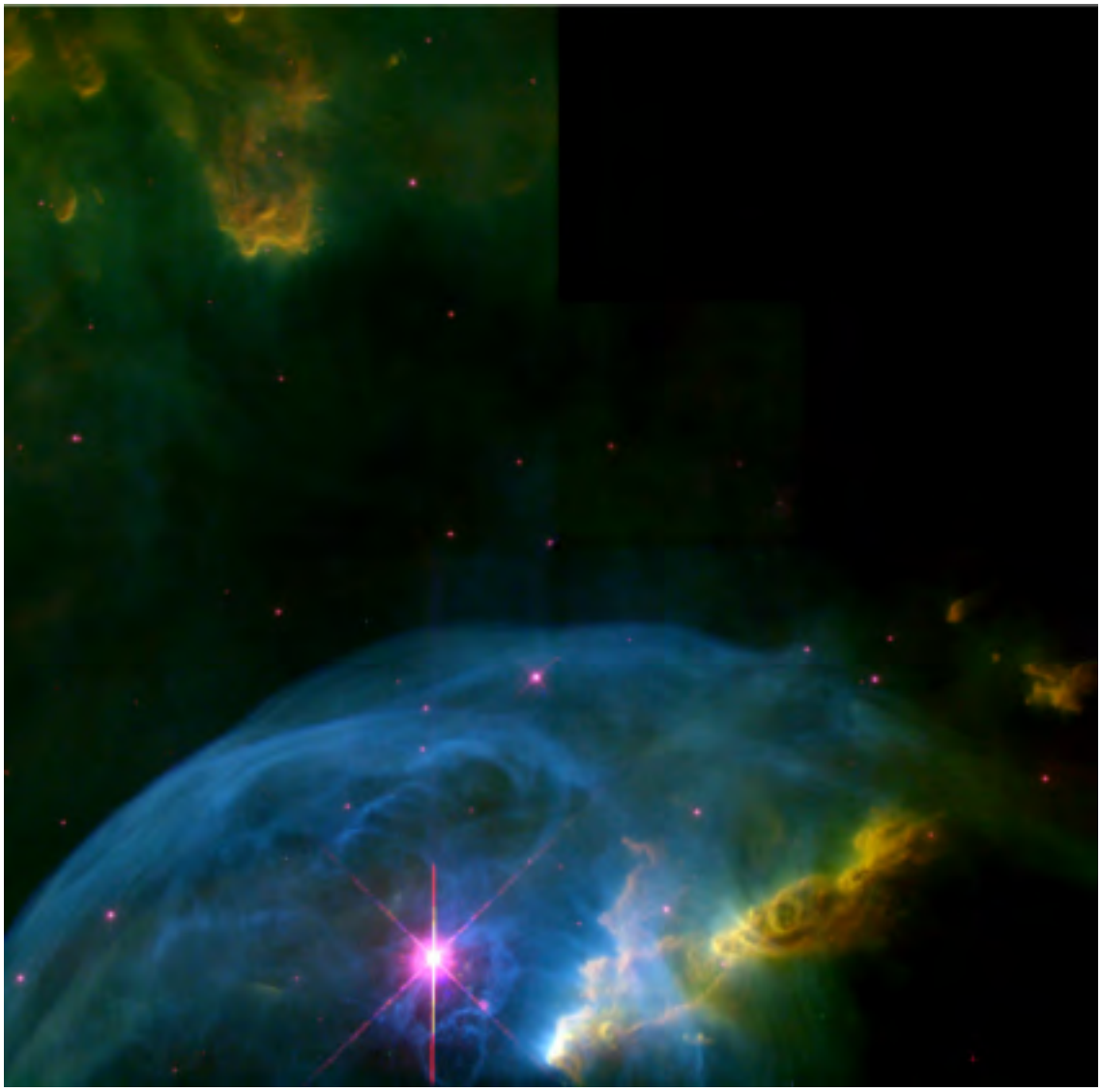
Space Physics & Astronomy

Annual Departmental Report

To the President



The "Bubble Nebula", observed by the Hubble Space Telescope
By R. J. Dufour, Patrick Hartigan and Brent Buckalew
and spac alumni Don Walter, Brian Moore and Paul Scowen

Rice University **January 2000**

SPACE PHYSICS & ASTRONOMY
OFFICE OF THE CHAIRMAN

MEMORANDUM

Date: 14 January 2000

To: Malcolm Gillis, President
David Minter, Interim Provost
Kathy Matthews, Dean of Natural Sciences

From: Patricia H. Reiff

Subject: Department Annual Report, 1 January - 31 December '99

I am pleased to provide herewith the last full Annual Report to the President of the Space Physics and Astronomy Department, covering 1 January - 31 December 1999.

This has been a dramatic time period for us. Our research is at a high note, with many new discoveries coming out of our department and new spacecraft launched and others ready to launch. Our courses reach nearly half of the Rice student body. Our Visiting Committee gave a ringing endorsement to our research and teaching program. Our 35th departmental reunion brought 183 former students, staff, and faculty back to celebrate the Department and the accomplishments of its 185 Ph.D. and many M.S. alumni. Our alumni and our public outreach programs span the globe. Our innovative BA/BS programs and professional Master's programs were approved. Our five-year plan poised us to move into new and exciting research directions as our many retirements allowed growth and change. And the abolishment of our Department was announced.

Certainly I am personally disappointed that the Department will no longer exist as such after July 2000. I was planning to be a part of our department through its 50th anniversary. Many alumni have expressed to me their dismay at the profound change, interpreting the action as a negative reflection on the department. Yet the merger with Physics brings new opportunities, an expectation of more effective graduate recruiting, a hope for a new joint facility where interdisciplinary research can be more readily accomplished, and the creation of a dynamic cadre of physicists with more visibility on the national and campus scenes.

The merger will require a great deal of additional effort in realigning course offerings, graduate programs, budgets, and staffing. This coming year will involve a great deal of turbulence as all the various programs get sorted out. We are optimistic, however, that the end result will be a more streamlined, more effective whole. Barry Dunning has already demonstrated his effective leadership and we look forward to continuing to work with him in the future.

The recent creation of the "Rice Space Institute" will allow the Department's space-related research activities to maintain visibility and high impact. Already a number of new collaborators from other departments have expressed an interest in participating. The RSI will have focus areas in space weather research, computational space physics, solar physics, astrophysics, planetary and extra-solar objects, remote sensing, history and philosophy, spacecraft operations, education and public outreach, By spanning many departments we can leverage our efforts into new areas with new expertise.

2000 will be a time of profound change. We are ready for the challenge.

Strategic Goals

Implementing our Five Year Plan

The mission and goals of the Department of Space Physics and Astronomy are commensurate with those of the Wiess School of Natural Science, Rice University, and its founders. To reach these goals we have recently reviewed our five-year plan and outlined in our first-ever departmental retreat three different potential new directions for departmental research, presenting them to our Visiting Committee for expert advice.

Mission

> **".....to create a community of scholars and learners that will attract the best minds in the world to generate scientific and technical knowledge at the forefront of inquiry and discourse, and to educate new generations of scientists and scientifically literate citizens, and to contribute to the common good through outreach activities."**

Goals

- to continue to engage in superior, cutting-edge **research** that commands national and international respect, focusing on the high visibility fields of observational astronomy, theoretical astrophysics and experimental and theoretical space physics;
- to continue to contribute to the excellent **undergraduate learning and research** experience for which Rice is so well known;
- to continue to participate enthusiastically in Rice's commitment to a revitalized **general education** curriculum;
- to strengthen **graduate education** by a renewed dedication to teaching and student recruitment;
- to continue and even strengthen our commitment to **bring science to the public**;
- to build on our already substantial relationships with industry and government and continue to foster **technology transfer**;
- to continue to **serve the Wiess School and the Rice community**.

To accomplish these goals, we created a plan for the next five years that includes: 1.) the establishment of two undergraduate majors in Space Physics and Astronomy, at the BA and BS levels; 2.) the establishment of a permanent on-campus teaching telescope facility; 3.) partnership in a world-class, ground-based research telescope such as the proposed 6.5 meter telescope to be built by a Mexico/US consortium on the Baja peninsula; 4.) replacement of our five retiring or recently departed faculty with a clear vision of future research; 5.) enhancement of our research faculty by the hiring of two new Faculty Fellows; 6.) a new initiative for quality graduate student recruitment; 7.) designation of the Department as a NASA Center of Excellence; and finally 8.) a renewed commitment to Departmental advancement through greater attention to media and community communications and relationships to other Rice departments and nearby institutions and industry.

In our Departmental faculty retreat held May 18 at the Clear Lake Conference Center, several scenarios for future faculty distribution were considered. The "Future Directions" document, which outlined three potential "go to" scenarios, was the result of that process and

continuing discussions afterwards (Appendix A, compiled by Patrick Hartigan and Tom Hill). Professor Emeritus William Gordon was our facilitator in that process.

Major Faculty Changes

Three faculty members announced their retirements effective June 30, 2000: C. Robert O'Dell, F. Curtis Michel, and John W. Freeman. This, in conjunction with last year's loss of Jon C. Weisheit to become the director of the Applied Theoretical and Computational Physics Division at the Los Alamos National Laboratory and the previous retirement of Robert C. Haymes means that we will have five faculty positions vacant as of July 1, 2000. This gives us an opportunity not available since the founding of our department in 1963 to make a major change in emphasis of research areas.

This made the Future Directions document (Appendix A) rather more immediate in its impact. The long-term result could either have an Astrophysics flavor, a Space Physics flavor, or even a Planetary flavor, by carving out a niche for planetary research from among the retirements.

The one common thread among the three alternatives was the need to immediately reinvigorate our Astrophysics group by two new faculty members. A request was made to the Dean to replace these faculty, and a faculty search was approved (Appendix D).

Visiting Committee

Dean Kathy Matthews convened our external Visiting Committee in September, 1999. It was the first time that our Department had ever had a Visiting Committee separate from the Physics Department. We were pleased to receive their advice on the conduct of the department and to help us find the best of the three alternative "future directions" scenarios.

The Chair of the Committee was Professor Eugene Levy, Dean of Science at the University of Arizona, and specialist in Planetary research. The other committee members were Professor Josh Grindlay of Harvard, specialist in High Energy Astrophysics; Professor Anneila Sargent of California Institute of Technology, specialist in Observational Astronomy, and Professor George Siscoe of Boston University, specialist in Space Physics. Each of the committee members is a major player in the national and international planning process, and is well aware of major future thrusts by NASA and NSF.

