ANNUAL REPORT 2012/2013
Pomona College Department of Physics and Astronomy

prepared by David Tanenbaum
Summer, 2013
This annual report of 2012/13, highlights an exciting transition as our department prepares to vacate the Andrew and Millikan buildings for a two year sojourn as we continue to work on the final design for the new Millikan Laboratory which will be the home for both Physics and Astronomy and Mathematics for the next 50 years. In addition to the new building, we are excited to host a new member of our department, Janice Hudgings, the new Seeley W. Mudd Professor of Physics, and Vice President for Academic Affairs and Dean of the College.

Graduating Seniors in 2013

During the academic year of 2011/12, our department of Physics and Astronomy graduated 10 majors, 1 minor, and has one student who has completed year 5 in the Caltech 3+2 engineering program. If you count Katherine Taylor who is completing the Caltech dual degree program, three of our eleven students in this class are women. One of our majors is hispanic. Six of our students are headed into graduate programs in physics, engineering, or applied mathematics programs all at highly respected institutions: MIT (2), Cornell, Berkeley, UW and CGU. Six of our majors have incorporated engineering courses in their programs, four completed double majors (3 in Math, 1 in Geology), two did a study abroad experience. Beyond academics, our students were active in sports, music, and outdoor programs during their time at Pomona. They are a terrific group and we look forward to their bright futures.

Summary profiles of each of these students and their plans are presented below.

**Daniel Contreras**

Daniel is a physics major who is going on to graduate school in electrical engineering at UC Berkeley. He did three summers of research working with Philip Choi on the KAPAO adaptive optics system for Table Mountain Observatory. Daniel also worked on an Engineering Clinic at HMC and as a mentor & TA for a range of our general physics courses. In his junior and senior years Daniel was honored with an American Physical Society Scholarship for Minority Undergraduate Physics Majors. Daniel’s thesis, “KAPAO: Design and Assembly of the Wavefront Sensor for an Adaptive Optics Instrument”, was primarily supervised by Philip Choi. Daniel shared the Brackett Astronomy Prize from our department this year with Lorcan McGonigle.

**Carolyn Cross**

Carolyn is a physics major who started our program in her sophomore year. She will begin a job with Deloitte Consulting as a Business Analyst this summer. Carolyn completed a Pomona summer undergraduate research program (SURP) with Dwight Whitaker which led to her thesis project. Carolyn was a department liaison and worked as a TA, mentor, and grader for our department. Carolyn’s thesis, "Slinging Spinning Seed Substitutes: An investigation into the explosive seed dispersal of the Acanthaceae", was primarily supervised by Dwight Whitaker. Carolyn shared the Edmunds Senior Physics Prize from our department this year with Ben Murphy and Sam Whitehead.

**Gretta Mae Ferguson**

Gretta Mae is a double major in both math and physics who transferred to Pomona from Davidson. She has returned home to work in a family business (a medical office) to support her parents for a while. Eventually she wants to move back to CA, perhaps Silicon Valley, to join a start up company. She did one summer SURP with Alfred Kwok doing experimental Quantum Optics. Another summer she worked in the Admissions Office at Pomona. Gretta Mae was a lab TA for Physics 42 and also
worked for the math department. Her thesis “An Outdoor Assessment of Organic Solar Cell Performance” was primarily supervised by David Tanenbaum.

**Rylan Grady**

Rylan is a physics major who spent a semester on leave in Svalbard studying sea ice, which became the focus of his senior thesis. He has accepted a full time consulting position as an executive compensation business analyst. He did one summer SURP with Dwight Whitaker. Rylan worked as a mentor in our department. His thesis “Tidal Deformations of Sea Ice in Shallow Arctic Regions” was supervised locally by Alma Zook, along with faculty from Unis Svalbard.

**Kevin Ludlum**

Kevin is a physics major who played varsity football all 4 years. He is now working at Spectra Sensors on quality engineering, and will enter into the applied math master’s program at CGU as well. Kevin did one summer SURP at Pomona, and spent another summer doing research at Carnegie Observatory. He worked in our department as a teaching assistant as well. His thesis “Optimizing Flywheel Design for use as a Kinetic Energy Recovery System for a Bicycle” was primarily supervised by Alfred Kwok.

