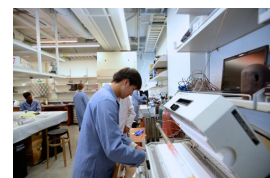
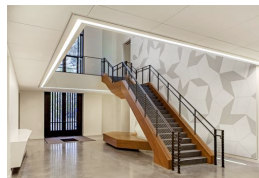




Physics and Astronomy

# ANNUAL REPORT 2014/2015

*Pomona College Department of Physics and Astronomy*



prepared by David Tanenbaum  
Summer 2015

## DEPARTMENT OF PHYSICS AND ASTRONOMY ANNUAL REPORT

Prepared by Dr. David Tanenbaum, chair  
Summer 2015

This annual report of 2014/15, covers our second year in the SGM library building, part of a two year sojourn as we watched the construction of the new Millikan Laboratory which will be the home for both Physics and Astronomy and Mathematics for the next 50 years. We have spent much of this summer moving into and commissioning the new building.

Graduating Seniors and Faculty in Spring 2015



*Physics Graduates '15 and Faculty, from left: [back row] Prof. Kwok, Prof. Tanenbaum, Prof. Mawhorter, Prof. Whitaker, [middle row] Prof. Hudgings, Erika Carlson, Nicholas Cho (Caltech 3-2), Ben Girodias, Alex Cole, Jonathan Wong, Dillon Dong, Robert Goldman (minor), Fernando Ortega, Prof. Choi (holding Penelope), [front row] Prof. Moore, Prof. Zook, and visiting Prof. Vetere. Not pictured are Sallie Walecka (minor), Prof. Penprase, and visiting Prof. Soldatenko,*

During the academic year of 2014/15, our department of Physics and Astronomy graduated 6 majors, has one student completing year 4 of the Caltech 3-2 engineering program, and another student starting that program in the fall. Two members of the class participated in

Engineering Clinic projects at Harvey Mudd College. Students are headed into graduate programs at highly respected institutions: Cambridge University, University of Michigan, and University of Wisconsin. One has a Downing Fellowship, another is working at Carnegie Observatories, another has a position as a software engineer. Three of our majors have incorporated time abroad in their time as Pomona students (Hong Kong, Budapest, and Germany). Three completed double majors with math. Beyond academics, our students were active in sports, music, outdoor programs, outreach and education programs during their time at Pomona. While this was a small group of majors, they were very strong in both their abilities and achievements.

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

### **Erika Carlson**

Erika is a physics major in the astrophysics program. She will be working at Carnegie Observatories in the coming year, expanding upon her senior thesis work done in collaboration with Carnegie. Erika did summer research for three years with Profs. Zook and Whitaker as well as her thesis project at Carnegie. She also worked as a Mentor for both physics and astronomy courses, particularly those for non majors.. Erika was active in the AARC programs, led our  $\alpha$ LPhA chapter, and is considering a future in education. Her thesis, "A Photometric Investigation of Stellar Populations in the Dwarf Galaxy NGC 6822", was primarily supervised by Prof. Philip Choi and Dr. Barry Madore from Carnegie. Erika shared the Brackett Prize in Astronomy from our department this year with Dillon Dong.

### **Alex Cole**

Alex is a double major in physics and mathematics who will enter the PhD. program at University of Wisconsin this fall. Alex did three summers of research once with Prof. Kwok, once with the LIGO project at Caltech, and finally on his thesis work on string theory with Prof. Sahakian at HMC. He served as a department liaison, and worked as a TA, and mentor, for our department almost every term. Alex's band, the Inland Emperors, played at many Physics events. His thesis, "Non-commutative Geometry and Information Scrambling in Matrix Theory Black Holes", was primarily supervised by Profs. Thomas Moore and Vatche Sahakian at HMC. Alex shared the Edmunds Physics Prize from our department with Ben Girodias.

### **Dillon Dong**

Dillon is a double major in physics and mathematics in the astrophysics program who will be starting a Downing Scholarship in Cambridge England this fall, after which he plans to enroll in the PhD. program at Caltech. Dillon did summer research all three summers with Dr. Eric Murphy at Carnegie Observatories and Caltech. He worked as a mentor in both Physics and Astronomy courses and did a study abroad in Budapest, Hungary in a prestigious mathematics program. His thesis "Studying Star Formation in Nearby Galaxies with 33GHz Radio Interferometry" was primarily supervised by Prof. Philip Choi and Eric Murphy from the Carnegie Observatories.

He is the recipient of a highly competitive Goldwater Fellowship. Dillon shared the Brackett Prize in Astronomy from our department this year with Erika Carlson.

