Cornell Society of Physics Students
2013-2014 Annual Report

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1 Part I: Activities within the Cornell community

1.1 SPS Physics and Pizza Lecture Series

Description: Approximately once a month, we sponsor a physics talk aimed toward the undergraduate students. The physics department and many others (Astronomy, Engineering, etc.) sponsor weekly colloquia that are open to the physics community, but unfortunately most of these talks are aimed at the graduate level. Therefore, our talks are designed to be accessible to our undergraduate population, giving them an opportunity to learn about cutting edge physics research. Thanks to the help of our advisor, Professor Mueller, and our officers, this has grown from a sporadic practice to a mainstream activity in the department.

Attendance: Usually, over twenty students attend these talks. Most are physics majors, but some engineering students also attend. We had the talks on different days of the week each time to accommodate as many schedules as possible.

The Activity: In the first half an hour, we have pizza and offer a chance for socialization with the speaker. The talk then lasts for an hour after which many students stick around to ask questions. We use the time just before the talk to make announcements about upcoming events.

Funding: The Cornell Physics Department provides the financial support for the pizza and drinks for this event. Department Liaison Kareem Hamdy coordinated the pizza and soda with the department undergraduate coordinator Christina Price. Treasurer Airlia Shaffer coordinated with the speakers.

Advertising: For the first talk of the year, the officers attempt to visit all of the introductory physics lecturers to make an announcement about our activities for the semester, especially promoting the first talk. We have flyers for every talk, which we put up around the physics buildings about a week before the event. We then send reminders to the SPS listserv (which has over 250 students) before each talk. Underclassman Coordinator Sarah Marie Bruno put up the flyers. President Benjamin Pichler emailed the listserv. We also post the information about each talk, with flyers, on our website and to the TV monitors around the Physical Sciences Building.

Below is a list of the talks that we had, with the title of the talk and a short abstract.

September 19th, 2013: Professor Kyle Shen (Cornell, Laboratory for Atomic and Solid State Physics)

Title: Creating and Investigating New Artificial Electronic States of Matter

Abstract: Our ability to control the electronic properties of matter has had enormous
scientific and technological implications. We can now utilize materials which possess inherently strong quantum interactions as our building blocks to create artificial structures with targeted electronic and magnetic properties. I will describe some recent progress in creating and exploring new electronic and magnetic phases which arise in these "artificial quantum materials".

November 6th, 2013: **Professor Ralf Eichhorn** (Cornell Laboratory for Accelerator-based ScienceS and Education)

Title: *The Cool Thing About Accelerators*

Abstract: As physicists, we’re pushing the technological frontiers in order to perform nuclear studies and elementary particle physics. Many of us find ourselves working on accelerators - and find that this field is very rewarding. Today, Cornell’s Laboratory for Accelerator-based ScienceS and Education (CLASSE) is working on the next generation of superconducting particle accelerators being used in particle and radiation physics. Currently, the group holds the world record on achieving the highest cavity quality factor of a superconducting accelerating cavity, getting the highest electrical RF field inside, and accelerates the highest CW beam current. Come to the talk and learn what that all means, see the role of superconductivity in this industrial scale application, understand the background of this research, and see how students are involved.

November 21st, 2013: **Professor James Sethna** (Cornell, Laboratory for Atomic and Solid State Physics)

Title: *Discovery of the Higgs Boson*

Abstract: “With four parameters I can fit an elephant; with five I can make it wag its tail.” Systems biology models of the cell have an enormous number of reactions between proteins, RNA, and DNA whose rates (parameters) are hard to measure. Models of climate change, ecosystems, and macroeconomics also have parameters that are hard or impossible to measure directly. If we fit these unknown parameters, fiddling with them until they agree with past experiments, how much can we trust their predictions? Multiparameter fits are sloppy; the parameters can vary over enormous ranges and still agree with past experiments. Nonetheless, they can often make useful predictions about future experiments, even allowing for these huge parameter uncertainties: a few stiff combinations of parameters govern the behavior. Third, these sloppy models all appear strikingly similar to one another – for example, the stiffnesses in every case we’ve studied are spread roughly uniformly over a range of over a million. We will use ideas and methods from differential geometry to explain what sloppiness is and why it happens so often. Finally, we shall show that models in physics are also sloppy – that sloppiness makes science possible.
February 13th, 2014 : **Professor Mukund Vengalattore** (Cornell, Laboratory for Atomic and Solid State Physics)