**Lorcan McGonigle**

Lorcan is a physics major who has focused on engineering. He is working at Northrup Grumman this summer and will enter the PhD. program in Aeronautics and Astronautics at University of Washington in the fall. Lorcan worked on the KAPAO project with Philip Choi every summer. His thesis “KAPAO: Design and Simulation of the Static Optical and Mechanical Systems” was primarily supervised by Philip Choi. Lorcan shared the Brackett Astronomy Prize from our department this year with Daniel Contreras. He is also a recipient of a William Lincoln Honnold Fellowship from Pomona College.

**Colin Mitchell**

Colin is a physics major who minored in philosophy and played varsity football all 4 years. He is headed home this summer and will refocus on a job search, perhaps in consulting. Colin spent a summer working with the department to help prepare for our move out of Millikan. His thesis “Measuring the Air Speed Created in a Wind Tunnel” was primarily supervised by Alma Zook.

**Benjamin Murphy**

Ben is a double major in physics and geology who has excelled in both fields. While he was admitted to two of the three Geology graduate programs he applied to, he realized that these were not the right place for him to continue his studies. He is now working in hydrogeology for S.S. Papadopulos & Associates in Bethesda and applying to different graduate programs for next year. He has done summer research and published papers with Prof. Mawhorter and with Geology faculty. His Physics thesis “Investigations into Anomalous Spectroscopic Effects in GE124 and Recommendations for Alternative Materials” was primarily supervised by Alfred
Kwok. Ben shared the Edmunds Senior Physics Prize from our department this year with Carolyn Cross and Sam Whitehead. He is a recipient of the prestigious Goldwater Scholarship.

**Jonathan Raiman**

Jonathan is an international student from France with a double major in both math and physics with a focus on engineering. He will enter into the artificial intelligence and machine learning engineering program at MIT in fall 2013. Jonathan had a summer internship at NASA Ames, and has done significant computer programming in the private sector. His thesis “Wireless Electricity and Impedance Matching” was primarily supervised by visiting faculty member Gregory Ogin.

**Katherine Taylor** *(completed Caltech 3-2 Engineering dual degree program)*

Katherine is a physics major in the 3-2 Engineering program at Caltech. She has now completed three years at Pomona and two at Caltech. Katherine is going to do graduate work at MIT. Her work at Caltech includes a recent presentation at the APS Fluid Dynamics Meeting where she presented on “Start-up Dynamics Of Vertical Axis Turbines” used for wind energy with her advisor, John Dabiri, a MacArthur "genius grant" awardee.

**Samuel Whitehead**

Sam is a double major in both math and physics who will be entering the Physics PhD program at Cornell University this fall. He did one summer SURP with Prof. Whitaker which led into his thesis project. Sam also worked regularly as a mentor or grader and a tutor in our department. He spent a semester in Budapest focusing on math. Sam’s thesis “A Computational Analysis of Inertial Particle Transport from Peat Moss Vortex Rings” was highly sophisticated involving mathematical and physical concepts that are rarely mastered by undergraduates. Our department nominated the thesis for the APS Apker Award for best undergraduate physics theses. Sam shared the Edmunds Senior Physics Prize from our department this year with Carolyn Cross and Ben Murphy.

While the focus here is clearly on the majors, we had one physics minor graduate this year as well, Abe McKay (major in environmental analysis), who wrote an interesting thesis entitled, “Floatovoltaics.”

Our class of 2013 was clever, fun, diverse in both their backgrounds and their interests, and they are leaving well prepared for their future plans.

**Student Learning Objectives and Assessment**

Our department continues to discuss our curriculum in light of our learning objectives, which include the following key elements:
• Students will understand the important conceptual models used in the core subject areas of physics and demonstrate their ability to correctly draw logical conclusions from these models and use them to make accurate quantitative predictions in realistic situations.

• Students will understand a broad range of experimental and data-analysis techniques and demonstrate their ability to use these techniques in both designing and conducting scientific experiments and observations.

• Students will develop certain fabrication skills useful in the field, such as the ability to design and construct electronic circuits and other experimental devices.