### **Ben Girodias**

Ben is a double major in physics and mathematics who will enter the Physics PhD. program at University of Michigan in the fall. He did two summer SURPs with Profs. Mawhorter and Whitaker, as well as a DAAD RISE fellowship in Germany. Ben worked as a TA, a grader and a mentor in our department. Throughout his time at Pomona he excelled in long distance running, and was named to the Capital One Academic All-America Second Team for Division III Men's Cross Country and Track and Field. His thesis "Ultracold Atoms in Lineworld: Bose-Einstein Condensates in a Quasi-One Dimensional Gravitational-Optical Surface Trap" was supervised by Prof. Whitaker. Ben shared the Edmunds Physics Prize from our department with Alex Cole.

### **Fernando Ortega**

Fernando is a physics major who is looking toward a future in engineering. He worked as a TA in our department in courses for non majors. Fernando did summer research with Profs. Choi and Kwok in adaptive optics and biophysics respectively. He enrolled in both computer science and engineering classes and clinic at Harvey Mudd College. His thesis connected with his clinic "Using Single Qubit Control to Reduce Decoherence in Quantum Information Networks" was supervised by Prof. Mawhorter.

### **Jonathan Wong**

Jonathan is a physics major who is working as a software engineer at Principle development group that does consulting for the entertainment industry. Jonathan took several engineering courses including engineering clinic at Harvey Mudd College. He did extensive work with the 3D printers in our department. Jonathan did three summers of research twice with Prof. Choi and then an independent SURP in Hong Kong. He was a superb department liaison, worked as both a TA and mentor for our department., "Analysis of Equisetum Arvense Spores", was supervised by Prof. Whitaker.

Our class of 2015 was small but impressive. In addition this class includes Nicholas Cho who has completed year 4 of the Caltech 3-2 program and Sallie Walecka (math) and Robert Goldman (geology) who completed the minor in physics.

## **Physics and Astronomy Faculty and Staff**

The Physics and Astronomy department has has a wonderful team of talented hardworking personnel. Faculty routinely go above and beyond their job descriptions to support students and the college. Staff help turn a wide range of ideas into a smoothly operating reality. We were fortunate to be able to hire Loredana Vetere and Adrian Soldatenko as full time

visiting faculty, and Aaron Roy, Hillary Smith, and John Koulakis (Po '06) as part time visiting faculty in the department this year. We are pleased to retain Prof. Vetere for the coming year and were excited for Prof. Soldatenko to land a tenure track position even though we will miss his many contributions.

Glenn Flohr, Anthony Grigsby, David Haley, and Natalie Hughes all made numerous contributions this year, which was our second in the SGM Library building with outposts in both Seaver North and Seaver South. We could not have been successful without those extra spaces for teaching labs, research labs, and shops and we developed stronger bonds with our colleagues in the biology and chemistry departments. Their staff were extremely cordial and supportive during our visit to the west side of College Ave. Our own staff supported an incredible number of projects, workshops, meetings, and social events under difficult circumstances. Most of our senior theses acknowledgements have special praise for our staff and their contributions.

Our regular faculty continue to be active well beyond their classroom teaching. Each submits a detailed professional activities report at the end of the calendar year. However, a few notable highlights are provided here as well.

**Philip Choi** has successfully deployed the facility version of the Pomona Adaptive Optics instrument (KAPAO) on the Chambers 1-meter telescope at the JPL Table Mountain Observatory (TMO). With a new generation of KAPAO students at the helm, the project has transitioned into a regular on-sky operation mode. Beyond KAPAO, Professor Choi recently began a new project in collaboration with colleagues from JPL to implement an innovative new blind search technique for detecting ultra-faint near-earth asteroids (NEAs) and Kuiper Belt minor planets (KBOs). This summer marks the beginning of a two-year TMO observing campaign that will enlist the support of a large team of student observers and analysts.

“KAPAO First Light: the design, construction and operation of a low-cost natural guide star adaptive optics system”, Severson, S. A.; Choi, P. I.; and 15 additional co-authors, Proceedings of the SPIE (2014).

“KAPAO: a MEMS-based natural guide star adaptive optics system”, Severson, S. A.; Choi, P. I.; Contreras, D. S. (P '13); Gilbreth, B. N. (SSU '11); Littleton, E. (HMC '13); McGonigle, L. P. (P '13); Morrison, W. A. (P '12); Rudy, A. R. (P '11); Wong, J. R. (P '15); Xue, A. (HMC '11); Spjut, E.; Baranec, C.; Riddle, R., Proceedings of the SPIE, Volume 8617, id. 861709 10 pp. (2013).