The Visiting Committee met with each of the major groups of the department: astronomy/astrophysics faculty, space physics faculty, faculty fellows, graduate students, and post doctoral fellows. They also met with the Chair of the Physics Department and selected Physics faculty and students as well. They also met with President Gillis and Acting Provost David Minter. The Chair's report to the Visiting Committee overviewed the Department, highlighting research funding and student and alumni statistics. That report is attached here as Appendix B.

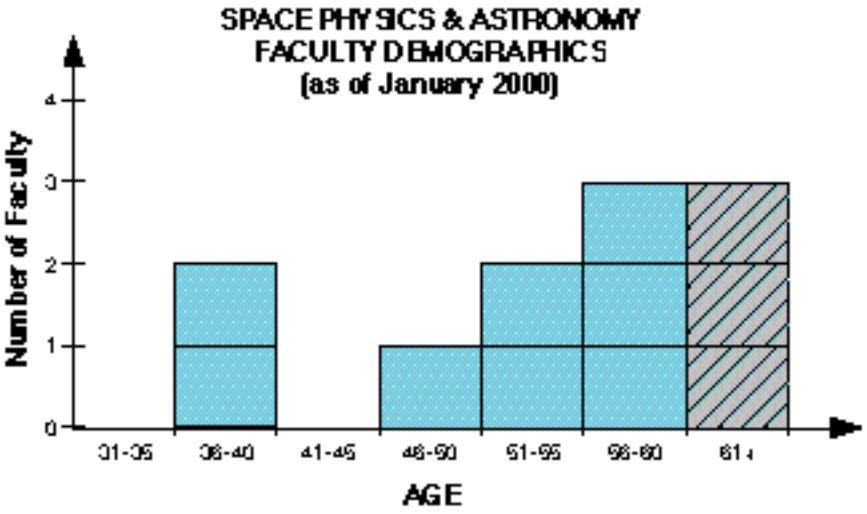
The report of the Visiting Committee (Appendix C) was in general quite favorable to the Department and the research performed herein. They supported our view that the appropriate size of our department is 13 faculty members in the long term. They suggested that we enhance our experimental program (a move which is difficult to do with limited resources and limited space). They favored Rice's participation in a large Research telescope consortium, and argued for the construction of an inexpensive teaching telescope on campus. They particularly noted the Space Physics group as being world-class in reputation. Their recommendation with the greatest impact, however, was that the Dean consider a merge between the Space Physics and Astronomy Department and the Physics Department. This was a move that had been briefly discussed around the Department, but not at great length. It was something that was certainly controversial (the views of the faculty ranged from strongly in favor to strongly opposed), with most of the alumni of the department who responded also in opposition.

Nevertheless, the Dean welcomed their advice and decided that the merger would be in the best interest of both departments. The Dean also recommended that continuing the visibility of the space physics group best be done by means of a Center or Institute.

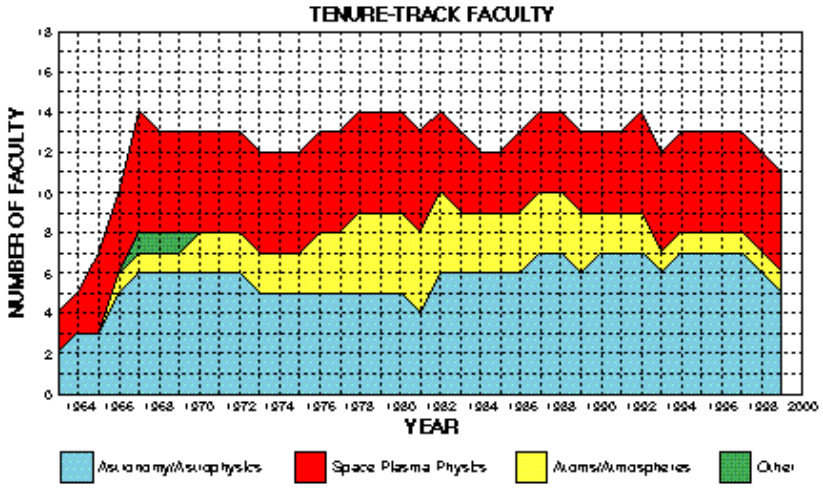
Faculty

Faculty Demographics / Announced retirements

This year, as a result of the retirement package offered by the University, three of our most distinguished faculty (including both Buchanan Chairs) have announced their retirements effective 30 June 2000: C. R. O'Dell, John W. Freeman and F. Curtis Michel. Although we will be saddened to not have them on our teaching team any more, we are pleased that both Freeman and Michel expect to remain associated with the Department and will continue to perform research here. We wish O'Dell well in his return to his family in the Huntsville, Alabama, region, and will miss his experience and guiding hand.



At present, our faculty consists of ten tenured professors (one of whom, Chan, received his promotion to Associate Professor with Tenure this year) and one assistant professor, Hartigan, who has been recommended this year by the Department for promotion to Associate Professor with tenure. The present age distribution of our faculty is shown in the graph to the right. The announced retirees are shown crosshatched - we will lose all of our faculty members aged 61+ this year. We expect that with our three new hires from our open searches (see below) that our age distribution will fill in the lower age brackets. In addition, Space Physics & Astronomy has four research faculty fellows, two affiliated faculty (joint appointments budgeted to other departments), and eight adjunct faculty.



The distribution of our present faculty research areas is shown in the graph to the left. If the three new hires proceed as advertised, we will continue our present distribution of 5 astronomers, 5 space physicists and one atmospheric physicist. This still leaves us 2 members below our historical level, and we hope to hire two more faculty members in the coming year. No additional retirements are expected in the near future, based on the current demographics.

Open Searches

High Energy Astrophysics

At present we have three open faculty searches. The first search, recommended by our faculty and endorsed by the visiting committee, is for two high energy or theoretical astrophysicists. The advertisement went out in the fall of 1999, and consideration of applicants begins later this month. One position has been approved at the junior faculty level (Assistant) and one at the Assistant to Associate Professor level. The search committee is chaired by Edison Liang and includes Curt Michel and Anthony Chan of our department, and Marge Corcoran and Randy Hulett of Physics. Over a hundred applications have been received so far, and Dr. Liang conducted many interviews at the recent AAS meeting in Atlanta. The advertisement is included as Appendix D. A modest startup package would be required for each of these positions. If perhaps one brings an experimental program, more laboratory space would be needed. However, when we were asked to leave the building which NASA had built for us in the 60's, we were assured that laboratory space would be provided for us if we ever had a demonstrated need for it.

Computational Space Plasma Physicist

Our department has also been approved to search for a computational space plasma physicist at the Assistant Professor level. The advertisement went out in November 1999, and consideration of applicants begins in February. The search committee is chaired by Dick Wolf and includes John Freeman and Patrick Hartigan of our department, Petr Kloucek of Computational and Applied Mathematics and Peter Nordlander of Physics. The advertisement is included as Appendix D. A modest start-up package would be needed, but no special facilities (our department recently purchased a parallel computer, and this should be adequate with some minor upgrading).

Present Space Physics & Astronomy Faculty

TENURE-STREAM FACULTY

Chan, Anthony A. (Ph.D., Princeton, 1991) Associate Professor

Cloutier, **Paul A.** (Ph.D., Rice, 1967) Professor

Dufour, Reginald J. (Ph.D., Wisconsin, 1974) Professor

Few, Arthur A., **Jr** (Ph.D., Rice, 1969) Professor

Freeman, John W., Jr. (Ph.D., Iowa, 1963) Professor

Hartigan, Patrick M. (Ph.D., Arizona, 1987) Assistant Professor

Liang, Edison P. (Ph.D., UC Berkeley, 1971) Professor and Assistant Chairman

Michel, F. Curtis (Ph.D., Cal. Tech., 1962) Buchanan Professor

O'Dell, C. Robert (Ph.D., Wisconsin, 1962) Buchanan Professor

Reiff, Patricia H. (Ph.D., Rice, 1975) Professor and Chairman

Wolf, Richard A. (Ph.D., Cal. Tech., 1966) Professor

RESEARCH FACULTY

Hill, Thomas W. (Ph.D., Rice, 1973) Distinguished Faculty Fellow

Lindsay, Bernard G. (Ph.D., Queen Mary College, 1987) Faculty Fellow

Smith, Ken A. (Ph.D., Rice, 1976) Distinguished Faculty Fellow

Toffoletto, Frank R. (Ph.D., Rice, 1987) Faculty Fellow

FACULTY WITH JOINT APPOINTMENTS

Dunning, F. Barry, Professor and Chair of Physics

Walters, G. King, Professor of Physics (Retiring 30 June 2000)

ADJUNCT FACULTY

Black, David C., Adjunct Professor, Lunar & Planetary Institute

Chiang-Diaz, Franklin, Adjunct Professor, NASA/Johnson Space Center

Horton, Jr., C. Wendell, Adjunct Professor, Institute for Fusion Studies, UT-Austin

Newman, James H., Adjunct Associate Professor, NASA/Johnson Space Center

Stepinski, Tomasz F., Adjunct Associate Professor, Lunar and Planetary Institute

Sumners, Carolyn, Adjunct Professor, Houston Museum of Natural Science

Weisheit, Jon C., Adjunct Professor, Los Alamos National Laboratory

Winningham, J. David, Adjunct Professor, Southwest Research Institute, San Antonio

Young, David T., Adjunct Professor, University of Michigan, Ann Arbor (has recently resigned because he has moved from the area to accept the faculty position at Michigan)

Recent Faculty Awards

Our faculty have received several outstanding awards this year (in addition to the many awards announced in previous years):

Dr. John Freeman was named Sverdrup Visiting Scientist at Augsburg College, 1999. He is chief organizer of the GEM conference (and will be succeeded by Frank Toffoletto in 2001).

Dr. Dick Wolf was named Fellow of the American Geophysical Union, December, 1999, and is Chair of the GEM Steering Committee.

Dr. Patricia Reiff was named "Outstanding Aerospace Educator" by Women in Aerospace, October 19, 1999. Presented by Hon. Ken Bentsen, this award was listed in *Space News*.

Dr. Edison Liang was an invited keynote speaker at the U.S. Air Force AMOS technical conference, and is organizing "the Third International Conference on Laboratory Astrophysics", which will be held at Rice this March.

Dr. Robert O'Dell is the Vice Chair of the AAS Centennial Committee.

Dr. Reggie Dufour is a Fellow of the Royal Astronomical Society.

Dr. Tom Hill was named University Representative to the Texas Space Grant Consortium.

