

**Williams College**  
**Department of Astronomy and the Hopkins Observatory**  
*Williamstown, Massachusetts 01267*

The following report covers activities from July 2002 through June 2003.

## 1. FACULTY AND STUDENTS

### 1.1 Kwitter

#### *(Planetary Nebulae and Galactic Chemical Evolution)*

Kwitter's research on the chemical composition of planetary nebulae continued with several publications detailing the behavior of sulfur, chlorine, and argon, elements that are not expected to be affected by nuclear processing in the nebulae's parent stars, and therefore serve as markers for the composition of the original stellar material. With Richard Henry of the University of Oklahoma, Kwitter will use these observed abundances to compare and to test theoretical models of stellar nucleosynthesis yields and galactic evolution. In collaboration with Jacquelynne Milingo of Gettysburg College, Kwitter and Henry have received telescope time at Kitt Peak National Observatory and at Cerro Tololo Interamerican Observatory to examine a class of planetary nebulae that come from the more massive end of the mass range that produces planetary nebulae. The goal here is to examine in particular the abundances of nitrogen and oxygen to search for evidence that fusion near the bottom of the star's convective envelope has resulted in the conversion of some of the oxygen into nitrogen.

In the summer of 2002, Matthew Hoffman '04, and Keck Northeast Astronomy Colloquium (KNAC) Summer Fellow Mun Keat Chan (Middlebury '03) worked with Kwitter on high-dispersion spectroscopic observations of several planetary nebulae, aimed at determining the abundance of iron and other heavy elements in these objects. Hoffman and Chan accompanied Kwitter on an observing run at Kitt Peak National Observatory in June 2002. An early result from this study was the determination for DdDm-1, a planetary nebula located in the halo of the Milky Way Galaxy, of its radial velocity ( $D310 \pm 5$  km/sec) and its expansion velocity ( $12.7 \pm 1.6$  km/sec, based primarily on the wavelength splitting of forbidden lines of  $Fe^{+2}$ ). The students presented their results at the annual KNAC Student Research Symposium held at Haverford in November of 2002. For more information about KNAC see <http://www.wellesley.edu/Astronomy/keck/>.

During the summer of 2003, Lissa Ong '04, Davis Stevenson '04, and KNAC Summer Fellow Megan Roscioli (Haverford '05) worked with Kwitter on various projects relating to spectroscopic analyses of planetary nebulae. These include analysis of high-dispersion echelle spectra of planetary nebulae to search for emission lines of heavy elements and a study of archived ultraviolet observations of a sample of planetary nebulae taken with the now-defunct International Ultraviolet Explorer satellite, in order to plan for upcoming observations of the same objects with the improved capabilities of the Hubble Space Telescope. Stevenson will continue her research with Kwitter as a senior honors thesis.

### 1.2 Pasachoff

#### *(Sun, Eclipse, Pluto, Transit of Mercury, Transit of Venus, Deuterium, History)*

Pasachoff resumed his liaison with James L. Elliot of MIT in observing the atmospheres of outer planets and their satellites through occultation studies. He worked through the year with Williams colleagues Bryce Babcock and Steve Souza and undergraduate David Ticehurst '04 to observe and to study Pluto's atmosphere by using a specialized CCD detector that is normally used by the Williams team at total solar eclipses. Pasachoff, Souza, and Ticehurst brought the CCD and a portable telescope to Chile to prepare for the July 2002 occultation. Changing predictions and deployment needs led them to be in a position where they didn't actually observe this occultation themselves but participated as team members in the subsequent *Astronomical Journal* paper (Buie *et al.*, in preparation). The situation was very different at the August 2002 occultation, when Pasachoff, Babcock, and Ticehurst took the eclipse CCD to the University of Hawaii's 2.2-m telescope at the Mauna Kea Observatory, where they obtained excellent observations of the occultation, including 2400 exposures at an 0.5 s cadence. Their visible-light observations clearly showed the occultation, revealing through later analysis that Pluto's atmosphere has expanded since the only previous similar observation in 1988 (Elliot *et al.*, *Nature* **424**, 165-168, July 10, 2003; Pasachoff *et al.*, in preparation). The latter paper will elaborate, in particular, on the observations of layering in Pluto's atmosphere, which shows up as spikes in the occultation light curve. The team also delivered a paper and was coauthor of other papers at the meeting of the Division of Planetary Sciences of the American Astronomical Society in the fall of 2002 and the meeting of the AAS in January 2003. Pasachoff, Babcock, and Souza are planning future collaboration with the MIT team and are formulating joint instrument and research proposals.