**Janice Hudgings** taught the Physics 41 lab in the spring. This summer she taught in the PAYS program with Phil Choi, along with reestablishing her lab in the new Millikan.

**Alfred Kwok** spent the 2014 - 2015 academic year in Gerard Wong's lab in the Bioengineering Department at UCLA. Charged nanoparticle-induced gelation of regular phosphatidylcholine (PC) molecules in lipid bilayers was observed by Steve Granick's lab a few years ago. Alfred's main project was to study nanoparticle-induced gelation in synthetic PC molecules with "inverted" headgroups. (The dipole moment of the headgroups of these synthetic PC's are in the opposite direction of the dipole moment of the headgroups of regular PC molecules.) In order to not just repeat Granick's experiments, Alfred decided to study the tilt of the lipid headgroups that occurs when gel domains are formed in bilayers. Unfortunately, his efforts in using SAXS (small angle X-ray scattering) at the Stanford Synchrotron Radiation Laboratory and surface FTIR (Fourier Transform Infrared) spectroscopy at CalTech to study lipid headgroup tilt failed. So, Gerard Wong and Alfred decided that they should just use the fluorescence technique that Granick's lab used. Since Alfred has ready access to the microplate reader in the Biochemistry teaching lab in Seaver North, he moved back to Pomona in mid May to carry out these fluorescence assays.

**Richard Mawhorter** had an active year in both teaching and research. Fall teaching highlights included Physics 101 lab field trips to the San Francisco Bay area (Exploratorium and Lawrence Livermore National Laboratory) and nearby Mt. Baldy to count atmospheric muons. In the spring, the two very large bio/chem/premed Physics 42 classes enjoyed several special lectures, including one by Robbins lecturer and Nobel laureate Jack Szostak.

A big fall effort to submit a Simons Foundation Theoretical Physics proposal, although ultimately unsuccessful (too much experiment?), pushed research goals forward significantly, and the two papers below appeared or are accepted. These articles grew out of on-going collaborations with scientists at the Jet Propulsion Laboratory (Pasadena), Leibniz Universität (Hannover, Germany), SUNY Stony Brook, and the St. Petersburg Nuclear Physics Institute. Increased physics SURP funding from the college enabled 3 students to join the research trip to Hannover for the first time, where copious data was gathered for 2 senior theses and 3 future publications. David Sharfi '16 also spent a successful week at Arizona State University with collaborator Prof. Tim Steimle. Much appreciated faculty and student travel support from the college enabled presentations with and by students at 3 conferences, Lepton Moments (Cape Cod, MA), Pacific Spectroscopy (Asilomar, CA), and the European Symposium on Gas Phase Electron Diffraction (Frauenchiemsee, Bavaria, Germany).

L.V. Skripnikov, A.N. Petrov, A.V. Titov, R.J. Mawhorter, A.L. Baum, T.J. Sears, and J.-U. Grabow, Further investigation of g-factors for lead monofluoride ground state, PbF, Physical Review A, accepted.

J. Machacek, D. P. Mahapatra, D. R. Schultz, Yu. Ralchenko, A. Chutjian, J. Simcic, S. M. Madzunkov, and R. J. Mawhorter, Measurement and Calculation of Absolute Single and Double Charge Exchange Cross Sections for O<sup>6+</sup> Ions at 1.17 keV/u and 2.33 keV/u Impacting He and H<sub>2</sub>, *Physical Review A* 90, 052708 (2014).

**Thomas Moore** has ongoing success with his textbooks. He completed the manuscript for the third edition of his six-volume introductory physics textbook series *Six Ideas That Shaped Physics*, and is currently working on the proofs. The new edition will be published by McGraw-Hill in early 2016. He also started a new effort to develop software that will both support and record the processes students go through in solving physics problems, working with three students this summer to lay the foundations for the project. He also continues to work on and be recognized for his text *A General Relativity Workbook*. This spring, he wrote and released an “online study guide” for the book, designed especially for students studying the book alone without the benefit of being in a formal college course.

**Bryan Penprase** is on leave and working at the Yale-NUS College in Singapore, where he is leading an interdisciplinary course on “Foundations of Science” and leading new initiatives on Liberal Arts in Asia. The Foundations of Science course explores topics in science, and applies those in teams of four toward a “Global Challenge” question. This year the question is - “how will communities and organisms adapt to the anthropocene”, and students will study the biology, physics and chemistry of global warming.