• Students will demonstrate their ability to read, understand, and critically analyze the physical ideas presented in published textbooks and journal articles.

• Students will demonstrate their ability to present information clearly, logically, and critically, both orally and in writing.

• Students will demonstrate both understanding and the practical application of the ethical standards implicit in science, such as appropriate attribution of ideas, good record-keeping, and truthful presentation of data and conclusions.

• Students will be fully prepared for graduate study in physics or astronomy and/or careers in scientifically oriented jobs in the public or private sector.

We will continue our discussion of the assessment of the senior exercise in Appendix A.

Recent department reports have highlighted specific changes of individual courses. Last year we focused on the deployment of student driven projects in many courses across our curriculum and the benefits that these creative independent projects have on preparation for theses, research, and success beyond Pomona College. This year we have had significant outside recognition of these projects (especially from Dwight Whitaker's electronics course) which have been promoted via the internet. The department received a 3 dimensional printer as a grant from Instructables.com based on these projects. You can see these projects on-line: http://www.instructables.com/id/Pomona-College-Electronics-Projects/.

Summer research positions are another important opportunity for students to use creative problem solving strategies to deal with real world problems. There is a long history of placing summer research students in our laboratories at Pomona College as well as at a wide range of institutions beyond Claremont. In summer 2013, we had 6 students at Carnegie Observatories, 2 students at Brookhaven National Laboratories, 2 students at Caltech, and many other students scattered about both industrial and academic laboratories. In addition we had - 15 students doing research with Pomona faculty funded by a combination of SURP, Sontag, and external grants. Some of these students even get the opportunity to work on international collaborations, such as Zach Glassman who worked with Prof. Mawhorter in Germany both in summer 2012 and 2013.
With the support of separate NSF Major Research Instrumentation grants, two of our major research facilities continue to thrive. The first is the Adaptive Optics system development for our Table Mountain Observatory. This project headed by Philip Choi has seen enormous success over the past year with the first on sky testing being a major milestone. This facility is unique for a small liberal arts college, and the progress has been compared to much higher level systems developed at R1 institutions. When complete the adaptive optics on the 1-meter telescope will be a truly spectacular achievement enabling the highest caliber imaging of any undergraduate research observatory in the world. In contrast, the new Hitachi SU-70 Thermal Field Emission Scanning Electron Microscope system installed at Pomona has gone fully online this year. It combines the capability for SEM, STEM, EDS, Cathodoluminescence, and BSE imaging. In addition, this year we installed the pattern generation system and students from our Contemporary Experimental Physics course (Phys 174) created the first e-beam lithography patterns with this facility. The facility is in use for research and teaching with faculty from Pomona, HMC, Keck Sciences, and RSABG, covering fields of Physics, Chemistry, Engineering, Geology, and Biology. The ability to acquire and maintain these types of research facilities with NSF support is something that truly takes advantage of our role in the Claremont Consortium and elevates our students research training to levels typically only seen at large universities.

This year our department has worked along with the Mathematics department to design a new state of the art building to house our departments. We are tremendously excited about this opportunity and grateful to have been included in the selection of the architects, the lab planners, the contractors, etc. We have worked tirelessly with Facilities and Campus Services on many aspects of this project. The design goal of a LEED gold or platinum laboratory facility with state of the art shops, research facilities, classrooms, planetarium, and teaching laboratories has been a challenge, particularly within the given economic climate. In addition, because the new facility will be built on the site of our original building, we have worked tirelessly to orchestrate the complete move of all our programs in the summer of 2013 largely into the newly renovated Seeley G. Mudd Science Library, as well as to spaces generously made available to us in Seaver South and Seaver North. This will ensure that our programs continue to thrive with strong connections to all the other Division II departments and programs.