Title: *Macroscopic Quantum Behavior: Seek and ye shall find*

Abstract: Nanokelvin atomic gases are unique among mesoscopic quantum systems in that they permit unprecedented quantum control at the single atom level. I will describe some of our group’s recent studies on developing techniques to cool, control and measure these systems at the limits of precision allowed by quantum mechanics. At these regimes, the very act of measurement can be used to influence the quantum evolution of the system under study. I will discuss ongoing applications of these techniques being pursued by our group, ranging from the creation of novel quantum phases to the development of quantum sensors.

March 26th, 2014 : **Professor Erich Mueller** (Cornell, Laboratory for Atomic and Solid State Physics)

Title: *Physics on the Frontier of Cold*

Abstract: Man strives to push back frontiers: climbing the highest mountains, diving into the deepest oceans. I will talk about the quest to explore ever-lower temperatures. What drives it, and what is found there.

April 10th, 2014 : **Professor Eanna Flanagan** (Cornell, Laboratory for Elementary Particle Physics)

Title: *Gravitational Waves from Black Holes and the Big Bang*

Abstract: I will review the decades long experimental effort to directly detect gravitational waves from black holes and other astrophysical sources, using laser interferometer detectors on the ground today and in space in the future. Gravitational waves will open a new window on the Universe and will likely lead to surprises and discoveries in astrophysics. Gravitational waves from the early Universe have recently been discovered via their imprint on the cosmic microwave background. I will review the theoretical predictions that led to this discovery, and how the detection has impacted our understanding of gravity and of the early Universe.

April 22th, 2014 : **Professor Ehsan Afshari** (Cornell, Electrical and Computer Engineering)

Title: *Terahertz: The Last Untapped Spectrum*

Abstract: There is an increasing interest in low cost THz systems for medical imag-
ing, spectroscopy, and high data rate communication. Recent results in the lower THz frequencies (less than 600 GHz) suggests that a standard CMOS process can compete with compound semiconductors for some applications. In this talk, after a brief introduction to our research group at Cornell, we present a few “real” applications for the CMOS THz systems as well as a few “fake” ones. Next, we discuss major challenges in realizing these systems in CMOS. Moreover, we show several novel methods to overcome these challenges to generate mW-level powers at 300-500 GHz with relatively low noise using oscillators, amplifiers, and frequency multipliers. Finally, we show how similar approaches can result in over 100 mW at 500 GHz using GaN HEMT devices.

1.2 Special Lunch Lectures

1.2.1 Bethe Lectures

Hans Bethe was a Nobel Prize winning physicist at Cornell. From the Physics Department website, “This lectureship will bring to Cornell distinguished persons working in physics to enrich and stimulate the intellectual atmosphere of the University in the manner that Hans Bethe did throughout his career”.

This fall, we were lucky to have Dr. Fabiola Gianotti, CERN as the Bethe Lecturer. Dr. Gianotti gave several talks about her work at ATLAS, A Toroidal LHC Apparatus, on the Higgs boson. The main physics talk and the public lecture were well attended by undergraduates. In addition, we were given the opportunity by the department to have a special lunch for interested undergraduates. About 20 undergraduates attended this lunch on Wednesday, November 13th in Clark 700. Moe’s was catered.

This spring, we were delighted to have Professor David Awschalom, University of Chicago as the Bethe lecturer. Professor Awschalom gave several talks on spintronics and engineering novel quantum systems. About 10 undergraduates attended lunch with Professor Awschalom on Wednesday, March 27th in Clark 701. Aladdin’s was catered.

Figure 1: Left: Dr. Fabiola Gianotti, CERN. Right: Professor David Awschalom, University of Chicago.
1.2.2 A.D. White Professor at Large Lectures

This fall, we were excited to have Cornell’s A.D. White Professor at Large Nima Arkani-Hamed, Institute for Advanced Study Princeton, give a series of lectures defining the big questions in high energy physics and possible directions for solutions. Undergraduates in SPS also had the opportunity to eat lunch and receive an informal lecture from Professor Arkani-Hamed. 20 undergraduates attended this lunch catered by Moe’s.