As part of Bryan’s research with the Caltech Zwicky Transient Factory (ZTF) project, he began the first of an annual Summer Undergraduate Astronomy Institute. This year seven Pomona and seven Caltech students participated in four days of in-depth studies of astronomy and astrophysics, and enjoyed tours of laboratories and observatories at Caltech and Pomona College. Pomona’s Philip Choi, Loredana Vetere, helped make the program a success. Bryan has been helping lead the Singapore component of the new Luce Foundation proposal known as “Envirolabs Asia,” and is developing a week-long environmental science research project in Singapore and Malaysia which will begin in January 2016.

**David Tanenbaum** is department chair and serving as the point person for the department on the Millikan building project. The time invested in the building has been substantial, working with the contractors, project managers, and vendors very closely. In addition he led the design of the new physics outdoor laboratory exhibits in the courtyard. The result should be a truly functional and wonderful new part of the Pomona campus.

David continues to have active research in organic photovoltaics (plastic solar cells), graphene, and electron beam lithographic processing. He gave an oral presentation at the IEEE 42<sup>nd</sup> Photovoltaics Specialists Conference in New Orleans in June and has one new paper this year, submitted for publication, “Comparative Indoor and Outdoor Degradation

of Organic Photovoltaic Cells via Inter-laboratory Collaboration” submitted to the the IEEE *Journal of Photovoltaics* which is based on the theses of Charles Owens (Po '14) and Gretta Mae Ferguson (Po '13) and the work of several international collaborators but performed here at Pomona College largely on the rooftop solar laboratory at Pomona Hall.

David received an outreach grant from the Nanoscale Informal Science Education Network to run a series of outreach programs for NanoDays in 2015 with Pomona College students, faculty, and staff. He also created workshops on 3D printing for the Claremont Consortium with support from the creativity committee.

**Loredana Vetere** returns to us as a visiting faculty member in our department. She continues her research on Gamma Ray Bursts (GRB) with NASA's SWIFT Gamma-Ray Burst Explorer Mission. She has begun a new collaboration including one Pomona student with the Center for Data-Driven Discovery (CD<sup>3</sup>) at Caltech. The central focus of CD<sup>3</sup> is the methodologies for handling and analysis of large and complex data sets, in facilitating the data-to-discovery process. With her student Dr. Vetere is exploring the use of immersive virtual reality platforms to visualize GRBs data looking for interesting structure and patterns in the dataset that may exist in hyper dimensional data spaces.

**Dwight Whitaker** has been extending his work on the biomechanics to study the flight of seeds from a species of Acanthacea. This work, which was done with both Pomona students and his PAYS research group was presented at the annual Division of Fluid Dynamics meeting in San Francisco. Additionally Dwight continues to collaborate with Jonathan Wright in Biology to study the running of a particularly fast local mite. For the coming year Dwight has been appointed as the co-director of the new (as yet unnamed) 5C center for creativity and innovation.

“The efficient flight of *Ruellia ciliatiflora* seeds” Franklin Marsh (PO '17), Peter Chen (PO '17), David Vejar (PO '18), Patrick Babb (PAYS, HMC '19), Josue Castillo (PAYS), Sabrina Cordero (PAYS), Maharani Lumban-Goal (PAYS), Tania Partida (PAYS, PO '19), Julian Pineda (PAYS), Aaron Rodriguez (PAYS).

**Alma Zook** has designed and supervised the construction, by several summer research students over three years, of a more compact and lighter polarimeter for the telescope at Table Mountain. The new instrument is also compatible with Phil Choi's adaptive optics system. She plans to spend her Fall 2015 sabbatical testing the new instrument. She appears as a co-author on a new paper, Buson, S. et al., “Unusual flaring activity in the blazar PKS 1424-418 during 2008-2011,” *Astronomy & Astrophysics*, Volume 569, A40, 2014.



She also continues her expansion of the solo English horn repertoire with a transcription of the first movement of the Clarinet Sonata No. 2 by Johannes Brahms for English horn, working off the 1895 Simrock edition.