Staff

Space Physics & Astronomy has an excellent and experienced administrative staff:

Maria Byrne, administrative secretary
Umbelina Cantú, department coordinator
Norma Cowley, word processing operator
Anita Schell, accounting assistant
Wayne Smith, department administrator

These people work closely with faculty and students to facilitate the department's research and teaching activities. U. Cantú handles all administrative items pertaining to faculty and staff, and helps the department chair. She organizes all external conferences. M. Byrne helps the assistant chair, and handles work related to current and prospective graduate students and the upkeep of our departmental web pages. Wayne Smith, who handles budgets and grant paperwork, is shared between Physics and Space Physics and Astronomy. We are pleased that as of next year, approximately 18% of Bryan Bales' time will be paid by the University, in recognition of his many hours of effort in performing system management on departmental computers. We hope that this fraction might increase in the years to come.

In addition to the administrative staff, we have seven research staff members in this department, supported by one or more of our research projects:

Bryan Bales, systems analyst III
Markus Boettcher, postdoctoral research associate and Chandra Fellow
Bonnie Hausman, programmer analyst II
Colin Law, research scientist
Ian Smith, research scientist
Robert Spiro, senior research scientist
Brian Cudnik, research technician

Staff Awards

We are pleased that special meritorious bonus awards noted Wayne Smith's and Umbe Cantu's exceptional efforts last year.

Postdoctoral Associates and Visiting Scientists

During the past year and a half, four postdoctoral research associates were in residence for periods exceeding six months, and three senior scientists were here for an extended visit. (Dr. Rejoub just joined Rice in December 1999). These people have made major contributions to our research and educational efforts. Dr. Huang, for example, has recently opened a solar telescope at Prairie View A&M with help from Dr. Dufour. We are saddened to report that Dr. White, who worked here on occasion while undergoing treatment for leukemia, died in 1999.

Postdoctoral Fellow	Faculty Advisor	Research Specialty
Dr. Yuri Balashov	**A. van Helden**	**SPAC/CSST**
Dr. Markus Boettcher	**E. P. Liang**	**Gamma-Ray**
Dr. Michael Mangan	**B. Lindsay**	**Atomic Physics**
Dr. Riad Rejoub	**B. Lindsay**	**Atomic Physics**
Dr. Peter Walker	**P. A. Cloutier**	**Mars Observer**

Visiting Scientist	Home Institution	Research Specialty
Dr. Dean Sieglaff	Grove City College	Atomic Physics
Dr. Tian-Sen Huang	Prairie View University	Space Physics
Dr. Richard White	NASA/GSFC	Astronomy

Alumni

35th Reunion

On March 5th and 6th of this year the department held a 35th anniversary reunion, bringing back our alumni (http://spacsun.rice.edu/reunion/) to tell us how our training has helped their careers. A series of lectures was held at the Baker Institute conference room, given by our alumni on the exciting research they are now accomplishing. The evening of the 6th, a banquet was held at the Crowne Plaza. The keynote speaker was Harrison Schmitt, who talked about his experiences as a scientist on the Moon and how humans could exploit the Moon for its resources in the future. The event drew 183 former (and current) faculty, staff, and students.

Department Coordinator Umbe Cantú with keynote speaker Harrison Schmitt

The reunion was a resounding success - the participants said, "Let's not wait another ten years for the next one!" (Our previous reunion was our 25th). Accordingly, the next one is tentatively scheduled for March 2004.

Outstanding Alumni

At the reunion banquet, the Department presented its Gordon (to Dechun Lin) and Marlar (to Tony Crider) awards. This year we instituted our "Outstanding Alumni" awards, (http://spacsun.rice.edu/alumni/outstanding_alumni.html) showcasing some of the most distinguished of our alumni. The alumni had been nominated by their peers, and a selection made by a committee of present faculty. The selection was difficult, because of the many very capable alumni of the department, but the winners this year were:

1960's: Dr. Jim Burch, Vice President of Southwest Research Institute.
1970's: Dr. Stan Woosley, Chair, Astronomy and Astrophysics Department, University of California at Santa Cruz.
1980's: Dr. Jeff Hester, Professor, Astronomy and Physics Dept., Arizona State University.
1990's: Dr. Wei Peng, Vice President of Global Trading Division - Analytics, Chase Manhattan Bank, New York.

Dr. and Mrs. Wei Peng and his "Outstanding Alumnus of the 90's" award.

Educational Programs

Curriculum Changes

BA/BS degree

The most exciting curriculum change that we have in process is the establishment of three new degrees. In response to suggestions made as part of the Wiess School of Natural Science strategic planning exercise, we have proposed separate BA and BS degree tracks. The essence of our proposal was that our present "SPAC Option" degree through the Physics Department would be abolished and in its stead a new "Astrophysics" degree will be offered jointly with the Physics Department. When the new BS degrees become available in the school of Natural Science, the BS in Space Physics and Astronomy will be that degree program. We then would offer a second degree that would be a BA in Space Physics and Astronomy. That course would not be as heavily research-oriented, since it would be training ground for teachers, writers, business majors and other students who are not planning additional graduate education. We anticipate that the BA majors will be students who would not otherwise have received a science degree. In addition, it will more readily permit double majors with other academic subjects such as history, philosophy, or languages. The new degree programs have been approved as part of the BA/BS program, but the details and course requirements will doubtless change somewhat as a result of the anticipated merger with Physics.

Non-thesis Masters Degree

We have recently reexamined the graduation requirements for our M.S. students. The university has just approved a change in our requirements to add a new non-thesis M.S. degree. In this manner we hope to identify more quickly those students for whom a Ph.D. is not the most suitable level, and to provide them with an education that provides many possible avenues of employment without undue delay. Public education at all levels, including informal public education, is a new national goal, and with our ties to the Houston Museum of Natural Science, we are training the next generation of scientists who can communicate effectively with the public. In addition, a one year non-thesis Master's Degree is appropriate for Air Force officers who need additional training on a short term basis. This degree plan was recently approved on second reading by the Rice faculty.

The non-thesis Masters program will also change somewhat as a result of the merger with Physics, but we are hopeful that we can continue forward on this innovative plan.

Undergraduate Student Enrollment

Our Department does not have a separate major, but rather has "Spac option" students through the Physics Department. Over 30 freshmen this year have expressed strong interest in majoring in our new BA/BS programs. Recent undergraduate "spac option" majors (seniors 1999 or 2000) are listed below:

Undergraduate Student	Major	Faculty Advisor	Post-Graduation Plans
Matthew Browning	SPAC Option	J. C. Weisheit	Univ. of Colorado
Christopher Coco	SPAC Option	C. R. O'Dell	Consultant for I.T.
James M. Parker	SPAC Option	P. M. Hartigan	Unknown at this time
Margaret H. Smith	SPAC Option	R. J. Dufour	Unknown at this time
Steven Degenno	SPAC Option	R. J. Dufour	Unknown at this time

In addition, we had one high school senior research student, Elizabeth Chan (mentored by Patricia Reiff) who has been accepted to Rice as an undergraduate for Fall 2000 admission (early decision).

Graduate Student Enrollments

Our graduate students are the lifeblood of the Department. We are attempting to maintain our graduate student population at nearly 1/3 women and roughly 1/3 foreign (although we could easily double our foreign student population). The number of women have decreased this year, but it is a statistical fluctuation. Data in the table below reflect the fact that several years ago we made a conscious decision to "downsize" our graduate population, from some 40-45 total students to a steady-state level of about 28-30, which we have successfully attained. In fact, given the number of job opportunities presently available, we may have overachieved our downsizing and need to put more effort into recruiting top-quality students. Our present student body includes one current astronaut (Takao Doi), and one NASA employee (Gwen Smith). We are pleased that we are able to maintain a high interest among women; however, we would like to increase our diversity among other underrepresented groups. We are working with Roland Smith to target our recruiting towards these other groups, and have made recent presentations to SACNAS (Society of Chicano and Native American Scientists) and to the "Diversity Council".

GRADUATE STUDENT STATISTICS

YEAR	92-93	93-94	94-95	95-96	96-97	97-98	98-99	Fall 99
STUDENTS	41	38	34	31	32	27	27	25
female	8	9	9	9	9	6	7	4
non-US	15	13	11	11	9	8	9	8
Ph.D.'s	8	11	6	4	3	3	7	

Some of our recent graduates are continuing along traditional postdoctoral fellowships (D. Crider, H.-J. Kim, P. Walker). Some are now working at companies with major NASA contracts. Others have gone to work for consulting firms or major federal laboratories. Breadth of education has always been one of our major goals, and our students again and again tell us how critical that breadth has been to their employment opportunities.

1999 Ph.D. DEGREE RECIPIENTS

Name	Advisor	Present Employment
Dana Crider	P. A. Cloutier	NRC Postdoc, NASA/GSFC
Anthony Crider	E. P. Liang	Naval Research Laboratory
Donna Dempsey	Young/Hill	Southwest Research Institute
David K. Geller	J. C. Weisheit	Draper Laboratory
Hee-Jeong Kim	A. A. Chan	Postdoc, Nagoya University (Japan)
Seth Orloff	J. W. Freeman	MIT Lincoln Lab
Peter Walker	P. A. Cloutier	Rice University

Our M.S. graduates have also been successful in putting their talents and experience into successful career paths. A number of our previous M.S. recipients are now planetarium directors around the country; some are working in industry, and of course many are continuing here working towards their Ph.D. degree. One of our Masters this year is successfully working towards a Ph.D. at Vanderbilt.

