

Williams College
Hopkins Observatory
Williamstown, Massachusetts 01267

This report covers the period 1 July 1994 - 30 June 1996

The Astronomy faculty included Karen B. Kwitter, Professor of Astronomy and Chair, Astronomy Department; Jay M. Pasachoff, Field Memorial Professor of Astronomy and Director of the Hopkins Observatory (on leave in residence 1994-5); James R. Voelkel '84, Visiting Assistant Professor of Astronomy and History of Science (1994-5); and Deborah L. Maraziti, Instructor in Astronomy and Observatory Supervisor.

1. RESEARCH

Pasachoff continued his studies of the solar corona at eclipses. In collaboration with Bryce Babcock, Staff Physicist, and Kevin Reardon '92, he carried out observations of the corona at the total solar eclipse of 3 November 1994 from a site in Putre, Chile, at an altitude of 3500 m. Reardon was then at the Institute for Astronomy of the University of Hawaii and is now at the Capodimonte Observatory in Naples, Italy, working with the Themis Solar Telescope located in the Canary Islands. Students participating in the expedition were Robert Galloway '96, Bonnie Schulkin '96, and Princeton student Eric Kutner '95. Also participating were Woody Printz of Richmond, Massachusetts; Lee Hawkins of Wellesley College, Keck Consortium technician; Jonathan Kern of New Orleans; and Robert Eather of Boston. As Chair of the Working Group on Solar Eclipses of the International Astronomical Union, Pasachoff had selected and arranged the site.

The main experiment was to study the heating of the solar corona through a search for oscillations of small coronal loops in the 0.5 to 2 Hz range. The observations were made on-band in a narrow spectral band including the coronal green line at 530.3 nm and off-band in nearby continuum. Instrumentation included two Princeton Instruments CCD detectors and Macintosh Quadra controllers. A second experiment used the Photometrics CCD supplied as part of the Keck Consortium to look through special filters chosen to be either at wavelengths especially sensitive to coronal temperature or at nearby non-sensitive nodes. Auxiliary experiments included Kern's radial-filter imaging, now being scanned at the Royal Observatory Edinburgh; Eather's IMAX movie; auxiliary photographs and videos. Skies during the eclipse were not photometric, so were not adequate for the coronal-temperature-mapping experiment. Summer students Sebastian Diaz '98 and Keck exchange student Rana Nichols-Kiley (Vassar '98) participated in the data reduction. Pasachoff delivered a joint paper by Pasachoff, Babcock, and Reardon entitled 'Coronal Heating Studies at the 1994 Total Solar Eclipse' at an eclipse symposium of the Bolivian Academy of Sciences at Lake Titicaca in May 1995. He also was Scientific Advisor to the conference, in his role as Chair of the Working Group on Solar Eclipses of the International Astronomical Union. He further delivered a summary paper

'Observations at the International Astronomical Union Site at Putre, Chile.' The work at the 1994 eclipse has been sponsored by grants from the National Science Foundation and the National Geographic Society. Preliminary results were reported at the San Antonio meeting of the American Astronomical Society in January 1996.

Pasachoff conducted an expedition to India for the total solar eclipse of 24 October 1995, in collaboration with Babcock and Reardon '92. They were able to repeat their 1994 experiments under more favorable observing conditions, though with a shorter totality. The expedition included students Sebastian Diaz '98; Keck-Foundation exchange students Rana Nichols-Kiley, Vassar '98; and David Berger, Colgate '98; and Eric Kutner, Princeton '95; Lee Hawkins, Instructor at Wellesley College and Keck Technician; Jonathan Kern; and Robert Eather. The coronal-oscillation experiment was modified with a special optical train used with a 35-cm telescope and beamsplitter to capture side-by-side images of the corona on individual frames of a single Princeton Instruments CCD at a 5-Hz rate. One image was taken on-band at 530.3 nm and the other of the nearby continuum. They also repeated their ultraviolet coronal-temperature mapping experiment. The expedition was carried out in Mukundgarh Fort, Rajasthan, India in favorable weather. The data were studied during the summer of 1996.