## Physics and Astronomy Facilities

The second year of our sojourn in Seeley G. Mudd Library went very well. We worked together with the Math department and also used rooms in Lincoln, Edmunds, Seaver South and Seaver North. The new building opened for us to move in on June 1. Preparations for the move started in the spring term as we packed up laboratory equipment from fall courses and ordered new systems to install in the new building, particularly for the new shops, the new planetarium, and laboratories. Each new system requires accessories, training, and complex installation. Many require learning new software packages as well. This year we greatly expanded our 3D printing facilities now with 5 different printers using 3 different technologies for 3D printing. Our staff have been phenomenal working with facilities, and the contractors to make sure everything will be ready and operational in the fall of 2015. The outdoor physics laboratory features a series of interactive experiences where a student becomes an integral piece of the experiment, not simply an observer of the experiment. These whole body experiences internalize fundamental physics concepts without abstraction, build physical intuition, and emphasize the reality of forces, reference frames, torque, balance, and other key concepts. The courtyard features two rotary turntables (merry go round), swings, linearly accelerating carts, a lever and fulcrum (teeter totter), whisper dishes, and a sundial all designed by Pomona College faculty. We have been making major upgrades on the 1 meter telescope facility at Table Mountain Observatory. We have made upgrades to the Microscopy Facilities as well, now having Scanning Electron Microscopy, Optical Microscopy, Raman Microscopy, and Atomic Force Microscopy all housed together in a centralized facility.

## Grants and Fundraising Efforts

Our department has continued working with the Advancement Office in efforts to help raise support for the new Millikan Laboratory. We provide tours, suggestions of foundations and donors, data and concepts to highlight why this is a compelling project. This year we learned that we received a grant from the Rose Hills Foundation for the beautiful John Argue Auditorium, and other more modest gifts for research laboratories. Many others deserve credit for this effort, but Martina Ebert and Jennifer Gillo in particular have been very important and deserve recognition as well as Jacquelyn Sliker who has been careful to make sure all the donors are properly acknowledged. In addition we have been looking at

our needs beyond the physical building for facilities, staff, and programmatic support for our students.

In our research, we closed out Prof. Tanenbaum's NSF MRI grant to create the now heavily used Electron Microscopy Facility. Prof. Hudgings is ramping up her research here supported by her role in the NSF funded Center for Hierarchical Manufacturing.

We were thrilled this year to support our first group of Sontag Physics SURP students using endowment funds from a major grant from the Sontag Family to the Department of Physics and Astronomy. Income from this endowment grant supported 7 students working on research in the department starting in the summer of 2015. We greatly appreciate that Associate Dean Mary Paster and Sandra Fenton worked with us to optimize the use of these funds which also were able to support student travel and supplies for some of these research projects.

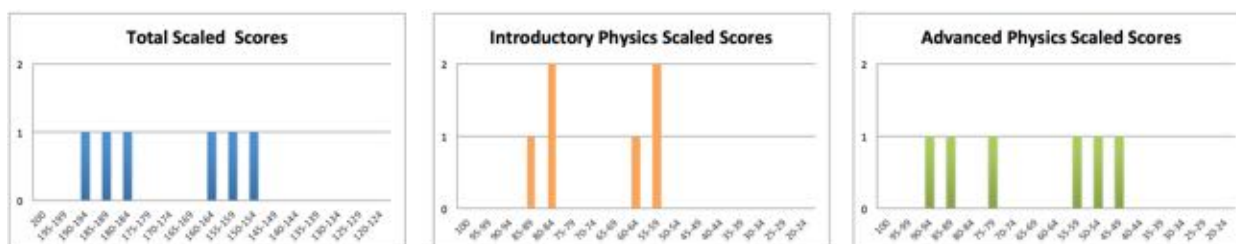
## Student Learning Objectives and Curriculum Assessment

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.*

The MFT exam is administered by our own faculty within our senior seminar course and results are compiled and available to the department with total scores, two subscores, and some nationally comparative data and scores in specific topic areas. A subset of this is reproduced below:

<b>Pomona Physics '15 / National 2014 MFT</b>	<b>Mean</b>	<b>Standard Deviation</b>
<b>Total Test Scaled Score</b>	172 / 150	17 / 15
<b>Introductory Physics - Subscore 1</b>	72 / 50	14 / 15
<b>Advanced Physics - Subscore 2</b>	69 / 51	18 / 15



*Physics MFT data for the class of '15. Pomona students means are more than a standard deviation above the national means in each sub score and in the total scores. When compared with the previous year's national data, the top third of Pomona students ranked 99<sup>th</sup> percentile, while the bottom third ranked 60<sup>th</sup> percentile. In an institutional comparison we ranked 99<sup>th</sup> percentile, at the top of the 96 institutions that use the MFT exam!*

In addition to the breakdown between introductory and advanced material, the MFT provides departments with data that highlights overall department scores by topic. Overall our students scored highest in the area of Classical Mechanics and Relativity (78% correct answers), then Electromagnetism (67%), Special Topics (64%), Quantum Mechanics and Atomic Physics (59%), while Optics/Waves and Thermodynamics (58%) were the weakest scores. In comparison with the other 96 institutions nationally that use the MFT, these subtopic scores rank us from 99<sup>th</sup> to 97<sup>th</sup> percentiles.