1999 M.S. DEGREE RECIPIENTS

Name	Advisor	Present Employment
Matthew M. Huddleston	D. Young/Hill	Continuing towards Ph.D. degree at another university.
Wayne Keith	P. H. Reiff / D. Winningham	Continuing towards Ph.D. degree
Dechun Lin	E. P. Liang	Continuing towards Ph.D. degree
Peter D. Thacker	F. C. Michel	Computer company

Students registered for Fall 1999 semester

Year	Student	Research Advisor	Support
1	Yue Fei	E. P. Liang	Rice Fellow
1	Carl Huffman	E. P. Liang	Rice Fellow
1	Shuo Ji	E. P. Liang	Rice Fellow
1	Daniel Kocevski	E. P. Liang	Rice Fellow
1	Andrew Lemanski	E. P. Liang	Rice Fellow
2	Takao Doi	C. R. O'Dell	Self-supported/Japanese Fellow
2	Andrea Hirst	A. A. Chan	(now on leave of absence)
2	Colby Lemon	F. R. Toffoletto	Research Grant
2	Gwyn Smith	P. A. Cloutier	Self-supported/NASA fellowship
3	Brent Buckalew	R. J. Dufour	NASA Traineeship
3	Yue Chen	P. A. Cloutier	Research Grant
3	Menelaos Sarantos	P. H. Reiff	Research Grant
3	Dimitrios Stamatellos	Black/Hartigan	Research Grant
3	David Streutker	Few/Reiff	Research Grant
4	Vance Henize	P. H. Reiff	Research Grant
4	Katherine Keilty	E. P. Liang	Research Grant
4	Stephen Naehr	R. A. Wolf	Research Grant
5	Trevor Garner	R. A. Wolf	Research Grant
5	Wayne Keith	Reiff/Winningham	Research Grant
5	Dechun Lin	E. P. Liang	Research Grant
5	Irina Romanovskaya	K. Smith	Self-supported
6	Parviz Ghavamian	P. M. Hartigan	Research Grant
6	Timothy Glover	Chan/Chang-Diaz	Research Grant
6	Andrew Urquhart	T.W. Hill	Research Grant
8	Mark Mulrooney	R. J. Dufour	Self-supported

Courses and Curricula

Although most of the courses that our faculty teach are listed in the SPAC department, we also help teach an important Natural Science course (NSCI 111), and a number of non-major courses that fulfill science distribution requirements (SPAC 201, 202, 205, 403, 443). Counting just these service courses, our faculty reached 214 non-SPAC undergraduates in 1999, a substantial fraction of the student body. Other non-major courses offered in other years include Spac 203 and NSCI 230. Adjunct faculty and research scientists (shown in italics) helped teach three of our courses this year. The table below covers 1999.

Instructor	Course	Title	Enrollment
Y. Balashov	SPAC 205	From Space & Time to Space ...	13
P. A. Cloutier	SPAC 512	Ionospheric Physics	4
	SPAC 800	Graduate Research (2 sem)	6
	SPAC 470	Solar System Physics	4
R. J. Dufour	SPAC 360	Galaxies and Cosmology	3
	SPAC 800	Graduate Research (2 sem)	4
	SPAC 201	Stars, Galaxies, and the Universe	33
	SPAC 700	Teaching Practicum	1
A. A. Few	SPAC 443	Atmospheric Physics	6
	BAKE 201	Shakespeare	15
	BAKE 205	Baker in London	13
	SPAC 500	Graduate Seminar	27
J. W. Freeman	SPAC 202	Exploration of the Solar System	30
	SPAC 202	Exploration of the Solar System	30
P. M. Hartigan	SPAC 201	Stars, Galaxies and the Universe	28
	SPAC 800	Graduate Research	2
	SPAC 602	Special Topics: Star & Planet ...	4
	SPAC 800	Graduate Research	2
T. W. Hill	SPAC 800	Graduate Research	3
	SPAC 800	Graduate Research	1
E. P. Liang	SPAC 350	Introduction to Astrophysics	3
	SPAC 800	Graduate Research	3
	SPAC 551	Solar & Stellar Astrophysics	4
	SPAC 800	Graduate Research	2
F. C. Michel	SPAC 516	Numerical Methods	8
	SPAC 561	General Relativity	10
	SPAC 800	Graduate Research	1
	SPAC 500	Graduate Seminar	20
C. R. O'Dell	SPAC 552	Introductory to Astrophysics II	4
	SPAC 800	Graduate Research	1
	SPAC 201	Stars, Galaxies & the Universe	33
	SPAC 800	Graduate Research	1
P. H. Reiff	SPAC 202	Exploring the Solar System	30
	SPAC 500	Graduate Seminar	30
	SPAC 800	Graduate Research (2 sem)	5
	SPAC 403	Astronomy for Teachers	8
K. A. Smith	SPAC 800	Graduate Research	1
Ian Smith	SPAC 403	Astronomy for Teachers	8
	SPAC 201	Stars, Galaxies and the Universe	25
C. Sumners	SPAC 403	Astronomy for Teachers	8
F. R. Toffoletto	NSCI 111	Physics & Astronomy Today	8
	SPAC 800	Graduate Research	1
	SPAC 800	Graduate Research	1
R. A. Wolf	SPAC 532	Classical Electrodynamics	7
	SPAC 800	Graduate Research (2 sem)	2

Colleges

A substantial majority of the department's faculty is affiliated with a residential college:

Professor Few and his wife Joan have just completed a term as masters of Baker College
Professor Chan is a faculty associate of Richardson College
Professor Freeman is an honorary master of Lovett College
Professor Hartigan is a faculty associate of Will Rice College
Professor Liang is a faculty associate of Hanszen College
Professor O'Dell is a faculty associate of Baker College
Professor Reiff is a faculty associate of Brown College
Dr. Spiro is a university associate of Brown College
Professor Emeritus Stebbings is an honorary master of Jones College

Continuing Studies

In the fall of 1999 Reiff gave a lecture on the Space Program in the Continuing Studies course "Ten Events that Shaped the Century". The response to that course was so high that a second section was offered in fall of 1999. When the second section sold out as well, continuing studies decided to offer the course again in Spring 2000.

Colloquia

An important part of our educational program is a weekly series of departmental colloquia, mostly given by notable scientists visiting Rice. This past year, the department spent over $7,000 of its annual supply/expense budget on costs associated with the program, whose speakers are listed below. More than once, faculty from this department generously agreed to share costs with their invited research collaborators. In addition, we have a major "Marlar Lecture" (funded by the Marlar Foundation) each year. In Fall '99 our Marlar lecturer was Prof. Frank Shu, speaking on "The Origin of Sunlike Stars and Planetary Systems".

SPRING '99 COLLOQUIUM SPEAKERS

Dr. Mike Seeds, Franklin & Marshall College
Dr. J. L. Burch, Southwest Research Institute
Dr. Ian Smith, SPAC Dept., Rice University
Dr. Wendell Horton, Institute for Fusion Studies, University of Texas at Austin
Dr. Steve Howe, Los Alamos National Laboratory
Dr. Hikaru Kitamura, University of Tokyo & SPAC Dept., Rice University
Dr. Bill Feldman, Los Alamos National Laboratory
Dr. Albert van Helden, History Dept., Rice University
Dr. Mary Hudson, Dartmouth College
Dr. Jimmy Raeder, UCLA
Dr. Frank Bash, University of Texas
Dr. Margaret Hanson, University of Cincinnatti
Dr. Jim Gelb, U.T. Arlington
Dr. Mike Jura, UCLA

FALL '99 COLLOQUIUM SPEAKERS

Dr. Patricia H. Reiff, Chair, Dept. of Space Physics & Astronomy, Rice University
Dr. Kouichi Hirotani, National Astronomical Observatory, JAPAN
Dr. Carl Agee, NASA/JSC
Dr. John Raymond, Harvard-Smithsonian CfA
Dr. T. L. Wilson, Director, Submillimeter Telescope Observatory Steward Observatory
Dr. Henry A. Kobulnicky, Dept. of Astronomy, University of Wisconsin
Dr. Henry Goldwire, Lawrence Livermore National Lab

Dr. Robert E. Johnson, University of Virginia
Dr. Charles Goodrich, University of Maryland
Dr. Moshe Elitzur, University of Kentucky
Dr. James Oberg, Author, Former NASA Contractor
Dr. Albert Van Helden, History Dept., Rice University
Dr. Frank Shu, University of California, Berkeley
Dr. William Latter, Jet Propulsion Lab
Dr. Alex Gurshtein, Russian Academy of Science
Dr. Vytenis Vasyliunas, Max-Planck Institute for Aeronomie

Initiatives in teaching excellence

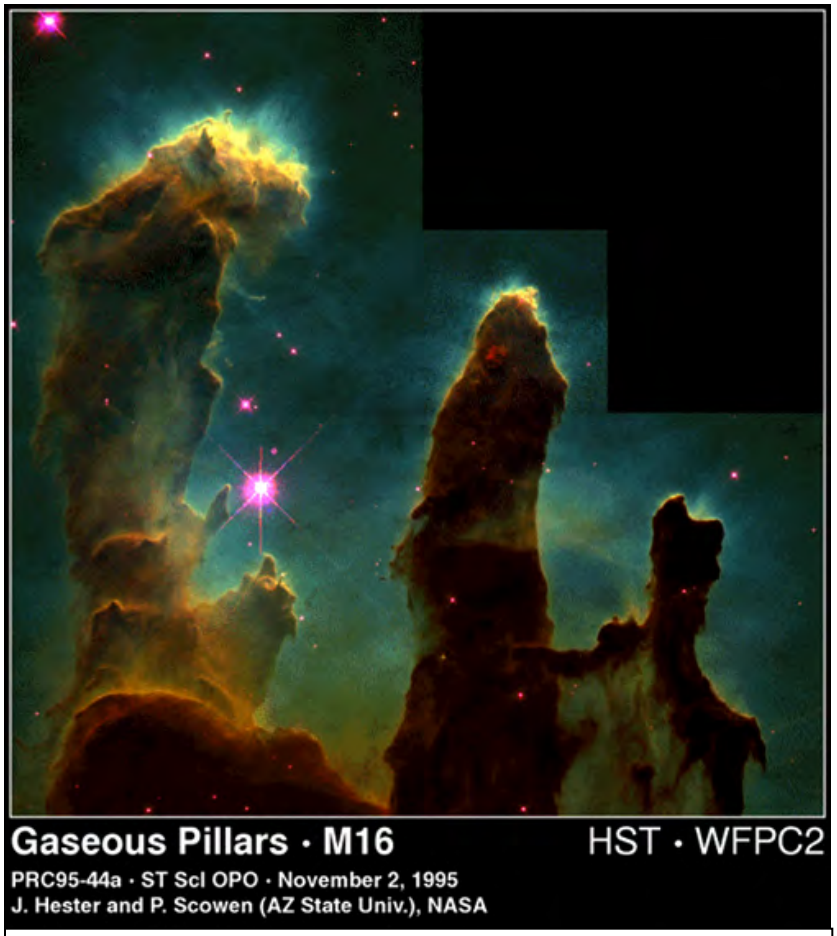
The establishment of an on-campus telescope facility remains our very highest priority. Our present facilities are more commensurate with a high school, not a major research university. We are very pleased to be working with Facilities and Engineering to make this happen. One present possibility includes having a facility in the new restroom facility in the playing fields. An on-campus observatory will make the skies much more accessible to the entire Rice community: students, faculty, donors, and families. We want to allow disabled students to be able to see the skies and perform real research in an accessible manner, and provisions need to be made for accessibility. We reach nearly half the student body with our non-majors courses, and this would increase the number of the Rice community who are familiar with the skies nearly tenfold.

Dr. Few's students on a field trip to Colorado learn firsthand about environmental systems.