Pasachoff was on leave during 1994-5 on a study of 'Comets and Meteors in 18th and 19th Century British Art and Science,' jointly with art-historian R.J.M. Olson of Wheaton College on collaborative grants from the Getty Grant Program. During 1995-96, they completed the manuscript for their book, *Fire in the Sky: A History of Comets and Meteors in British Art and Science*. Their work took them to archives at the Royal Observatory in Edinburgh, the Royal Society in London, the Royal Astronomical Society, the Old Greenwich Observatory and the National Maritime Museum in London, and to museums, print rooms, and other archives at the British Museum, the Tate Gallery, the Fitzwilliam Museum, and elsewhere. Pasachoff and Olson are describing the tremendous interest among scientists and the public following the work of Halley and Newton on the comets of 1680 and 1682 and the discovery of Uranus by Herschel in 1781. Their study continues through the 1910 apparition of Halley's comet and up to the future Rosetta mission.

Pasachoff continued to work with D. Lubowich of the American Institute of Physics and Hofstra University on studies of interstellar and stellar deuterium and its relation to cosmology. The abundance of the light elements has proved to be an equal supporting column of current cosmology, along with the expansion of the Universe observed as redshifts and the existence and distribution of the cosmic background radiation. Pasachoff, Robert Galloway '96, Robert L. Kurucz of the Harvard-Smithsonian Center for Astrophysics, and Vern Smith of the University of Texas delivered a paper

entitled 'Upper Limit for the Deuterium Abundance in the Halo Star HD 140283' at the American Astronomical Society meeting in Tucson, Arizona, in January 1995, discussing their observations at the Kitt Peak National Observatory of the spectrum of a star in the halo of our galaxy. They discussed limits of the deuterium-alpha spectral line in the star, and how they indicate that the reported possible discovery of extremely redshifted deuterium in a distant quasar probably resulted from confusion with spectral lines of ordinary hydrogen.

Kwitter's main projects continue to include haloes and chemical abundances of planetary nebulae, interactions of old planetary nebulae with the interstellar medium, and a search for lithium in the neutral envelopes of planetary nebulae.

Kwitter's studies of old planetary nebulae are in collaboration with Richard Tweedy (Steward Observatory, University of Arizona), making use of the large-format (2048×2048 pixel) CCD detector at the Burrell Schmidt telescope on Kitt Peak, Arizona. Tweedy and Kwitter results include discovery possible of planetary nebulae around two hot white dwarf stars. In November 1994, Deborah Maraziti observed with Tweedy. In May 1995, Kwitter and Tweedy were joined on an observing run by Christina Reynolds '97. Kwitter's studies with Tweedy culminated in the paper entitled 'An Atlas of Planetary Nebulae and Their Interaction with the Interstellar Medium,' published in the *Astrophysical Journal Supplement Series*.

Kwitter is also continuing to work on carbon abundances in planetary nebulae. The only emission line appearing in the visible part of the spectrum is a transition in singly ionized carbon, C^+ , which is intrinsically very weak compared to the normally observed emission lines in these objects; there are stronger lines of C^{++} and C^{3+} available in the ultraviolet. Along with Richard Henry (University of Oklahoma) and his graduate student Richard Buell, Kwitter is working under the auspices of a NASA Astrophysics Data Program grant to use newly recalibrated archived data from the International Ultraviolet Explorer satellite to study the production of carbon in intermediate-mass stars. Kwitter and her colleagues presented two papers at the American Astronomical Society meeting in Tucson, Arizona, January 1995: 'A New Look at Carbon Abundances in Planetary Nebulae' and 'Helium in Planetary Nebulae and Asymptotic Giant Branch Models.' Summer 1995 Keck exchange student Dan Pierkowski (Colgate '96) and Tim McConnochie '98 participated in analyzing the more than 300 spectra required for this project. As an adjunct to the ultraviolet observations, Kwitter and Henry obtained optical spectrophotometry with the Kitt Peak National Observatory 2.1-m telescope, using the Goldcam CCD spectrograph. McConnochie accompanied Kwitter, Henry, and Henry's graduate student on that observing trip.

