

ANNUAL REPORT
2008 - 2009
Department of Astronomy

I. INTRODUCTION

The Department of Astronomy maintained its outstanding performance in research and teaching during the past year. Our department members continued their exceptional leadership in planetary studies with new results from the stunningly durable Mars Exploration Rovers as well as from the Cassini spacecraft. The ALFA Pulsar, Galaxy and Interstellar Medium radio surveys at Arecibo are ongoing projects that shed light on the Universe at densities ranging over 45 orders of magnitude -- from above nuclear densities to the near vacuum of the Universe itself -- and time scales from nanoseconds to billions of years. Computer calculations of exceptional accuracy were performed to mine gigantic data sets for astronomical nuggets, as well as to understand fundamental issues such as the collisions of black holes and the magnetohydrodynamics of gas flow onto neutron stars. Our department continued to be a center for the development of novel astronomical instrumentation, for both ground based and space based observations. Theorists probed important astrophysics questions ranging from the nature and cause of the observed acceleration of the expansion of the Universe to the extreme physics of compact objects and their surroundings.

A bittersweet milestone was reached toward the end of the academic year: after almost 2100 days of observing, the Infrared Spectrograph on the Spitzer Space Telescope, which was developed under the leadership of Professor **James R. Houck**, boiled off the last of its liquid Helium. During its lifetime, IRS was a revolutionary instrument for infrared astronomy on scales ranging from the Milky Way to high redshifts.

Cornell Astronomy also continued its deep commitment to teaching with new innovations in its courses, particularly in the introductory courses, Astronomy 1101 and 1102. Professor **Peter Gierasch**, assisted by Senior Research Associate **Don Banfield**, spent much of the year developing experimental demonstrations using a rotating fluid tank purchased with a Faculty Innovation in Teaching Grant. These experimental demonstrations illustrate phenomena in fluid mechanics that are important in a host of atmospheric and astronomical situations, and have already begun to be employed in courses.

A notable contribution to education in the sciences was the development of a touring exhibit of photographs of Saturn led by Professor **Joseph Burns**. This exhibit had its debut at the Johnson Museum, but was also shown at museums such as the American Museum of Natural History, and the National Air and Space Museum.

A notable event was the 40th meeting of the Division of Planetary Sciences of the American Astronomical Society which was held at Cornell in October 2008. The co-organizer of this meeting, which attracted more than 600 planetary scientists to Ithaca during Fall Break, was co-organized by Professor **James F. Bell**. A singular feature of this conference was the debut of "Anillos", a percussion concerto inspired by images of the rings of Saturn from the Cassini satellite, written by Cornell composer Professor Roberto Sierra. The concerto was accompanied by a video display coordinated by Professor **Joseph Burns** and Research Associate **Matthew Hedman**.

During the past year **823** students participated in courses offered by the Department, **2** undergraduates completed their Astronomy Major and **8** graduate students finished their Ph.D. programs. The Department continues to emphasize the participation of undergraduates in its diverse research programs. Approximately **50** undergraduates were involved, including those who took part in summer programs supported by the National Science Foundation's REU (Research Experience for Undergraduates) program,

by the New York State Space Grant Consortium, and by NASA space projects such as Spitzer, Cassini, and MER (Mars Exploration Rovers).

Cornell Astronomy faculty received notable awards and delivered prestigious lectures. Assistant Professor **Rachel Bean** received a Cottrell Scholar Award in recognition of her promise and accomplishments in cosmology. Professor **James R. Houck** was given the Weber Award of the American Astronomical Society at their January, 2009 meeting. Professor **Yervant Terzian** received the Gold Medal of the Republic of Armenia, and Gold Medals from the University of Yerevan and the Academy of Sciences in Armenia in recognition of his outstanding scientific achievements. Professor **Steven Squyres** delivered several prestigious lectures, including the Bunyan Lecture at Stanford and the Wildt Lecture at Yale. Assistant Professor **James P. Lloyd** was selected for recognition as "the Cornell faculty member who most significantly contributed to [her] college experience" by Merrill Presidential Scholar Angie Wolfgang.

Cornell astronomers also are playing central roles in planning the future of astronomy in the United States. Professor **Martha Haynes** is Vice-Chair of the Astronomy and Astrophysics 2010 Decadal Survey commissioned by the National Research Council, and Assistant Professors **Rachel Bean** and **James Lloyd** are members of the The Cosmology and Fundamental Physics (CFP) and The Planetary Systems and Star Formation (PSF) Panels, respectively. Professor Steven Squyres is Chair of the Planetary Science Decadal Survey. These decadal surveys are extremely influential in prioritizing new facilities and missions for exploring the cosmos, and it is noteworthy that our relatively small department is playing an influential role in these deliberations.

The **Cranston W. and Edna B. Shelley Award for Graduate Research in Astronomy** was given to **Phil Muirhead**. The **Cranston W. and Edna B. Shelley Award for Undergraduate Research in Astronomy** was awarded to **Jennifer Burt**. The 2009 **Eleanor Norton York Prize in Astronomy** was shared by **Ann Martin** and **Briony Horgan**. The **Cranston W. and Edna B. Shelley Outstanding Teaching Assistant Award**, was given to **Kassandra Wells**. We are fortunate that we are able to recognize the achievements of a few of our outstanding students via these generously endowed prizes.