Initiatives in Instructors

We regularly use Adjunct faculty to teach courses in their specialties, and this has definitely enriched our course offerings. We expect our Adjunct faculty to help with a course at least every other year (without pay), or to serve on a graduate committee. We are also now using Research Faculty (Frank Toffoletto), postdocs (Trevor Garner) and Research Scientists (Ian Smith) as occasional instructors. This is a benefit to them in their professional growth and it also helps us offer more sections, and thus more personalization, of several of our more popular courses. Having a named instructorship, such as the Evans Instructors in Math, is the next logical step in this process, and we would be eager to have such a position available.

We also offer summer Continuing Studies courses that give selected graduate students significant experience in teaching (which they tell us they would like to have for their own marketability). Anthony Crider led the teaching of SPAC 402 in summer 1998, and did an excellent job. We prefer not to have graduate students teach our academic year courses, but they do routinely perform important grading, tutoring, and lab instruction. This semester (spring 2000), one student (Trevor Garner) who had been expected to finish his degree this fall is teaching a course (Spac 203) on the advice of Dr. Arthur Few, who is on sabbatical this year. So we will have our first experience of graduate student teaching of a regular course, albeit rather unexpected. He should defend his thesis later this month.



World-famous Eagle Nebula image from Hubble Space Telescope. Image credits spac alumni Jeff Hester (our outstanding alumnus of the 80's) and Paul Scowen of Arizona State University.

Research and Scholarship

Members of the Space Physics & Astronomy Department are proud of their many research accomplishments this year. More details of the research, and selected references, are given in our report to the Bulletin of the American Astronomical Society, available through our web pages (http://spacsun.rice.edu/baas.html).

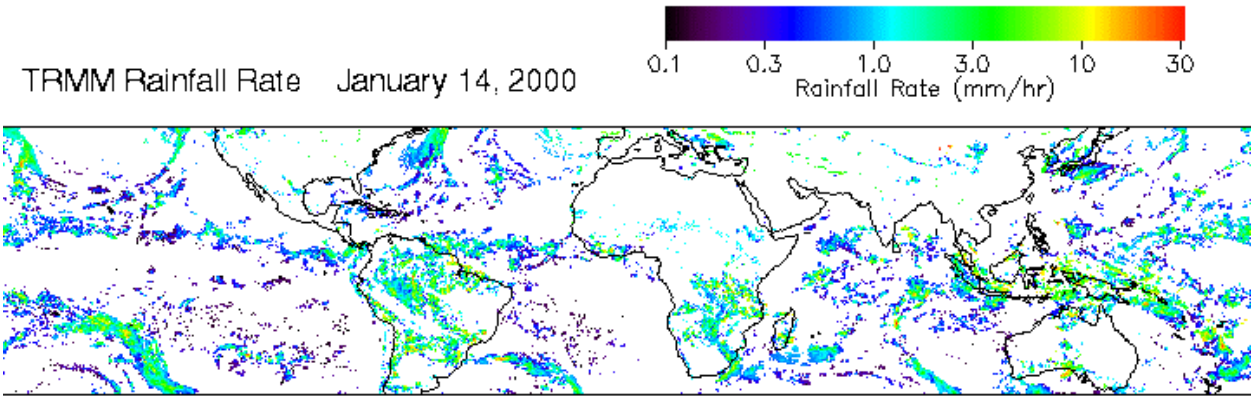
Key Areas of Research

The department has two major, and two minor, areas of research. The largest groups are the astronomy/astrophysics group, and the space physics group. A common thread of astrophysical plasmas bridges these two areas. We also have a small but effective effort in Atomic and Molecular Physics (begun by Ron Stebbings and now carried out by Faculty Fellow Bernard Lindsay), and a revitalized effort in atmospheric science led by Arthur Few.

Accomplishments: Atoms and Atmospheres

Atmospheric Physics

Professor A. Few's research interest is in atmospheric physics with a special emphasis on atmospheric electricity and Earth system science. Few is active at the national level in global change or Earth system science education. He is an author-participant in the Global Change Instruction Program (NSF and UCAR), and in the Earth System Science Education Program (NASA and USRA). These programs share the goal of developing undergraduate courses and teaching materials in the interdisciplinary areas of global change or Earth system science. His current project is to develop national field schools in Earth systems; for additional information visit his web site at http://www.page.ucar.edu/fieldsch/. Most of his Ph.D. graduates have positions at national laboratories such as Johnson Space Flight Center, Marshall Space Flight Center, National Center for Atmospheric Research, National Severe Storms Laboratory, and MIT Lincoln Laboratory. He and graduate student David Streutker are presently using NASA data sets for remote sensing applications, and are creating daily images of numerous earth data sets for the public, now available from our web site http://earth.rice.edu/mtpe/. (For example, the rainfall rate from the recently-launched Tropical Rain Measuring Mission is shown here).



Atomic Physics

Professor Emeritus R. F. Stebbings and Faculty Fellow Bernard Lindsay continued their program to study the interaction of ions, atoms, and electrons with atoms and molecules.

These interactions are essential to the understanding of a broad range of large-scale physical systems such as planetary atmospheres, astrophysical plasmas, gas discharge lasers, semiconductor processing plasmas, and fusion plasmas. This research group has developed new techniques to study collisions of energetic ions and neutrals at an exceptionally detailed level. Much of the current program is directed toward understanding the basic physics of the collision processes that occur in the upper atmosphere and development of accurate data that are needed for modeling the atmospheres of the Earth and other planets.

The IMAGE spacecraft getting readied for launch in February 2000 depends on neutral atom imaging to view particles trapped in Earth's magnetic field.

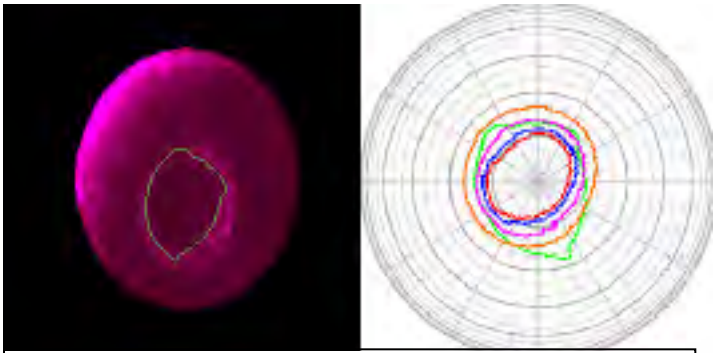
The focus of recent work has been charge transfer of protons and oxygen ions with atomic oxygen. These processes are aeronomically very important and are also particularly difficult to deal with experimentally. In collaboration with Dean Sieglaff (Grove City College), the differential charge transfer cross sections for state-selected oxygen ions with several simple molecules were determined. These measurements are the first of their kind to be performed anywhere and have provided some insight into the cause of the large discrepancies between the total cross section data of different workers. Research has also continued into processes that involve electron collisions. Many electron impact ionization cross sections, particularly those for dissociative processes, are not well known. Over the past several years a unique apparatus has been utilized to study the electron-impact ionization of numerous atomic and molecular species. Results of the work on water vapor were published during the past year, and Postdoctoral Fellow Riad Rejoub has recently joined the program. The group is currently completing measurements on NO_2 and CO. These experiments are critical to understanding the data from new space missions, such as IMAGE, which will launch in February 2000.

Accomplishments: Space Physics

Magnetospheric Physics

The Space Physics side of the department has been very active in research. Much of their research is related to the national "Space Weather" initiative, where different agencies share the effort to characterize and predict the effects of geospace on humans and hardware. The group as a whole recently won a major Sun-Earth Connections Theory competition. The effort at Rice is divided among several major groups.

Faculty Fellows Tom Hill and Frank Toffoletto continue to improve their open magnetosphere model. They are developing a model which includes the effects of field-aligned currents in a self-consistent way. Hill, Toffoletto and graduate student Andrew Urquhart are finishing a study to compare auroral images taken by the Polar spacecraft with the theoretical predictions of their open magnetosphere model (see figure). This project is supported by NASA as part of their Global Geospace Science Guest Investigator Program.



Observed aurora from Polar (left), compared to predictions from the Toffoletto-Hill model (right)

The Rice magnetospheric modeling effort has also led to other profitable collaborations. In collaboration with J. Raeder of UCLA, Toffoletto has begun to combine Raeder's Global MHD code with the Rice Convection Model (RCM). Preliminary results showing an RCM run that used the MHD code's magnetic, electric and plasma information can be found at http://koala.rice.edu/~toffo/raeder/raeder.html. It is expected that the coupling will involve running each code on its respective home machine using a message passing protocol over the Internet to exchange information.

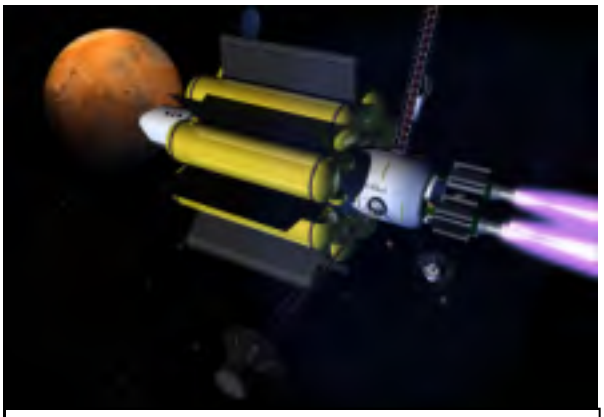
With Tom Hill, Anthony Chan, and Frank Toffoletto, and graduate student Steve Naehr, Professor Dick Wolf is starting a new project to compute the trajectories of energetic electrons in the outer magnetosphere. Observations indicate that energetic electrons can be stored for many hours in the outer magnetosphere during the main phase of a magnetic storm, then finally injected earthward and accelerated further. This typically causes a killer-electron event - a dramatic increase in the outer-belt MeV electrons that pose a hazard to operating spacecraft. It is not clear how energetic electrons can be stored in the outer magnetosphere for long periods without escaping. That is the question that the group will address theoretically, by tracing particle trajectories through realistic magnetospheric magnetic fields.

In collaboration with Dr. Brian Anderson of the Applied Physics Laboratory at Johns Hopkins University and Dr. Mary Hudson of Dartmouth College, and students, Professor Anthony Chan is studying transport and loss of ring-current and radiation belt particles by breaking of the first adiabatic invariant on the night-side of Earth's magnetosphere. The breaking of the first adiabatic invariant and subsequent particle transport has been demonstrated numerically for ions; Chan is especially interested in the effects of this process on energetic electrons.