Kwitter is continuing a collaboration with Don Lubowich (American Institute of Physics/Hofstra University) to search for lithium in planetary nebulae. Lithium enrichment has been documented in main-sequence stars, giant stars, and pre-planetary nebula stars; this investigation proposes to continue the search farther along the evolutionary path to planetary nebula envelopes. Kwitter and Lubowich have applied

for time on the Kitt Peak 4-meter telescope to obtain high-dispersion spectra of suitably-chosen planetary nebulae in which to search for evidence of lithium.

Voelkel finished his Ph.D. dissertation in history of science for Indiana University. His dissertation, 'The Development and Reception of Kepler's Physical Astronomy, 1593-1609,' was subsequently awarded the Esther L. Kinsley Ph.D. Dissertation Award for 1994, the highest honor for graduate research Indiana University offers.

Maraziti, a graduate student at the Institute for Astronomy at the University of Hawaii, is progressing in her dissertation research on galaxy clusters. Certain moderate- to high-redshift galaxy clusters appear to have an excess of galaxies with blue optical colors when compared to low redshift clusters of comparable richness, the 'Butcher-Oemler Effect.' Most attribute the blue color to enhanced star-formation, but the trigger that accelerates the star formation in these galaxies is not understood. She is observing the galaxies in two clusters at infrared wavelengths to search for evidence that galaxy-galaxy interactions trigger the star formation and to investigate whether their star-forming properties are similar to those of nearby star-burst galaxies. This work is under the direction of Robert Joseph and Patrick Henry at the University of Hawaii. All infrared data for this project must be collected at the high and dry location of the UH 2.2-meter telescope atop Mauna Kea on the Big Island in Hawaii. Maraziti was awarded observing time each year on the project. She also obtained images of the cluster Abell 370 in October 1994 with NASA's IRTF telescope on Mauna Kea. In the galaxies examined so far, there is no evidence for the Butcher-Oemler effect in the infrared colors. This suggests that if star formation is responsible for the blue optical colors of the cluster galaxies, then that star formation may be different than the star formation of galaxies in less crowded environments.

Alexandria Ware (Wellesley '96), on exchange at Williams, accompanied Maraziti on an observing run in March 1995 as part of her semester-long independent study of Infrared Studies of Galaxy Clusters. She also assisted with the reduction of data from a study of a third galaxy cluster, Abell 370. In collaboration with Patrick Henry and Jeffrey Goldader (then University of Hawaii; now STScI), Maraziti completed the data reduction and analysis of this cluster.

Maraziti's infrared images and photometry of a tremendously violent interacting galaxy system, IIZw96, will be submitted to be published in the *Astronomical Journal* in a paper by Goldader *et al.* (Space Telescope Science Institute). New observations by the Hubble Space Telescope and others show that the universe is filled with many more small, faint galaxies than anticipated. The origin of these galaxies is a mystery. Until recently, little attention has been paid to the tremendous potential of galaxy-galaxy collisions to clutter the universe with fragmented star clusters – galaxies in their own right. Maraziti is interested in exploring the outer regions of colliding galaxies to search for such self-gravitating groups of stars in the process of breaking free from their parent systems. Jennifer Heldman (Colgate '95), a student on Keck exchange to Williams for the summer, observed 6 systems for this project.