The Pluto observations bear on the important question of whether Pluto's atmosphere will freeze out in the next decade or so, to remain unable to be further investigated for over 200 years as Pluto moves farther from the sun in its 250-year orbit. The result is therefore vital for the pending Pluto spacecraft. And the observations are leading to a major revision of astronomers' understanding of Pluto's atmosphere and, potentially, of its relation with the increasingly important class of objects known as Kuiper-Belt Objects.

Pasachoff headed a Williams College team that carried out observations at the total solar eclipse of December 4, 2002, which they observed from Ceduna, South Australia. They studied the temperature of the solar corona through ultraviolet mapping and made visible-light observations to compare with space extreme-ultraviolet telescopes aboard the Transition Region and Coronal Explorer (TRACE) and Solar and Heliospheric Observatory (SOHO) spacecraft. Stu-

dents participating included essentially all the astronomy and astrophysics majors who had not been on the Zambian expedition: David Ticehurst '04, Kristen Shapiro '03, Davy Stevenson '04, Sarah Croft '04, Lissa Ong '04, Galen Thorp '04, Jesse Dill '04, Paul Crittenden '03, Terry-Ann Suer '05, Kamen Kozarev '05, John BackusMayes '05. Alumnus Rob Wittenmyer '98 also participated. Staff from Williams College included Bryce Babcock and Steven Souza, and they were assisted by Lee Hawkins of Appalachian State University. They were joined on site in Australia by Raymond Smartt from the U.S. National Solar Observatory, recently retired to Australia; Robert Lucas of the University of Sydney; and Stephan Martin, former Observatory Supervisor. See <http://www.williams.edu/astronomy/eclipse>.

During the summer of 2002, KNAC Summer Fellow Mansi Kasliwal '05 of Bryn Mawr College, now of Cornell University, worked on prior eclipse data; during the summer of 2003, KNAC Summer Fellow Peter Forshay '05 of Haverford College and Terry-Ann Suer '05 began work on the 2002 eclipse data.

Pasachoff worked with Glenn Schneider of the University of Arizona's Steward Observatory and Leon Golub of the Harvard-Smithsonian Center for Astrophysics on observations from NASA's Transition Region and Coronal Explorer (TRACE) of the 1999 transit of Mercury. Their paper on the 1999 transit is in press in *Icarus*. They obtained some observations of the 2003 transit of Mercury. But the main event will be the 2004 transit of Venus, since no transit of Venus has been visible on Earth since 1882, while there have been over a dozen transits of Mercury since then. Transits of Venus have been observed only in 1639, 1761, 1769, 1874, and 1882, and in the 18th century were the main way that the size and scale of the solar system were obtained. Schneider, Pasachoff, and Golub showed that the dreaded "black-drop effect," the ligature joining the disk of Mercury to the dark, background sky, came from a combination of the point-spread function of TRACE's telescope and the limb darkening of the Sun. Since TRACE is outside Earth's atmosphere and Mercury has only a negligible atmosphere, the black-drop effect is not atmospheric, which has applications to the black-drop effect that bedeviled past observations of the transits of Venus, limiting the accuracy of our knowledge of the size of the solar system. Pasachoff prepared a joint report on the observations for the special symposium on Mercury held at the 2003 General Assembly of the International Astronomical Union in Sydney. The Mercury transit observations and the history of and plans for Venus transit observations are available from a Web site Pasachoff supervises at <http://www.transitofvenus.info>.