Professor Patricia Reiff's research group is active in studies of the Earth's magnetosphere and space weather. Reiff is a Co-Investigator on the Polar spacecraft. She and graduate students Andrew Urquhart and Vance Henize are studying the detailed response of the magnetosphere to changes in the interplanetary field, particularly when the IMF is nearly parallel to the Earth's field near the boundary. Reiff is also a Co-Investigator for the IMAGE mission that will be launched February 15, 2000 and the ESA/Cluster2 spacecraft scheduled for launch summer 2000. IMAGE will use new techniques such as neutral atom imaging and radio sounding for remote sensing of the entire magnetosphere. Cluster will be the first-ever four spacecraft mission to uniquely separate spatial from temporal changes of the magnetosphere.

Fusion Plasma Rocketry

Anthony Chan and graduate student Tim Glover are working in collaboration with NASA astronaut Dr. Franklin Chang-Diaz and his team at the Advanced Space Propulsion Laboratory (ASPL) of the Johnson Space Center. The primary objective of the ASPL is to develop plasma rocket technology for NASA interplanetary missions. A research version of a plasma rocket, which uses magnetically-confined high-temperature plasma, is currently being developed at the ASPL. By means of such fast rockets (right), a manned Mars mission may be eventually accomplished with reduced risk to astronauts from solar and galactic radiation.

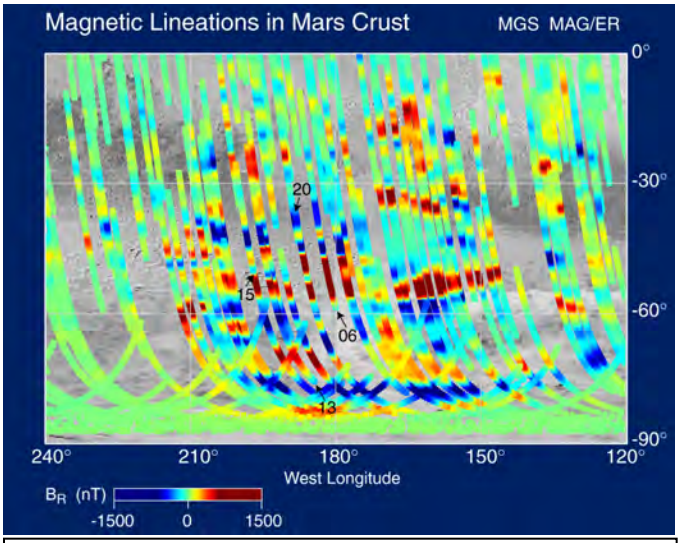


Plasma rockets may allow fast trips to Mars, protecting astronauts from radiation.

Solar System Plasmas

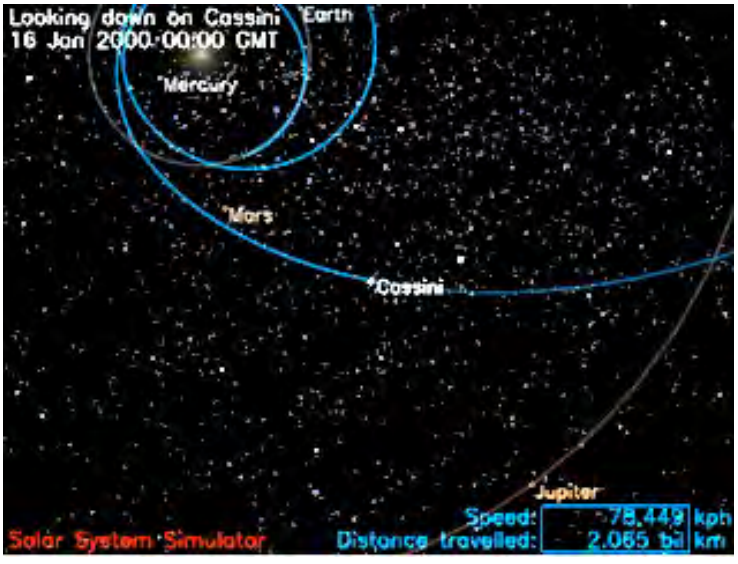
Professor Paul Cloutier and his students continue their analysis of 14 years of Pioneer Venus Orbiter data. Accomplishments to date include extensive study of the dayside

ionosphere of Venus covering a variety of topics such as: (1) wave-particle interactions at the ionopause, including missing pressure in the Venus ionosphere, and a model of superthermal ion behavior; (2) structure and dynamics of the Venus ionopause and ionosphere, including Venus ionopause formation, and magnetic signatures and structure in the dayside Venus ionosphere; and (3) flows and fields in the Venus ionosphere, including refinement of the flow/field models of the ionosphere with comparative applications for other solar system bodies. In addition, progress continues to be made in understanding the dynamics of the nightside ionosphere of Venus, such as the structure, instabilities, and electric field noise in Venus' ion troughs.



Martian crustal magnetism from the Mars Global Surveyor Mission

A great opportunity for comparative studies of Mars and Venus has been provided by the data obtained by the Mars Global Surveyor spacecraft during the past two years. Results based on data from the Magnetometer/Electron Reflectometer Experiment, for which Professor Cloutier serves as a Co-Investigator, has provided evidence that Mars possessed a strong intrinsic dynamo magnetic field during the first few hundred million years after crustal formation, and linear magnetic remnants observed in the ancient crust may be evidence of magnetic field reversals in conjunction with plate tectonic activity on Mars. However, evidence indicates that the Martian magnetic dynamo became inactive approximately 3.5 billion years ago, and that Mars at present interacts with the solar wind in a manner similar to Venus. A recent paper by Cloutier's group showed a number of phenomena associated with the solar wind interaction with the Martian ionosphere and neutral atmosphere which were nearly identical with Venus observations. An additional important result was the discovery that electron impact ionization of atmospheric neutral hydrogen and oxygen by solar wind electrons can produce large water loss from Mars and Venus, which implied that a persistent planetary dynamo magnetic field may be necessary for a planet to retain significant quantities of water over geologic time. A paper on this subject by the Cloutier group [Crider et al.] in the Jan. 1, 2000 issue of Geophysical Research Letters was highlighted by EoS in its "In GRL this week" section and by Science (Jan. 21, 2000) in its "Editor's Choices" section. Currently Cloutier and graduate students Yue Chen and Gwyn Smith are analyzing data to model the magnetic field "pile-up" at Mars and Venus and the connection between surface crustal fields and the ionospheric magnetic field configuration.



Distinguished Faculty Fellow Hill is a Co-Investigator in the Cassini mission, now on its way to rendezvous with the ringed planet Saturn. Cassini just successfully accomplished an Earth flyby to gain momentum. In the process it demonstrated just how fast a planetary

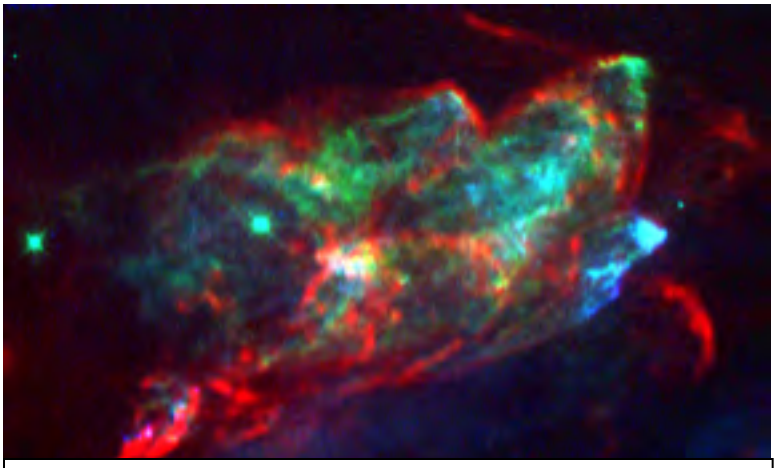
flyby is (the entire transit through the Earth's magnetosphere only took 3 hours). Working with the CAPS plasma instrument (the PI is Rice alumnus and Adjunct Faculty David Young), this research builds on our successful theoretical study of Jupiter's Magnetosphere.

Hill and Toffoletto's open magnetosphere model is also used by graduate student Menelaos Sarontos to predict the magnetosphere of Mercury and explain the time variability of its tenuous sodium exosphere.

Accomplishments: Astronomy and Astrophysics

Star formation and stellar jets

Assistant Professor Patrick Hartigan is PI on an HST project with S. Kenyon (CfA) to examine spectra of close binary T Tauri stars to determine how material accretes onto very young binary systems when they are still surrounded by their nascent disks of gas and dust. The new data will test predictions of theoretical models that indicate higher mass accretion rates for the less massive component. A new code developed for extracting spectra from long slit data where the spatial profiles of two stars overlap has proven to be very useful in obtaining spectra for the closest pairs. The interim results from this work will be presented at a conference in Germany this spring. Graduate student Dimitris Stamatellos continued to work toward his Master's thesis, which involves modifying an SPH code to account for the spectrum of a binary system surrounded by an accretion disk.