2. PROFESSIONAL SOCIETIES

Kwitter was a member of the Scientific Organizing Committee for a conference on Asymmetric Planetary Nebulae, at the University of Haifa at Oranim, Israel, held 8-11 August 1994. She was an invited participant at the Fifth Mex-Tex Meeting in Astrophysics, on the subject of Gaseous Nebulae and Star Formation, sponsored by the Universidad Nacional Autonoma de México, the University of Texas, and Rice University, held 3-5 April 1995, in Morelos, Mexico. She delivered a paper entitled 'A New Look at Carbon Abundances in Planetary Nebulae – Results for Four Nebulae.' Kwitter served as Chair in her final year as a member of the Electorate Nominating Committee of Section D on Astronomy of the American Association for the Advancement of Science. She continues to review manuscripts and other teaching materials for the National Center for Science Education, based in Berkeley, CA. She has also contributed to the McGraw-Hill Encyclopedia of Astronomy and the Encyclopedia of Science and Technology.

Pasachoff continued on the Education Advisory Committee and the News Committee of the American Astronomical Society. He was a Sigma Xi National Lecturer, and as such spoke about the 'Triumph of the Hubble Space Telescope' at Northwestern University, Syracuse University, Oakland University, Tennessee Technical University, University of Southern Mississippi, and Eckerd College in 1994-5 and at Quinnipiac College, the University of Hawaii at Hilo, and the University of Hawaii at Manoa during 1995-6. He gave the Phi Beta Kappa colloquium on 'The Sun and Solar Eclipses' at the University of Massachusetts at Amherst.

He was elected American Association of Physics Teachers/American Physical Society Member-at-Large of the Forum on Education of the American Physical Society, and attended the Executive Committee meeting in Washington. He was elected Chair-Elect of Division D (Astronomy) of the American Association for the Advancement of Science, with his term as Chair to begin in February 1997. Pasachoff continued his positions as U.S. National Representative to Commission 46 (The Teaching of Astronomy) of the International Astronomical Union and chair of a new subcommittee on public education on the occasions of solar eclipses; and as Chair, Working Group on Eclipses of Commission 12 (The Radiation and Structure of the Solar Atmosphere) of the International Astronomical Union. He served on the Scientific Organizing Committee of a NATO Advanced Research Workshop, "Theoretical and Observational Problems Related to Solar Eclipses," at Sinaia, Romania, in June 1996. He delivered papers on his solar coronal research, on future eclipses, and on public education on the occasion of eclipses.

Pasachoff continued to serve on the advisory boards of the educational projects of the American Association of Variable Star Observers (Hands-On Astrophysics), the Astronomical Society of the Pacific (ASTRO), and the American Astronomical Society (AASTRA). He is on the advisory board of *Odyssey*, a children's magazine (Cobblestone Publishing) and on the Physical Science Board of *World Book Encyclopedia*. He is consulting editor for the *McGraw-Hill Encyclopedia of Astronomy* and for its yearbooks.

Voelkel attended the History of Science Society meeting

in New Orleans in fall 1994. He gave a talk at Bennington College entitled 'Johannes Kepler as Publisher and Scientist,' and the inaugural talk entitled 'Tycho and Kepler' of the summer observing season to the Arunah Hill astronomy club. He also gave a talk to the staff of the Adler Planetarium in Chicago entitled 'The State of the Astronomical Art, 1540.' Book reviews by Voelkel appeared in *Isis* and *Physics Today*.

3. GRANTS

The family of Truman Henry Safford, second director of the Hopkins Observatory (1876-1901), has kindly given a fund for the benefit of the Observatory, centered on support of student participation in research. Principals of the family involved in the gift include Mr. and Mrs. Arthur Safford of West Hartford, Connecticut; his daughter, Joan Safford Wright of Princeton, New Jersey; and Mr. and Mrs. C. Louis Safford of Williamstown.

The Department was pleased to receive an NSF Academic Research Infrastructure grant, which, along with matching funds from the College, funded a DEC Alpha workstation, an additional X terminal for the astronomy network, and an upgrade to the 24" telescope control system as well as new focus apparatus and filter wheel.

4. MISCELLANEOUS ACTIVITIES

4.1 Outreach

The Hopkins Observatory hosted a large number of public observing sessions this year, especially in conjunction with the fortuitous appearance of the bright comet Hyakutake. Kwitter and Maraziti in 1995 and Pasachoff and Maraziti in 1996 ran day-long workshops to show teachers of local schools the basics of obtaining astronomical images via the World-Wide Web and other computer resources. Maraziti is an active pen-pal scientist in the Science-By-Mail program sponsored by the Boston Museum of Science and regularly corresponds with six groups of elementary school children throughout the United States.

