ranging from cancer development to power outages to ecosystem collapses. The algorithm and ready-to-use software were published in June in Nature's Protocol Exchange. Related work, in which the approach is applied to various real network problems, was published by the authors' companion article in *Nature Communications*.

Read more at
http://www.nature.com/ncomms/2013/130627/ncomms2939/full/ncomms2939.html

Ben Farr received the "Blue Apple Award" at this year's Midwest Relativity Meeting for the best student presentation at the meeting. Ben's talk was entitled "A Hierarchical Approach to Rapid Gravitational Wave Parameter Estimation," and described his work on quickly and accurately extracting new constraints on compact objects from future gravitational-wave detections.

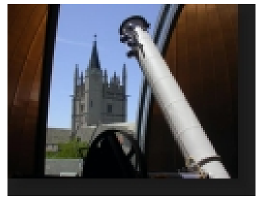
Read more at
http://www.gravity.phys.uwm.edu/conferences/mwrm2013/index.html

Andrew Kobach had a solo publication in *Phys. Rev.* D88, 116001 (2013). Titled " Measuring the Mass of Dark Matter at the LHC." Dark matter must have a greater than O(10 GeV) if it is going to be discovered at the LHC by using kinematic methods.

Read more at
http://link.aps.org/doi/10.1103/PhysRevD.88.116001

Chris Seck won the Molecular Spectroscopy Poster Prize at the ICOLS 2013 Conference, which was presented by the Journal of Applied Physics B. Chris works with Professor Brian Odom.

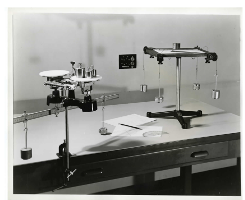
Undergraduate Achievements



Jonathan Kernes received the "Outstanding Junior in Physics and Astronomy award for 2013.

Two of our students won Undergraduate Research Grants from the college to support research Summer 2013:

Xiaowen Chen for "Ionic Quantum Newton's Cradle-ISEN." Xiaowen is working with Professor Odom.



Tyler Rehak for "Accuracy of MOller Scattering Analysis." Tyler is working with Professor Mayda Velasco.

Northwestern's Society of Physics Students (SPS)

The Northwestern University Society of Physics Students held their first event of the year. The contents of this events included an informal talk about what SPS does and how to become invloved, a demonstration of 3-D printing by Professor Art Schmidt, and the making of liquid nitrogen ice cream. Good times were had by all!

Welcome to our 2013 Incoming Graduate Students!

Keenan Avers

Daniel Baxter

Sumitabha Brahmachari

Katelyn Breivik

Daniel Case

Thoth Gunter

Kevin Kelly

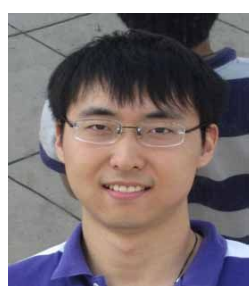
Rossen Rashkov

Robert Regan

Luke Robison

Stanislava Sevova

Patrick Stollenwerk



Yizhou Xin

Minchuan Zhou

Department Events

Fall 2013 CIERA Interdisciplinary Colloquium

CIERA, The Center for Interdisciplinary Exploration and Research in Astrophysics, had the pleasure of hosting Mario Juric on November 12th and 13th for the 2013 Fall Interdisciplinary Colloquium. Dr. Juric is the Data Management Project Scientist for the Large Synoptic Survey Telescope (LSST); Northwestern joined the LSST project earlier this Fall. In his talk was entitled "The Large Synoptic Survey Telescope: Entering the Era of Petascale Optical Astronomy." During his two days of visiting researchers at Northwestern, Juric summarized the data products that this new survey telescope will deliver once operational, the impact this large amount of data will have on astronomy, and how the field needs to prepare to make the best use of that data.

Physics & Astronomy Department Holiday Party 2013!

We had another successful Holiday Party for 2013. Good food and cheer was enjoyed by all.

Network Frontier Workshop 2013

Professor Anna Nagurney from the University of Massachusetts, Amherst

On December 4-6, Northwestern University held the 2013 edition of the Network Frontier Workshop – a biannual meeting on complex networks. The meeting attracted over 90 participants from 12 different countries. A selection of presentations from the meeting are available on the Workshop webpage http://netfrontier2013.northwestern.edu/. The meeting was organized by Adilson Motter (scientific organizer), Luciana Zanella (administrative organizer), Daniel Abrams (advisory board member) and Takashi Nishikawa (advisory board member), and supported by ARO, NSF, WCAS, and NICO.

Dimensions was compiled by Monica Brown

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.

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