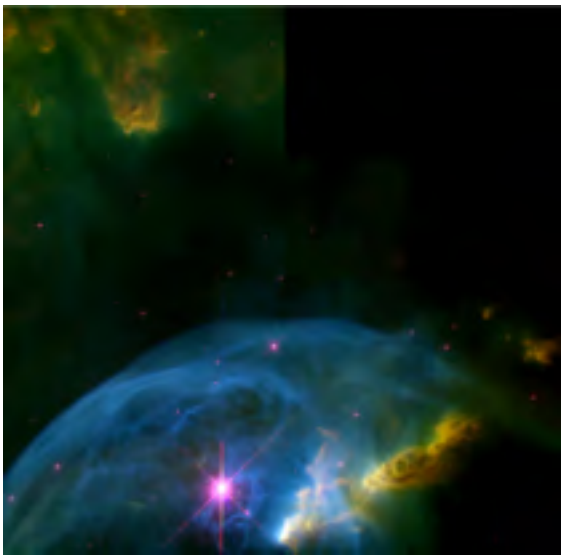


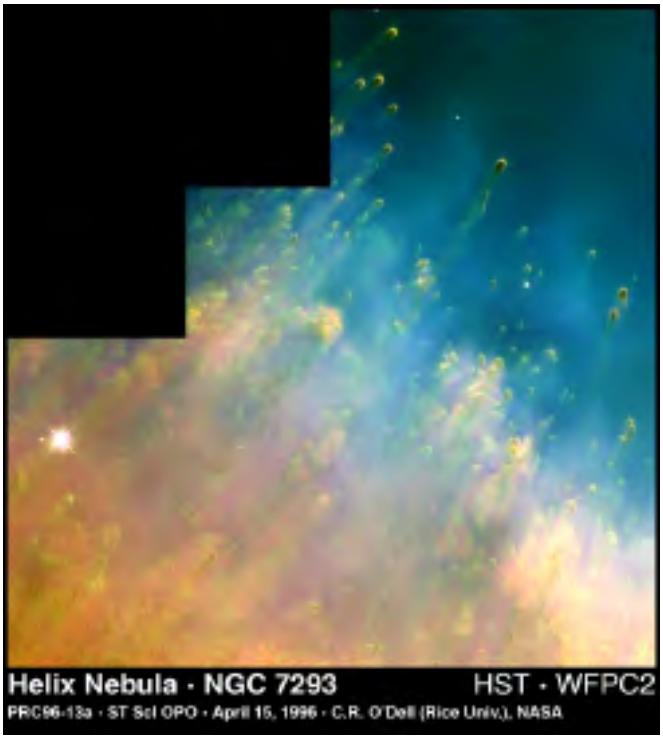
Cepheus A bubble in Molecular Hydrogen and atomic lines

Hartigan is PI on a project that includes J. Bally and J. Morse at Colorado to study the massive star formation region Cepheus A with narrow band emission line HST images. Cepheus A is probably the best example of a simple, extended bubble driven by a high velocity flow. The HST images are of excellent quality, and show a complex, frothy region of shocked gas within the bubble. Lying exterior to the bubble is a region of shocked molecular hydrogen gas. This spatial separation of molecular and optical emission is best explained by a magnetic precursor to the shocks. The imaging data are supplemented by spectroscopic maps of molecular hydrogen made with NASA's Infrared Telescope Facility (IRTF) on Mauna Kea in late December 1998. A paper presented at the AAS meeting in Atlanta in January 2000 summarized these results.

Hartigan is a Co-I on a team led by B. Reipurth (Colorado) to examine proper motions of HH objects with HST. The observations show obvious movement of emission line knots relative to images taken a few years ago, as well as marked variability in the brightness of some objects. The observed motions within jets will be compared with predictions from numerical simulations, and will help to quantify how energy and momentum is transferred in these collimated supersonic flows. Hartigan and Morse have constructed a new code to measure proper motions within complex emission line environments, and we are applying this code successfully to the current set of data. Hartigan and collaborators completed a paper on this subject for the Protostars and Planets IV meeting that will be included as a review chapter in the book scheduled for publication in 2000. Hartigan and O'Dell await the acquisition of second epoch images of the HH objects within the Orion Nebula in order to measure the proper motions of these objects.

Professor Reggie Dufour and graduate student Brent Buckalew have been analyzing the first HST STIS spectra of an HII region, NGC 7635 - the "Bubble Nebula" - as part of a collaboration (including P. M. Hartigan) led by Dr. D. K. Walter of South Carolina State University (Ph.D., Rice 1993). At present, the analysis indicates very little change in the physical conditions and abundances of C and N in the wind-driven bubble produced by an Of6.5III star compared to the surrounding HII region. These results were presented at the AAS meeting in Atlanta. Hartigan and O'Dell have received telescope time with the 4-m at Kitt Peak to map the entire Orion Nebula spectroscopically at echelle resolution. This work began in January 2000.





Professor Robert O'Dell has continued to investigate the circumstellar disks around the young low mass stars in the Orion Nebula cluster. The physical characteristics of individual proplyds in that region have been characterized (1998, AJ, 115, 263-273). Together with Will Henney (Morelia, UNAM) he has analyzed his Keck HIRES spectra of four characteristic proplyds in terms of their mass loss rates, which were found to be about one millionth of a solar mass per year (1999, AJ, 118, 2350-2368). Since the masses of the proplyd disks are believed to be about 1% that of the sun, then the photo-evaporation times are believed to be only about 10,000 years, presenting a fundamental conundrum in understanding their continued existence. Outflow from the proplyds are manifested by jets and general winds, the former being directly visible in about 20% of all the proplyds, and the latter are made manifest by the shocks they form in the surrounding nebular gas. WFPC2 images are available over a sufficiently long timebase that proper motions of these features can now be determined. This work is summarized in an article with John Bally (Colorado) and Mark McCaughrean.

O'Dell has also determined from CTIO images and spectra that the nearest bright Planetary Nebula, the Helix Nebula, is actually a disk. The central region is actually filled with nebular gas, rather than being a central cavity, as has always been considered to be the case. This result raises questions about the applicability of the standard models invoked for determining the structure of these nebulae. He has also continued with Andi Burkert (MPIA-Heidelberg) to analyze the properties of the Cometary Knots found in abundance in this nebula.

HII Regions

Professor Reginald J. Dufour continued several collaborative studies of abundances and physical conditions in Galactic and extragalactic HII regions utilizing UV-optical-NIR spectroscopy from ground-based and space-borne telescopes. Currently he is among a group (including O'Dell), headed by R. H. Rubin at NASA-Ames, who are studying HST UV-optical STIS spectra of the Orion Nebula obtained in 1999 and continuing into 2000. The results of a prior HST FOS and WFPC1 study of the unusual dusty H II region, N88A in the Small Magellanic Cloud, with former graduate student C. M. Kurt and collaborators (Kurt et al. 1999) appeared in the ApJ. Dufour and Kurt are now analyzing recently obtained HST WFPC2 imagery of this nebula, unique among the dust-poor H II regions of the SMC, with the first results presented as a poster at the 1999 May Chicago AAS meeting.

In addition to HII regions, Dufour has pursued related research on planetary nebulae with HST and ground-based telescopes. In collaboration with Drs. R. Rubin at NASA-Ames and P. Harrington at U. Maryland, he and undergraduate student, Matt Browning, analyzed HST WFPC2 imagery of the planetary nebula NGC 6818 to produce high spatial resolution maps of extinction by local dust and temperature variations in NGC 6818. Recently, the group have produced detailed color-coded images of NGC 6818 and NGC 6210 which now appear in the "Gallery of Planetary Nebulae" web site at STScI. More detailed photoionization-model based analyses of these results are currently being prepared for publication. These studies are being extended in 1999-2000 to the planetary nebula NGC 7009 with HST WFPC2 imagery and STIS spectroscopy time awarded to Rubin, Dufour, and an international group of collaborators for the most extensive study of a planetary nebula to date with HST.

Dufour is collaborating with several groups in the study of the stellar populations and abundances of star-forming galaxies using a combination of HST and ground-based imagery and spectroscopy techniques. He and E. Skillman at the University of Minnesota continue work on I Zw 18 using HST WFPC2 observations obtained in 1998-1999. Additionally, he is continuing collaborations with C. Esteban and D. I. Mendez of IAC in Spain studying the star formation properties of Wolf-Rayet Galaxies and potential affects that the winds from these objects have on the dynamics and abundances of the nearby interstellar medium. Recently, graduate student Brent Buckalew joined this effort and received a three-year NASA GSRP fellowship for multiwavelength observations of Wolf-Rayet Galaxies.

O'Dell has a new, accurate three-dimensional model for the main ionization front of the Orion Nebula. A 3-D model is now on display at the Baltimore Science Center. The ionization structure of the very close, large Helix Nebula has been determined by O'Dell (1998) from a program of spectroscopy and quantitative imaging from CTIO.

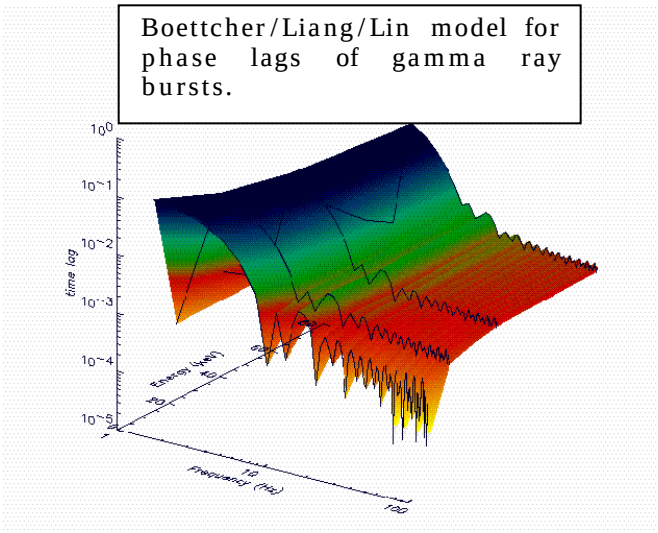
Neutron stars

Professor F. Curtis Michel continues to maintain his program of theoretical research on the properties of neutron stars and their evolution. The major direction here is to simulate the particle motions about a rotating neutron star with an inclined magnetic field. An extension of earlier work with Jurgen Krauss-Polstorff has been undertaken with research scientist Ian Smith. We have been able to simulate shut-down pulsars (aligned, with only emission of particles from surface), pair-production configurations (aligned, with pair production if E-fields sufficiently large), and have shown that the entirely filled magnetospheres originally proposed collapse to the inactive dome/torus configuration. We have also shown that, starting with the totally charged filled

The Crab Nebula (from Chandra)

magnetosphere originally postulated, when the space charge is truncated at some distance the configuration again collapses to the dome/torus one (originally it was postulated that the magnetosphere "had" to be filled.)

High Energy Astrophysics



Boettcher/Liang/Lin model for phase lags of gamma ray bursts.

This year has been an exciting one for the study of the enigmatic gamma-ray burst sources because fading counterparts at wavelengths other than gamma rays have been found for the first time in the 30 years of study of these objects. Continuing in our line of high-energy astrophysics research going back to the pioneering measurements of R. C. Haymes and students, Liang and graduate student Tony Crider completed the analysis of a large database of BATSE gamma-ray burst spectra. We are thrilled that postdoc Markus Boettcher received the prestigious 1999 Chandra Fellowship. Liang, with research scientist Ian Smith, Markus Boettcher and graduate students Anthony Crider and Dechun Lin, continue to make progress in the spectral modeling of gamma-ray bursts (GRBs). Using the unique broadband (optical-gamma-rays) data of GRB990123 they were able to demonstrate that multiple inverse Compton scattering in a Thomson thick hybrid thermal-nonthermal plasma can explain most of the observed data and the transition time to the afterglow. Liang has also explored new analytic forms to fit the generic time profiles of GRB pulses. Crider has systematically analyzed the data of GRB970111 with different absorption and attenuation models for the soft x-ray turnover observed by Beppo/SAX and was able to rule out most of these models.