The Department continued to receive generous support for its teaching, research and outreach activities from the Friends of Astronomy. Notable contributions include a grant from the Josephine L. Hopkins Foundation to support summer research by Cornell undergraduates in addition to funding six astronomy colloquia during the upcoming academic year. Mr. **Ed Hewitt** continued his generous support of education within the department by funding improvements to the Hewitt Laboratory for computing, and also the annual field trip by students in the Astro 6577 "Planetary Surface Processes" course to planetary surface analogue sites in the southwest US. Mr. **Fred Young** continued to support the CCAT (Cornell-Caltech Atacama Telescope) project with exceptional generosity.

During the 2008-09 there were approximately **99** individuals associated with the Department (not counting NAIC staff at the Arecibo Observatory in Puerto Rico). They included **27** faculty, **34** research associates, and **42** graduate students. Significant research achievements during the past year are described in the reports of individual faculty members in the main body of this report.

The Department's research was supported by **165** grants and contracts and sub-contracts totaling **\$92.0M**. An additional **\$11.7M** supported operations of the Arecibo Observatory. Most research funds for the Department come from NASA, with a significant contribution from NSF. Operations at Arecibo are supported by NSF.

Members of the Department, their students and associates published some **248** papers during the past year, in addition to presenting numerous colloquia and public lectures.

The Department's Colloquium Series, organized by Professor **David Chernoff** and **Philip Nicholson**

consisted of **28** colloquia including one "named" colloquium endowed by our Friends of Astronomy. These were:

The Josephine Lawrence Hopkins Foundation Colloquium was given by **Erik Asphaug**, UCSC: "Planetary Collisions".

The **Edwin Salpeter Lecturer** for 2008-9 was Professor **Gilles Chabrier**, ENS Lyon, who gave two lectures:

Astronomy Colloquium, April 23, 2009

"Star Brown Dwarf Formation and Early Stages of Evolution: Theory of the Initial Mass function"

Joint Physics/Astronomy Colloquium, April 27, 2009

"Recent Results in Exoplanet Formation, Structure and Evolution"

A sad event was the death of Professor Emeritus **Edwin Salpeter**, one of the giant figures of 20th century astronomy worldwide, in November, 2008. Ed was one of the founders of the modern Astronomy Department at Cornell, which he helped build into a major department. A commemoration of Ed's life was held on campus on March 14, 2009, featuring keynote speeches about Ed's life and career by Yervant Terzian, Freeman Dyson, Kip Thorne, Lars Bildsten and Ed's daughters Judy and Shelley. Scores of Ed's former colleagues and students attended this event and shared their fond memories of Ed as scientist and mentor.

II. DEPARTMENTAL NEEDS

Over the past 50 years, Cornell Astronomy has been built up to a prominent position in the world's astronomical community. However, to remain at the forefront will require continued upgrading of our capabilities.

The Department's pressing short term needs are:

1. Increase in number of Teaching Assistants. Enrollment in some of our new and extremely popular courses -- such as "Space Exploration", taught by Steve Squyres -- is limited by insufficient TA support.
2. Yearly allocation of \$10-20K to maintain up to date teaching and research facilities.
3. Phasing out and replacing the Fuertes Observatory.

Long term -- and more expensive -- needs include:

1. Departmental postdoctoral fellowships are common at other leading astronomy and astrophysics departments. They are keys to attracting the finest young minds to a department like ours, which keeps the intellectual atmosphere vibrant.
2. Provisions for additional space as we move into new and exciting projects that require more extensive facilities are needed. Department faculty are participating in planning and development of some of the most promising and exciting new astronomical experiments, both ground-based and on spacecraft. Maintaining the advantages of our intellectual prominence in these areas will also require adequate facilities. As the Space Sciences Building is filling to capacity, some expansion is needed.
3. To maintain and build upon our department's excellence we need continued access to ground-based telescopes. Presently, through generous support from the University, we have access to the 5m telescope at Palomar, which, while still useful to us, is now surpassed in light collecting power by several larger telescopes. Although we plan to continue our Palomar collaboration with Caltech at a reduced level for the next three years, what will happen next is not clear -- but we must maintain some access to powerful optical telescopes even as we look to lead new telescope development in other wavelength bands. In the

next decade, our department looks to CCAT to be our signature ground based facility at sub-millimeter wavelengths. The University and College have generously committed \$250,000 per year to the project beginning in January 2010, in addition to support they have given the project over the years. However, significant funds need to be raised, in the short term to pay for a major engineering study, and in the longer term for construction of the telescope. On a longer term, the Square Kilometer Radio Telescope Array (SKA), in whose development members of our department play a central role, will become the world's unique and most sensitive telescope for radio astronomy. SKA primarily needs space to accommodate its present and future development; financial support is expected to be primarily from national and international funding agencies. Although these longer term needs mainly center around research activities, Cornell Astronomy has long recognized the need to involve undergraduate as well as graduate students in our observational and theoretical studies. Indeed, experience in research is one of the best ways for undergraduates to learn how science is really done.

4. The department currently has 18.25 FTEs of which 17 are permanent FTEs. Nevertheless, during the next few years we anticipate needing to do some searches, based on department demographics. The departure of Associate Professor Jean-Luc Margot, a prominent young planetary scientist, for UCLA is doubly unfortunate as we had hoped he would be a leader in our department into the future.

Looking to the future, Astronomy has been engaged in an internal strategic review. One emerging area that we would like to enter more vigorously is the search for and modeling of extrasolar planets; this is natural for us, as it would link strong groups in our department. As CCAT and SKA come closer to first light, our faculty's efforts will naturally shift toward projects that make use of these powerful new facilities, and we anticipate that future searches would reflect this shift.