Pasachoff continued to work with Donald A. Lubowich of the American Institute of Physics and Hofstra College on a series of observations involving cosmic deuterium. Deuterium is a uniquely sensitive tracer of the physical conditions in the era of nucleosynthesis, which began about 1 second after the Big Bang and lasted about 1000 seconds. All the deuterium in the universe was formed during that interval. Pasachoff, with students Gabriel Brammer '02, David A. Ticehurst '04 and Kristen Shapiro '03, made observations the previous year with the 45-m millimeter radio telescope at

the Nobeyama Radio Observatory in Japan. Among the objects studied were two gas clouds in the outer Milky Way. Subsequent observations were made on related deuterium topics with the 12-m millimeter radio telescope of the Steward Observatory on Kitt Peak and with the Haystack Radio Telescope in Westford, MA, sometimes on site and sometimes remotely. A number of deuterated molecules were detected, and the observational results are under analysis.

As a major part of his 2001-02 sabbatical at the Harvard-Smithsonian Center for Astrophysics, Pasachoff had resumed work on the solar chromosphere, a long-time interest, by planning high-spatial-resolution observations with the Transition Region and Coronal Explorer (TRACE) spacecraft. He continued to work in 2002-2003 with Ed DeLuca and Leon Golub of the CfA, who are major figures in the TRACE program, to prepare a grant application to NASA to participate in the work. Seaton '01, who is working for the TRACE group at CfA, had made some preliminary measurements on existing TRACE data, showing the feasibility of the project.

Pasachoff continued his collaboration with Roberta J. M. Olson on the overlap of art and astronomy. Olson is at the New-York Historical Society and is Professor Emerita of Art at Wheaton College. Their article on "Comets, meteors, and eclipses: Art and science in early Renaissance Italy" appeared in *Meteoritics* **37**, November 2002, 1563-1578. They began a paper to be presented at the 2004 meeting of the College Art Association about Galileo's drawings of the Moon and other objects, dealing with the relation of Galileo and the Medici court.

Pasachoff collaborated with Kevin Kilburn of the Manchester Astronomical Society, U.K., on describing the contents and physical distribution of the unpublished but beautiful 18th-century star atlas by John Bevis. Owen Gingerich of the Harvard-Smithsonian Center for Astrophysics joined them for an article published in the *Journal for the History of Astronomy*, **xxxiv**, 125-144 (2003).

### 1.3. Souza Observatory Supervisor Instrumentation

Souza directs the department's observing program, supervising nine teaching assistants. This program offers varied nighttime and solar observing experiences for introductory students. He has been working to increase opportunities for quantitative measurements by advanced students, with the goal of offering similarly concrete exercises in introductory courses. He handles most of the daytime observing, and has hosted numerous visiting individuals and groups, including Friday-night planetarium groups, alumni, visiting classes from Williams (e.g., Geosciences) and elsewhere, and student previews and prospective students. He trains the observing and planetarium TAs in the use of our facilities, including the 0.6-m telescope. Souza also teaches most laboratory sections in the department. He is in the process of revising or replacing many of the existing laboratory exercises to make use of modern software, Web resources, and new data.

During the summer of 2002 Kamen Kozarev '05 and Lissa Ong '04 worked with Souza on detailed characterization of the Observatory's scientific-grade CCD cameras. During the summer of 2003 Ryan Carollo '05 began high-quality observations of the Sun, and Galen Thorp '04 did

preliminary work aimed at reducing the effects of atmospheric “seeing” on the Observatory’s 0.6-m reflector. Earlier, Souza began occasional monitoring of the “seeing” and found that it is predictably poor, varying between 3 and 6 arcseconds.

#### 1.4 Shapiro

Kristen L. Shapiro ’03 wrote her senior thesis on disk heating in nearby spiral galaxies, based on her work as a summer fellow at the Space Telescope Science Institute with Joris Gerssen and Roeland P. van der Marel. She worked on quantifying this heating through the comparison of the random motion occurring parallel to and perpendicular to the plane of the galactic disk, a ratio known as the velocity ellipsoid ratio. Since each of the proposed heating mechanisms acts on different components of a star’s motion and varies differently with galactic morphology, the trend in velocity-ellipsoid ratios over a range of galactic types can be used to ascertain the validity of competing theories. Recent work has shown that it is possible to extract his information from external galaxies by observing the major and minor axes of systems with intermediate inclination. Prior to this project, such analyses had only been performed on two external spirals, and while the results suggested that a trend in velocity ellipsoid ratio does exist, the error bars were too large to be conclusive. She studied four additional external galaxies, covering a slightly larger range in morphological type. The results are consistent with a decreasing velocity-ellipsoid ratio in later-type spirals; however the error bars continue to restrict the strength of the conclusions.