Liang and graduate student Kathy Keilty continued their modeling of radiative blast waves generated by intense lasers in the laboratory to simulate blast waves in supernova remnants and GRB afterglows. Using HYADES simulations they were able to reproduce the results of the FALCON laser experiments at LLNL, showing that the shock propagates slower than in the adiabatic (Sedov-Taylor) case. Liang and Keilty discovered a new analytic solution to the radiative blast wave evolution which agrees with numerical results to better than 1%. This analytic solution allows them to make direct estimates of the radiative cooling rates from experimental data. Application of this new analytic solution to various astrophysical arenas is being pursued.

Research Scientist Ian Smith has been leading international teams of observers in the search for sub-millimeter-wave emission from fading gamma-ray bursts using the SCUBA instrument on the James Clerk Maxwell Telescope in Mauna Kea, Hawaii and millimeter-wave emission from the Berkeley-Illinois-Maryland Array in Hat Creek, CA. The discovery of a fading sub-millimeter counterpart to GRB 980329 was particularly interesting. There is an indication that there is a quiescent sub-millimeter source at this location, which would imply that this very bright burst occurred in a very high redshift galaxy.

More Highlights

Geospace Environment Modeling (GEM)

Each summer the National Science Foundation hosts a week-long conference on modeling the magnetospheric environment. A number of our faculty and students participate each year in this important workshop, which is held in Snowmass, Colorado. John Freeman successfully completed his second year as head organizer of this conference, assisted by Ms. Cantú. An NSF grant funded travel for students and other expenses of the meeting. Dick Wolf will continue to be the head of the GEM Steering Committee. Tom Hill and Frank Toffoletto are leading the effort to develop a community global circulation model, which is a key goal of the program, and Anthony Chan is a working group chairman for the GGCM modeling. Dr. Frank Toffoletto has been selected to carry on the GEM conference leadership beginning 2001, also with the assistance of Ms. Cantú.

Outreach Activities

Most of our faculty are involved in outreach activities, at the K-12 level, writing for the national press, advisors for radio and TV programs, etc. Virtually all of the faculty give at least two or three public lectures per year. The most visible part of our outreach activity is the "Public Connection", which brings real-time Earth and space data and imagery to venues at the Houston Museum of Natural Science and other museums around the country.

This group is performing outreach activities for the Office of Space Science at NASA, the Office of Earth Science (under the project "Museums Teaching Planet Earth", and the IMAGE mission (under their "Poetry" program). We have also been approached to perform outreach activities for other NASA and ESA missions.

The most exciting recent development is the grand opening of the world's first immersive planetarium, with digital video giving a full view of the sky in full color. The planetarium was recently renovated, with $250,000 seed money from the NASA grant and nearly a million matching money from the Museum. The first shows opened December 1998 to rave reviews.

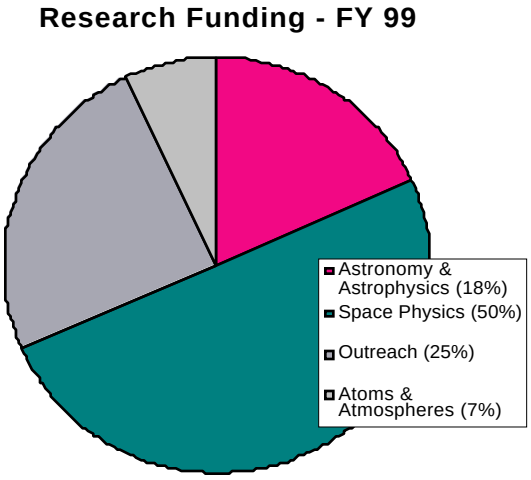
The latest show in the series "Powers of Time" highlights the cycles of Earth. It opened January 2000, heralded with a new higher-resolution projection system.

Our CD "Space Update" has sold over 3000 copies, and has reached over a million people in displays at various museums and schools around the country. Its companion CD "Earth Update" will be released in January 2000.

Resources

Our level of research funding continues strong. As detailed below, most of our funding comes from NSF and NASA. (The items listed as Southwest Research Institute and the Space Telescope Science Institute are also subcontracts of NASA mission-related work). The federal budgets for these agencies have recently stabilized, so we hope that this level continues into the future. (Note that the numbers listed are annual amounts, not grant totals.

With the merger with the Physics Department, SPAC per se will not be seeking external funds, but faculty members (as members of the new joint department) will do so. The Rice Space Institute will also seek funds for its outreach and communications programs.



YEAR	CAL 1998	**CAL 1999**
RESEARCH $	$2.84M	**$2.38M**
# PROPOSALS	37	**51**

The Space Physics & Astronomy Department has very modest restricted funds. Next year's activities involving these funds are expected to parallel in kind and in dollar amounts those listed below for 1999:

Restricted Funds

[1] The **Marlar Fund** is the primary account for enriching our research environment. This past January, we were delighted to receive a **$15,000** contribution, the same as last year. In CY 1999 we spent $15,209.04 (including some carryover from the previous year), which: (1) covered honorarium and expenses for our annual distinguished Marlar lecturer, Dr. Frank Shu; (2) provided $1,000 for an award to one advanced graduate student Tony Crider; (3) enabled us to purchase numerous important reference materials

for our A. J. Dessler Reading Room; and (4) we continued to fund computer and audio-visual equipment for classroom use.

[2] The **Conly Fund** provided **$7,594** in FY '99 with matching funds from Exxon for expenses in A. Few's research program in atmospheric electricity.

[3] The **Gordon Fund** provided one **$1,000** prize for research excellence to SPAC graduate student, Dechun Lin.

[4] The **Dessler Fund** grew to **$10,000**. We are happy to report that we have now reached the amount necessary to be fully endowed for the annual award given to the SPAC option major with the highest grade point average. A balance of $500 exists in the interest fund for awards this year.

External Support

By calendar year 12/31/98 - 12/31/99)

AGENCY	NEW FUNDING	EXPENDITURES	
AFOSR	$ 15,000	$ 71,748	Air Force Ofc Spon. Res.
CIT-JPL	23,750	46,144	Jet Propulsion Lab
LLNL	80,000	80,013	Lawrence Livermore National Lab
JHU/APL	20,000	9,999	Johns Hopkins Applied Physics Lab
MRC	10,000	44,169	Mission Research Corp.
NASA	1,252,598	1375,817	NASA
NSF	598,082	464,450	NSF
PVA&M	0	7,047	Prairie View A&M
RAY	40,000	0	Raytheon
Smithsonian	63,403	30,420	
SRI	26,556	13,819	
STScI	209,291	113,171	Space Telescope Science Institute (STSCI)
SWRI	41,258	52,716	Southwest Research Institute (SWRI)
USRA	52,198	31,080	Univ. Space Res. Assoc.
WELCH	51,521	41,537	Welch Foundation
Total	**2,502,171**	**2,388,526**	

Service Activities, 1999

SPAC FACULTY ON UNIVERSITY STANDING COMMITTEES

Committee	Faculty Member
ROTC Committee	**P. A. Cloutier**
Committee on the Undergraduate Curriculum	**R. J. Dufour**
Committee of College Masters	**A. A. Few**
New Colleges Committee	**A. A. Few**
Admissions Committee	**P. M. Hartigan**
Scholarships and Awards	**C. R. O'Dell**
Research Council	**P. H. Reiff**
Outreach Council	**P. H. Reiff**
Committee on Parking	**R. A. Wolf**

Of course, participation in University standing committees is not the only way that our faculty serves the University. Each individual faculty report to the President lists University and Departmental service, and our faculty are very major participants in service. Many ad-hoc task forces and working groups have strong SPAC participation.

Additional Resources Desired

As detailed in our previous five-year plan, significant additional resources must be identified before major advances can be made. We are very pleased that both the on-campus observatory and a major contribution to a research telescope facility have been put into the funding menu.

We estimate that $150,000 for an on-campus observatory (plus building modifications to ensure access and stability) will be necessary. We would like to name the observatory after Rice's first President, the Astronomer Lovett. Recently, an opportunity has arisen to site the observatory at a field house restroom facility in the playing fields. This would be a favorable location, and recognizes that many of its users are student athletes and musicians!

We have requested donations from our alumni for a telescope, and they are eagerly responding. At present over $6,250 in donations has been raised from our alumni. We expect that that number will continue to grow as the plans for the new observatory take shape. Our teaching facilities are more the kind appropriate to a high school, not to a major research university!

For the research telescope, any amount that can be raised (up to $8 M) translates directly into time allocations. We would like to reserve some fraction of the raised funds to be a travel endowment so that faculty and students can travel to the facility (which is planned for Baja California or South Africa). Realistically, it will take at least about $1.5 M to make a significant impact on the design of the facility (and to allow naming opportunities for donors.)

Graduate student Mark Mulrooney in the Liquid Mirror Telescope he has helped design, test, and build (photo courtesy Chip Simons).

Additional Staff

We do not anticipate needing additional staff for day to day operations; however, when the on-campus observatory becomes a reality, we would like to be able to hire students to "man the scopes". This should be very easy to do, since by then we should have both B.A. and M.A. majors in the pipeline, who will be excited about using the facility (and getting paid a very modest amount to run it). For most students, being trained means that they get a certain amount of use; for each hour of service, they receive a certain amount of "free" observing time. This keeps costs low and interest high.

Diversity Issues

Another exciting aspect of the new B.A. and M.A. programs is that they appeal to a more diverse student population. By training teachers and writers as well as future research astronomers, we will reach a more ethnically and culturally diverse population. Some will no doubt be encouraged to change to (or stay in) S&E majors that would not have chosen a less hands-on and exciting field. We will have our imagery accessible in real time over the web, which will also bring the excitement of science to students not in this state, students whom we hope will become part of our graduate population.

Summary

In summary, the dynamic SPAC department has been a leader in cutting-edge research for the past 35 years. It was the first academic department in the nation to specialize in space science. Just as we were set to implement our new academic programs, the merger with Physics was announced, creating a new "Physics and Astronomy Department" . We sincerely expect that the new degree programs and new research efforts will be continued at high visibility within the new department.

The Rice Space Institute will be the interdisciplinary research arm of the old department, and we trust that it will be the focus for the tremendous heritage of space research at Rice.

The Rice Space Institute will launch this year, along with the IMAGE spacecraft. (Shown above is a Delta launch vehicle, similar to the one which will launch IMAGE in February).

Appendix A: "Future Directions" document

Appendix B: Chair's Report to the Visiting Committee

Appendix C: Report from the Visiting Committee

Appendix D: Advertisements for High Energy/Astrophysics Faculty and Computational Space Plasma Physics Faculty (from our web page)