4.2 Milham Planetarium

The Milham Planetarium was operated by Jason Lorentz '96, Amy McDougal '95, and Corey Olsen '96 during 1994-5. The academic-year shows were entitled 'Lions and Spirals and Bears, Oh My!' and concentrated on constellation myths of the appropriate seasons. The summer 1995 show, principally given by Tim McConnochie '98, was entitled 'Now You See It, Now You Don't: Celestial Mysteries Unveiled.'

During 1995-6, over 80 presentations of 'The New Planets' was presented by Lorentz and Christina Reynolds '97. Woody Printz, department volunteer, also presented several shows. Summer shows were given by Mac Stocco '98, Aditi Rao '99 (Wellesley College), Karla Solheim '99 (Bryn Mawr College), and Reynolds '97.

4.3 Student Research

Williams had strong showings at the annual Keck Northeast Astronomy Consortium student conferences, held at Wesleyan University in October 1994 and Vassar College in October 1995, at which students reported on their research activities during the previous summer. During the summer of 1995, the following Keck exchange students were in residence at Williams: Jennifer Heldman (Colgate '96), working with Deborah Maraziti; Rana Nichols-Kiley (Vassar '96), working with Jay Pasachoff; and Daniel Pierkowski (Colgate '96), working with Karen Kwitter. During the summer of 1996, the following Keck exchange students are in residence at Williams: Aditi Rao (Wellesley '99) working with Karen Kwitter; Karla Solheim (Bryn Mawr '99) working with Deborah Maraziti and Stephan Martin; Matthew Pickard (Colgate '98), working with Jay Pasachoff.

4.4 Colloquia

Colloquium speakers included Richard Henry, U. Oklahoma; Soma Raychaudhury, Harvard-Smithsonian Center for Astrophysics; John Salzer, Wesleyan University; Edwin F. Ladd '86, U. Mass-Amherst; Ronald Walsworth, Harvard-Smithsonian Center for Astrophysics.

Maraziti gave colloquia about interacting galaxies at Colgate University and Swarthmore College. One of Maraziti's goals has been to maintain a sizable amount of contact with those outside of the college community who have an interest in astronomy. She delivered another version of the interacting galaxies talk to two groups of amateur astronomers, one to the Arunah Hill Club in Cummington, Massachusetts, and the other to the Rockland Astronomy Club (from New York, but at a campsite in Massachusetts). Pasachoff lectured to the Rockland group the following year.

5. POSTGRADUATE PLANS OF GRADUATING SENIORS

5.1 Astrophysics Majors

Teon E. Edwards: Looking for employment in science education, Boston area

Corey A. Olsen: Graduate School in Medieval English at Columbia University

Bonnie D. Schulkin: Computer Specialist operations prior to AXAF spacecraft launch, CfA and Huntsville; also, interning for Sky & Telescope magazine

5.2 Astronomy Majors

Nathaniel W. Farny: A year off, then continued violin study

Jason R. Lorentz: Documentary film intern and applying to film school

PUBLICATIONS

Books Published

Several new books and new editions of older texts by Pasachoff were published: *Astronomy: From the Earth to the Universe*, 4th edition, 1995 Version, with Saunders College

Publishing; *Calculus and Multiple-Variable Calculus* (L. Holder, J. De Franza and Pasachoff) with Brooks-Cole; *Physics for Scientists and Engineers* (2nd ed.) and *Physics for Scientists and Engineers, Extended with Modern Physics* (R. Wolfson and Pasachoff) with HarperCollins, *The Farthest Things in the Universe* (Pasachoff, H. Spinrad, P. S. Osmer, and E. Cheng) with Cambridge University Press.

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Jay M. Pasachoff