Beyond our physical facilities we continue to develop our curriculum and pedagogical techniques. Prof. Thomas Moore published both major articles on the teaching of General Relativity to undergraduate students and a new highly regarded textbook designed from the ground up to teach this highly sophisticated material to undergraduates. We have been on the leading edge of undergraduate programs using “Learning Assistants” upper class students in the classroom with our introductory physics courses. This enables even larger classes
to have tutorial style experiences which are highly regarded by many of our majors. Our faculty have given multiple talks this year on physics and astronomy pedagogy at meetings of the American Physical Society, the Gordon Research Conferences, Project Kaleidescope, etc. We became a PhysTec member site this year, and have worked with the CGU Teacher Education Program to enhance their connection to Pomona students, the Draper Center, and the Teaching and Learning Center. In addition we mentored 3 young PhD physicists who taught in our department this year. Greg Ogin and Mariana Lazarova leave us having accepted new visiting positions at Whitman College and Colorado College this fall. Sadly, Loredana Vetere struggles with VISA issues that make it difficult for her to be hired.

Mentoring our seniors is a primary part of our mission, even if they are not bound for graduate programs. To help us better mentor our students who are going on to careers outside of academia we have developed an active program with our alumni. This program has been very successful in both the eyes of alumni and students, and recently we were invited to the alumni board to discuss the potential for our department’s model to be expanded to other departments and programs in the college. The program is described by Prof. Choi in his PAR:

In the last two years, we have made a major innovation that could serve as a model for other departments. To address the problem that many of our students enter their senior year completely uncertain about their future, we have incorporated an alumni panel and alumni research into our class. We set up multiple skype panels with recent physics alumni who have graduated in the past 2-7 years to help give our current students a sense of what their next steps beyond Pomona will entail. We couple these panels with a research assignment in which our students are required to identify and make contact with at least two physics alum from our online physics alumni database (http://physastro.pomona.edu/directories/alumni/) and write up a short report of their findings.

A major national effort is underway to create more STEM majors, particularly in engineering fields. Historically our department is home to most of the future engineers at Pomona College. Many of our students enroll in Engineering courses at HMC, and we have a track in the major that simplifies this process. We have a long history of running a 3-2 Engineering dual degree program with Caltech, and have a newer program with Washington University in St. Louis. Both programs work, but only a small fraction of students who express interest in these opportunities complete these programs. We have been looking at this for the past few years, including interviewing students who have left these tracks. While Pomona continues to be unable to create a dual degree program with HMC, this year our department has brought a new program on line with the Thayer Engineering School at Dartmouth College. Unlike the 3-2 model where students do not graduate with their classmates and in fact miss their senior year at Pomona, the Dartmouth program is actually
a 2+1+1 program, where students spend a junior year at Dartmouth, return to Pomona for their Senior Year, graduate with their colleagues and then return to Dartmouth to complete their Engineering degree. This model seems like a much better fit for Pomona students, and we hope to see a much better retention of dual degree candidates with this model. Washington University has also expressed a willingness to experiment with this model. Nationally and locally dual degree programs are particularly attractive to under represented minorities and first generation college students. The Dartmouth Program should work well for these groups. It is our hope that we might eventually be able to make a similar program with another school in southern California, but to date efforts to develop dual degree programs with HMC and USC have yet to be successful.

Trends in Enrollment and Majors

Enrollment trends in our department are presented below with total enrollments in Physics and Astronomy versus time. Physics enrollments (green) and Astronomy enrollments (blue) are both shown. There are many ways to count enrollments, but the data shown here were taken directly from the Diversity in the Major spreadsheet provided by the Dean’s Office via Sakai, where the number is the product of the course credit and course enrollments for each course. The record numbers in 2013 are largely connected with enrollments in the General Physics courses, 41/42 and 70/71/72 and an overall increase in Introductory Astronomy enrollments. This is partly a result of the number of lab sections we can staff for the 41/42 sequence with support from the Dean’s office. We offered (and filled) 4 sections of Physics 42 labs and 3 sections of Physics 41 in AY 2012-2013 with last minute staff support from the college after pre-registration resulted in large numbers of PERM requests. Our sequence of offering 41/42 in a Spring/Fall format was based on historical patterns that best suited pre-medical students before the curricular changes in Biology. We are watching the enrollment patterns to see if this needs to change. The enrollments in Astronomy show the difference between years when an astronomy faculty member (Philip Choi) was on leave in AY 2009-2010 without a Steele Leave replacement, contrasted with AY 2012-2013 when an astronomy faculty member (Bryan Penprase) was on leave but was replaced with a full time sabbatical replacement (Mariana Lazarova.)
Enrollment trends for each academic year from 2006-2012, including total physics and astronomy enrollments, showing total physics enrollments (green) and astronomy enrollments (blue). Data taken from the Dean's Diversity in the Major spreadsheet (calculated by multiplying course credit by course enrollment for each course.)