1.2.3 Messenger Lecture Series

This spring, we were pleased to have Professor Leonard Susskind, Stanford University, give a series of lectures on a wide range topics in high energy physics geared to both the public and the physics community. Undergraduates in SPS had the opportunity to eat lunch with Professor Susskind. 20 undergraduates attended this lunch catered by Aladdin’s.

Figure 2: Left: Professor Nima Arkani-Hamed. Right: Professor Leonard Susskind

1.3 Physics Freshmen vs Physics Graduate Students Soccer Match

This year SPS held a semester kick off soccer match specifically designed to involve freshmen in the club. At this event, about 10 freshmen and even more graduate students played soccer. This event not only allowed freshmen to meet each other, but also allowed them to meet the graduate students. The soccer field was reserved from Cornell for free and a soccer ball was borrowed from a student.

1.4 Liquid Nitrogen Ice Cream

At this year’s first SPS meeting, we made ice cream by freezing the ingredients with liquid nitrogen. This event provided a chance for the freshmen physics students to socialize outside of the classroom. It also provided an opportunity for them to ask the upperclassmen about living and studying physics at Cornell. About 30 incoming physics majors attended. Funding for the ice cream ingredients and the liquid nitrogen was provided by the Physics Department.
1.5 Physics Graduate Record Examination Preparation Sessions

In the spring semester, SPS asked Daniel Citron, a physics graduate student, to hold 4 review sessions for the Physics Graduate Record Examination. He used powerpoint presentations to go over topics of interest to the students. At least 10 junior physics majors attended these sessions and they were deemed very beneficial.

1.6 Bethe House Physics Nights

This spring, Underclassmen Coordinator Sarah Marie Bruno organized an additional SPS event, which has now become part of our regular repertoire. Each Tuesday at 8pm at Cornell’s Hans Bethe residential house, Sarah Marie held a small physics study group. The casual environment provided a great opportunity for students to talk about physics or do homework around other physics majors. Around five students would come to this event each week.

2 Part 2: Activities outside of the Cornell Community

2.1 Northeast Conference for Undergraduate Women

This spring, Cornell SPS members helped advertise the Northeast Conference for Undergraduate Women in Physics (NCUWiP) at the State University of New York Stony Brook and Pennsylvania State University. NCUWiP empowers numerous undergraduate women to continue physics careers in both industry and academia via alumni mentoring, career, and graduate school information sessions, job and internship recruiting fairs, and career development workshops. About 10 female Cornell SPS members attended these conferences.

3 Part 3: Activities with the Public

As was the case in past years, our outreach efforts were more limited in the fall than in the second semester. Consequently, we have implemented a firm plan to do more outreach in Fall 2014. We were lucky to have an outreach officer, Michael Hammer, who coordinated all the outreach activities we did the second semester of this year.

3.1 Expanding Your Horizons

Expanding Your Horizons is a program to get middle school girls interested in science and technology. This day-long event consists of lectures, demos, and workshops for middle schoolers and their parents. On April 20th, SPS provided a variety of physics demos for the students to play and learn with. One favorite demo involves a bicycle attached to a generator which powers light bulbs. The students can feel for themselves how much harder it is to power incandescent bulbs than CFCs. About 10 SPS students
volunteered to help at the event. This year Michael Hammer developed a take home CD spectrometer demo for the students. At the event Michael and other volunteers described how one can make a spectrometer out of just a CD, piece of foil, and a cereal box and the cool ways to use it.

![Images of students and CD spectrometer](image)

Figure 3: Top Right: Treasurer Airlia Shaffer using her CD spectrometer. Bottom Left: Some excited SPS volunteers the morning of EYH. Bottom Right: A student trying the bicycle generator and a demonstration of Bernoulli’s principle.

### 3.2 Sciencecenter Family Science Night

Every year, the Sciencenter takes part in NanoDays, a national event to promote nanotechnology and related scientific ideas to elementary school students. This year, rather than just having NanoDays at the Sciencenter, the Sciencenter brought NanoDays to local elementary schools through their Family Science Night program. At these events, we travelled to these elementary schools located in the Greater Ithaca area and ran a variety of nano-themed activities. We attended 3 such Family Science Nights on February 11th, March 6th, and March 13th, with a total of 7 SPS members volunteering.
4 Part 4: Efforts to further the SPS Purpose and Mission

4.1 Cornell SPS Unifies Physics Students

4.1.1 Website

pages.physics.cornell.edu/sps
orgsync.com/72478/chapter

Our student created/designed/maintained website has up to date information about what the Cornell SPS is all about. The front page describes how to join the listserv and how to obtain access to our SPS lounge. It also has links to physics and other related department events. The second tab has information from the national SPS website describing the program. This page also has information about our advisor and our officers.