Other aspects of the senior exercise also received significant attention in the department. The senior seminar class was taught by Philip Choi and continued to provide an excellent entry to senior theses including literature reviews, timed oral presentations which are recorded and self-critiqued by the presenters, and drafting of introductory and background materials. The seminar helps students be successful beyond Pomona. A series of Alumni Panels and high profile guest speakers using Skype were combined with assignments where students research and speak with alumni continue to be very effective not only for our students, but also for our alumni relations. This year we created a LinkedIn group for Pomona College Physics & Astronomy Alumni, to complement our internal database.

We nominated one thesis for the prestigious Apker prize for best undergraduate physics theses in the nation. We also had significant conversations about the relationships between theses and engineering clinic in preparation for the coming academic year not only internally, but with our colleagues at HMC as well. Grant Yasanayake (father of our student Chanud) graciously offered our students a chance to take a course he offers in preparation for the *Fundamentals of Engineering* (FE) Exam which is part of the licensing of professional engineers. Two of our students took the course and both passed the exam.

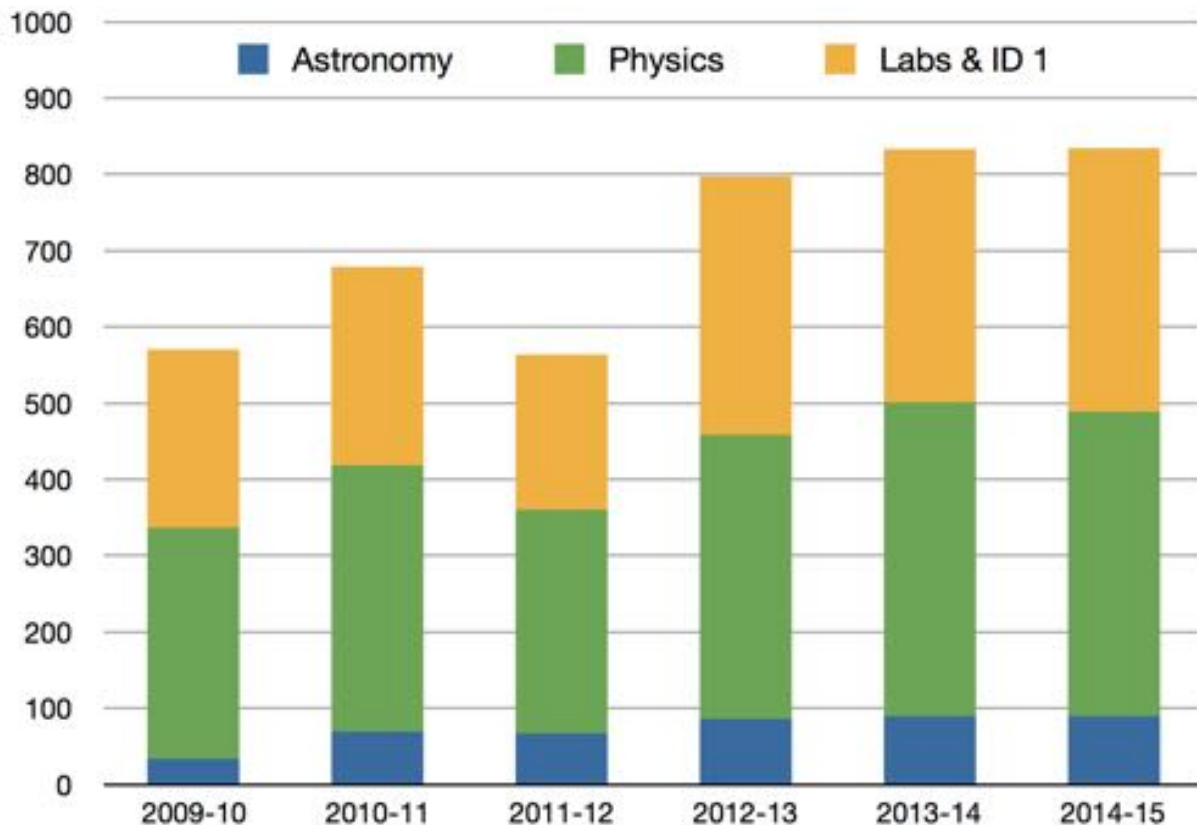
We continue to grow our use of field trips and guest lecturers in many of our courses both for majors and non majors. Getting out of the routine classroom sessions can really stimulate students and make them appreciate what they have learned when hearing from someone who is not their regular professor. We expanded that this year with the support of the Creativity Center bringing in alumni to lead workshops on 3D printing and Arduinos that not only enhanced classes but incorporated people outside our courses as well. Getting beyond the classroom also works when students become the experts either in outreach programs or even in the online community. Students report great satisfaction teaching at local school events, NanoDays, Observatory Open Houses, or in online forums like Instructables, where projects can go viral.