Our total number of Physics majors as a function of their graduation year, based on either completed majors (Spring 2006-2013) or declared majors (Spring 2014 and 2015) is shown in the blue bar graph below. This data clearly suggests we are moving in a positive direction. The drop in 2015 partially reflects that not all the members of that group have declared their majors although it is unlikely that 2015 will match 2014. The class of 2014 will be the biggest group of majors in our program since at least 2001 when we graduated 15 physics majors, and may be a new record for our department. We recognize that we need to continue to work on diversity in the major not only in terms of racial and gender issues but also in terms of career paths. One area where we need to focus is demonstration of support for students pursing our major who are not focused on graduate programs in physics. We have worked to revise our documentation for guidance of majors emphasizing the flexibility we have to support a variety of students such as those starting the major in the sophomore
year, and those interested in careers in engineering, teaching, medicine, law, finance, etc.

Number of Physics and Astronomy graduates since 2006, as a function of graduation year. The plot presents completed majors for past years, and declared Physics majors for the upcoming years (14+15).

In addition, we have been bringing a wide diversity of our alumni into our senior seminar via Skype to explain their career trajectories and answer questions for our students.

Statistically our current 3 year average of well over 10 majors per year would be in the top 10\% of Bachelor’s-Only Physics departments in terms of production of Physics Bachelor’s, independent of our total student body or FTEs according to the American Institute of Physics Sept. 2012 report, Focus on Physics Bachelor’s Degrees.

Our department continues to discuss both the diversity and overall enrollments extensively. We have been encouraging students to apply for APS fellowships for women and minority students. Daniel Contreras has had an APS scholarship the past two years. We hired two young women astronomers to teach in our department as visiting faculty substantially increasing the visible role models for women in our program. The hire of Dean Hudgings brings another tenured woman to our department. We encouraged all our female majors to attend the Western Regional Conference for Undergraduate Women in Physics held at Caltech on January 18th-20th, 2013 at Caltech and provided transportation for that event. We have hired Firuz Demir, a Canadian citizen who was raised in Turkey, and hope that he will bring something new to our department. There is a national push to increase the
minority enrollments in STEM fields, and as the predominant pathway to pre-Engineering at Pomona, we see significant untapped potential to bring more under represented students into our programs. We are working to make our program more attractive for these groups, and to enhance the visibility of our applied programs. We believe the applied programs will help place our graduates into the next generation of the STEM workforce which is seen as a key to the future of the American economy. The new 2+1+1 program at Dartmouth may be one route to enhance these enrollments. We also are publicizing our success with students who complete our Bachelor’s and then enter 1-2 year Master’s of Engineering programs.

We hosted Dr. Stephon Alexander from Dartmouth University to give one of our physics colloquia in February. In addition to the colloquium, he met with the Claremont Colleges chapter of Society for Advancement of Chicanos and Native Americans in Science (SACNAS) which also supports other under represented minorities in science fields. Dr. Alexander is an engaging speaker and we had excellent attendance beyond the regular physics crowd. He also met with faculty in our department. Stephon was selected as the 2013 Edward A. Bouchet Award recipient by the APS. This award recognizes a distinguished minority physicist who has made significant contributions to physics research. Locally we continue to have a strong presence from our department with members serving on both the Draper Center Board and the Advisory Committee for the new Quantitative Skills Center.

We are currently highly focused on the new building and our facilities, but we should be conferring about how to prepare for a future FPAC application. Even with all our faculty on campus this year we needed to request part time support to offer enough sections to satisfy demands for our courses. Overall enrollments in our programs are the highest they have been in many years, perhaps the highest ever.