The events page has all of the dates and times for current events and a list of past events. Along with all of the information for these events, we have an embedded Google calendar so members can keep up-to-date. New this year, we have linked an orgsync website to our page. If students join our orgsync page, they can more easily find our schedule and RSVP for individual events. Our outreach page describes current and past public outreach activities that we have done. The resources tab links to the SPS national website as well as to other physics related sites. Finally, we have a page devoted to helping students find research and internship opportunities. Here we keep a cumulative list of all REU opportunities announced by the department.

A special feature of the website is the undergraduate research spotlight. Inspired by a similar side bar on the Cornell Physics website for graduate students and faculty, our spotlight highlights research that Cornell undergraduates are doing. See below for a snapshot of the front page with the undergraduate research spotlight bar on the right.

4.1.2 Lounge

We have an undergraduate lounge just for physics students. The lounge has a white board, desk space and computers and is frequented by many physics students. We have many physics books for the lounge to encourage students to use the space to study and do homework.

4.1.3 Clubfest

In the beginning of the fall semester, there is a giant event where hundreds of clubs on campus advertise to prospective members in our indoor track. We have our own display board about our chapter and we hand out quarter cards to prospective members. We attracted many physics and physics-related prospective and current majors to our table. Our officers manned the table and talked with those interested about the club. We also
Figure 4: Screen shot from the front page of the SPS website.

Figure 5: Our lounge is Rockefeller B2.

had a sign up for our listserve which was a great way to get people to remain interested in our activities.
4.1.4 Cornell Days/Meeting with Prospective Students

We also frequently meet with prospective students who come to visit campus in order to discuss our experience as students studying physics. This is coordinated by Christina Price (staff undergraduate coordinator). As the undergraduate physics organization on campus, we are the go to group for the department in this respect.

4.2 Cornell SPS Provides Leadership Opportunities to Members

In addition to providing leadership opportunities to members via becoming officers, our various outreach activities allow students to lead others to learn physics. For example, the students who led the Expand Your Horizons outreach activities got the experience of standing in front of a group of students and leading them through physics activities.

4.3 Cornell SPS Helps Bridge the Gap to the Department

As a result of our events, the undergraduates are able to get to know the faculty. This is evident in the invitation by the department to the undergraduate physics students to the weekly department lunches as well as the holiday party (at which the SPS had a successful skit!).

Figure 6: Past example of quarter cards handed out at clubfest.
4.4 Chapter Improvement and Overall Health

Overall, this has been a great year for the Cornell SPS. This year, we have maintained the number of activities and attendance for SPS events. The 2013-2014 school year has also seen a continuation of the high level of student leadership. The consistent SPS physics and pizza events continue to be an expectation of the undergraduate physics majors. We also had successful outreach programs this year thanks to our Outreach Officer. Our websites continue to improve and offer more to students. Of course, our great success would not have been possible without some key players in the physics department. Below we have tried to highlight the key players in the success of our chapter this year.

5 Part 5: Acknowledgements

- **Prof. Erich Mueller** for his enthusiastic support in his first year as our advisor.
- Seniors **Benjamin Pichler** and **Christian Nguyen** for all of the time and effort they put into making Cornell SPS a useful club.
- Juniors **Michael Hammer**, **Airlia Shaffer-Moag**, and **Kareem Hamdy** for their continuing commitment to Cornell SPS.
- Sophomore **Sarah Marie Bruno** for her excitement about SPS and interest in creating new events.
- **Prabudhya Bhattacharyya**, Sophomore, and **Omar Alam**, Freshman, for becoming officers at the end of this year. We look forward to working with you even more next year!
- **Prof. Jim Alexander** (Director of Undergraduate Studies), **Prof. Jeevak Parpia** (Department Chair), and the Cornell Physics Department as a whole for their continued support.
- **Jenny Wurster** for providing fun demonstrations for our outreach events
- Last, but certainly not least, the Undergraduate Coordinator **Christina Price** – you are our go-to person in the department and have been key in our success!