Our temporary spaces limited us in some ways, but also helped us build relationships with colleagues as we used facilities outside of our building. We are excited to have colleagues joining us in the new building and using our new facilities.

## Trends in Enrollment and Majors

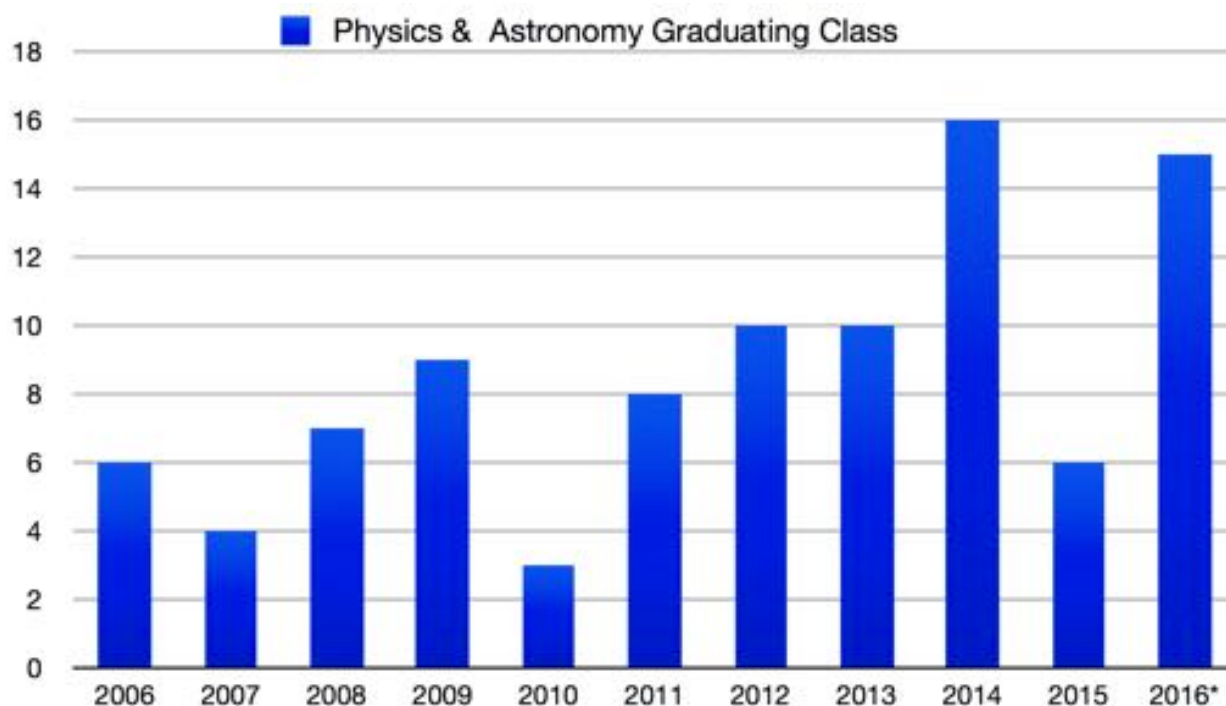
Enrollment trends in our department are presented below with total enrollments in Physics and Astronomy versus time. Physics enrollments (green) and Astronomy enrollments (blue) are both shown. The enrollments for lab sections and IDI sections (orange) which are substantial are shown as well. We saw record numbers in 2014-15, almost exactly matching the data from 2013-2014. We see this is driven by enrollments in the General Physics courses, 41/42 and 70/71/72, an overall increase in Introductory Astronomy enrollments, and a huge sophomore and junior class of majors. We greatly appreciate the support from the Dean's office and the Registrar staff based on pre-registration data and opening of hidden lab sections. We continue to split the ~80 students in Physics 40 and 70 courses into two sections rather than a single giant lecture. The enrollments in Astronomy show the value of keeping Visiting Prof. Vetere at Pomona while Prof. Penprase is away on LWOP.