**Physics and Astronomy Public Events**

The Physics and Astronomy department has worked hard to create strong bonds between students, faculty, and staff. Weekly events include a Physics Lunch, Star Trek nights in the planetarium, and a joint colloquium series with the Harvey Mudd Physics department. Special events this year included a retreat to Halona, a trip to Shakespeare by the Sea, Binary day celebration in collaboration with math and CS on 10/11/11 = 47, a department awards banquet held in the Halls of Millikan with our honored guest Amelie Frischknecht (Po ’92) from Sandia Albuquerque.
We held our annual “Physics Phest” a festival of Physics in the Arts with music, dancing, and physics demonstrations to kick off alumni weekend. Dwight Whitaker continues to be an active liaison between our department and the arts at Pomona being part of a Mellon grant to bring the museum into the curriculum of the college. David Haley works with art museum staff to archive art from Millikan and supports photography classes providing access to scientific imaging facilities. Bryan Penprase is actively collaborating with Sheila Pinkel on a sundial designs for the new courtyard to be built between Millikan and Seeley G. Mudd. Alma Zook continues strong interactions with the Music and Dance programs at the college.

Our outreach programs continue to provide educational opportunities for our students to recognize their own potential as future teachers. We worked with Science Fairs, hosted multiple Planetarium shows (including for Alumni Weekend and PAYS), hosted 3 Astronomy Open Houses at the Brackett Observatory, and used both the Observatory and the Electron Microscopy Facility as outreach events to mark the 125th Pomona College Founder’s Day. This year we received an external grant to support the national NanoDays program in our region. We hosted 4 different NanoDays events reaching over 450 people at Sycamore Elementary, the Claremont Public Library, on our campus for Claremont High School students, and at Cal Poly Pomona for students from Freemont Academy in Pomona.

**Future of the Department**

If there were one word to describe our program this year it would be “Transitions.” We have moved out of Millikan Labs into Seeley G. Mudd Science Library. We have also moved laboratories and shops into both Seaver North and Seaver South with the generous support of our division II colleagues. We have a new Academic Coordinator, Natalie Hughes, who joined us this summer, concurrent with our new Dean and colleague, Janice Hudgings.

We continue to hold a variety of events together with the Mathematics Department, Facilities and Campus Services, Jonathan Wright, and architects to discuss the future of our building. This is a once-in-50-years opportunity and it is tremendously important to do it well. It has not been an entirely smooth process, but we are enthusiastic that it is moving forward and are committed to doing everything we can to make the process go well. We have enjoyed working with the firm EHDD and look forward to our work with MATT construction. We are very pleased with the renovation of SGM Science Library into our home during the next two years. Our technical staff, David Haley, Glenn Flohr, and Anthony Grigsby have taken on an immense load this summer sorting through Millikan and Andrew and working with the movers, chemical safety, and Facilities and Campus Services.
on this summer. We could not have done it without them. In the longer term we hope the new building will not only enhance our existing programs, but inspire new ones as well. One example of this is the physics outdoor laboratory, a science museum playground inspired space where students experience physics directly with their own bodies. We anticipate a variety of new educational outreach programs when the long awaited project becomes a reality. We look forward to returning to a vibrant state of the art center for learning and research on our campus. We are well aware that this does not come without significant costs to the college and appreciate the support we have had to help make this a reality. We are also enthusiastic to work on proposals to help support this endeavor, such as the proposal to fund the new digitally immersive planetarium.

In preparing for the future we should begin a departmental self study in preparation for an external department review. Our last self study and external review was completed in Fall 2003. However given our transitions we plan to conduct our external review after we move into our new building. Our department curriculum, faculty, staff and research programs have changed dramatically since our last review in 2003. The approaches to physics education at a national level have changed as well. By doing the study and review after the move we will be able to capture our program without the many distractions, chaos, and limitations imposed during our migration.

We are still working toward several future goals that we believe will enhance our programs and the college:

- Bring outreach programs into the physics curriculum rather than outside it
- Create new interdisciplinary courses and curricula across departments
- Participate in the creation of a new “bridge” program for disadvantaged students
- Develop more regional ties to other scientific institutions
- Bring in new NSF grants for both research programs and revision of courses
- Increase flexibility within the major requirements