### Course Enrollments Physics and Astronomy



*Enrollment trends for each academic year from 2009-2015, including total physics and astronomy enrollments, showing total physics enrollments (green), astronomy enrollments (blue), and lab and ID 1 enrollments (orange). Data taken from the Registrar's spreadsheet (by multiplying course credit by course enrollment for each course, except for laboratories.)*

Our total number of Physics majors as a function of their graduation year, based on completed majors (Spring 2006-2015) is shown in the blue bar graph below along with an expectation for 2016. This data shows large fluctuations. It is hard to know what causes any given year to have a large or small group. Certainly many of our seniors were able to do research both here and with collaborators. We have systematically been enhancing the engineering options for our students as well. Senior exit interviews with this class noted that Physics 70, 128, 160, 170, 175, and Astro 51, and 101 inspired students. This class of 6 majors had only one woman and five men. Two pursued the Astrophysicists track. Our programs with the Carnegie Observatories have a major positive impact upon students with an interest in Astrophysics. The class was racially diverse with three asians, two caucasians, and one hispanic student. We continue to work on diversity in the major not only in terms of racial and gender issues but also in terms of career paths.



*Number of Physics and Astronomy graduates since 2006, as a function of graduation year. This year's class was small, but strong. We currently have 15 declared majors scheduled to graduate in 2016.*

Statistically our running 3 year average of 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*.

## Physics and Astronomy Events

The Physics and Astronomy department has worked hard to create strong bonds between students, faculty, and staff. Weekly events include a Physics Lunch, a Friday afternoon happy hour, and a joint Tuesday afternoon colloquium series with the Harvey Mudd Physics department. Special events this year included:

- a Welcome back reception
- a Physics Awards Banquet
- a Fleet Day at Puddingstone Reservoir with sailing and kayaking
- a Lunar Eclipse Party at Brackett Observatory
- a Solar Eclipse Party at Brackett Observatory
- a Physics Halona Retreat
- an *Interstellar* IMAX Movie Night

- a Physics Video Analysis Awards Luncheon
- trips to special Caltech and UCLA Colloquia
- an evening of Physics Caroling at the Mawhorter home
- multiple tours of the new Millikan Building in various stages of construction
- a Physics Bowling Night
- a Spring Physics Dept BBQ luncheon
- a Mt. Baldy hike
- our Annual Physics Festival
- a Physics Alumni Reception
- a Physics Senior Dinner
- a Physics Class Day Luncheon for families of graduates at the Tanenbaum home
- Physics Summer Research Prep Workshop
- a Summer Research Pool Party & BBQ
- a social to test the new Physics Outdoor Laboratory interactive equipment.

In addition to these events for our students, our students, faculty, and staff hosted a wide range of outreach programs and events as service and engagement with our local community. We strongly believe in the mission of educational outreach and have a rich and long history of a wide variety of programs. Outreach not only serves the communities, but also serves our mission to cultivate in our own students a vision of how they can “... bear their added riches in trust for mankind.” Students who collaborate with faculty and staff on outreach report extremely high satisfaction working together as educators. Faculty have been recognizing the value of outreach by building outreach components into alternative assignments in courses rather than purely an extra curricular opportunity. Typically such efforts are guided by faculty and staff but conducted with participation of our students. A brief list of several of this year’s outreach programs follows:

- Pomona College CIPT Lab Lending Outreach Program (hundreds of high school students)
- NanoDays Outreach Series (hundreds of participants at 3 events, grades 4-12 ++)
- Brackett Observatory Open Houses (hundreds of participants of all ages at four events)
- Sycamore Elementary Science Fair and Outreach event (over a hundred K-6 students)
- PAYS program events with the Draper Center (high school students)

## Future of the Department

It has been amazing to work with the firms EHDD and MATT construction on the new Millikan Laboratory. Pomona College has worked very hard to make this project a success. We know the new building will not only enhance our existing programs, but inspire new ones as well. Examples of this include the physics outdoor laboratory, a science museum

playground inspired space, the digital theater and planetarium, and the new colloquium room. We are excited to move into a vibrant state of the art center for learning and research on our campus and appreciate the support we have received to make this a reality.

We are in the midst of preparations for our upcoming self study.

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 including HMC engineering while balancing our limited teaching resources to offer our existing interdisciplinary offerings.*
- *Developing better support mechanisms for our students in academic issues*
- *Develop more regional ties to other scientific institutions*
- *Bring in new federal and private grants for both research programs and revision of courses*
- *Enhance staff support: - Longer term visitors, Outreach coordination, Astronomy facilities support*
- *Develop support for nationally recognized speakers similar to the Robbins Lectures in chemistry*
- *Continue to improve retention rates for under-represented students*
- *Continually strive for our physics curriculum to prepare students for top ranked graduate programs.*
- *Continue to enhance research opportunities for our students on and off campus though out the year.*