## 2. COURSES AND OTHER EDUCATIONAL ACTIVITY

The Astronomy Department offered two new courses this year. In the spring semester Kwitter taught Astronomy 402: *Between the Stars*, a heavily observational course concentrating on the interstellar medium, its composition, origin, behavior, and galactic context. As a guest lecturer, Howard Bond of the Space Telescope Science Institute spoke about the unique and fascinating object V838 Monocerotis. The dust shell surrounding this star has been illuminated by a sudden, flashbulb-like brightening of the star, yielding a CAT-scan-like time-series of images that reveal the three-dimensional structure of the dust shell. (See <http://hubblesite.org/newscenter/archive/2003/10/>.)

Another guest lecturer was Martín Guerrero of the University of Illinois at Urbana-Champaign, who discussed high-energy X-ray and ultraviolet observations of the interstellar medium with the space observatories ROSAT, Chandra, XMM, and FUSE. Also in the spring, Pasachoff taught Astronomy 336: *Science, Pseudoscience, and the Two Cultures*, in which the students learned about various aspects of scientific culture and nonscientific practices, both by reading and by interviewing local practitioners.

At the January 2003 meeting of the American Astronomical Society in Seattle, Kwitter gave a presentation to the special “Astronomy 101” session about a new web-based Gallery of Planetary Nebula Spectra. This database, which

incorporates a graphical package to display spectra, contains high-quality spectroscopic data on 86 planetary nebulae obtained by Kwitter and Henry. The website was designed with the help of several Williams Instructional Technology students in the summer of 2002. Kwitter developed two exercises, which are included on the website ([cf.williams.edu/public/nebulae](http://cf.williams.edu/public/nebulae)) to explicate the data and to illustrate basic concepts of atomic physics and radiation.

## 3. EVENTS

During 2003, a special exhibit, *The Heavens Revealed: Classics of Astronomy from Ptolemy to Copernicus to Einstein*, was mounted at the Chapin Library highlighting holdings from Pasachoff’s personal collection of rare astronomical books, including works by Copernicus, Kepler, Galileo, Newton, Halley and others. This exhibit honored Pasachoff’s 60th birthday, at which time there was a gala celebration attended by many of the over 100 astronomy alumni since his arrival at Williams in 1972. At that time, eight of the alumni, from the classes of ’75 through ’01, who are now professionally involved in astronomy spoke at an afternoon symposium. A catalogue was prepared by Wayne Hammond of the Chapin Library, with a foreword, introduction and historical overview by Pasachoff and with contributions by Felix Oyens of Christie’s on the “Academic as Collector”; by Roberta J. M. Olson of the New-York Historical Society on the Nuremberg Chronicle and the joint Olson/Pasachoff studies of its comet representations; by Owen Gingerich of the Harvard-Smithsonian Center for Astrophysics on the Pasachoff holdings of Galileo’s books; by James Voelkel ’84 on Kepler; and by Roger Stoddard of Harvard’s Houghton Library on the books that the Houghton Library has been able to obtain with Pasachoff’s contributions.

Alumni speakers at the symposium were Stuart Vogel ’75, University of Maryland, *CARMA: Imaging the Cool Universe*; Wayne Roberge ’76, Rensselaer Polytechnic Institute, *Fire and Ice: Shock Waves in Protoplanetary Disk*, Eric Pilger ’82, Hawaii Institute for Geophysics, *Remote Sensing of Thermal Surface Events from Space*; Brad Behr ’92, University of Texas, *A New Spin on Old Stars*, Kevin Reardon ’92, Italian National Astrophysical Institute at the Arcetri Astrophysical Observatory, Florence, *IBIS and EGSO: Building Real and Virtual Solar Instruments*; Timothy McConnochie ’98, Cornell University, *Mars Global Surveyor Thermal Emission Spectrometer: Atmospheric Observations*; Laura Brenneman ’99, University of Maryland, *Assessing the Accretion Disk Environment in NGC 4593 with XMM-Newton*; and Dan Seaton ’01, Harvard-Smithsonian Center for Astrophysics, *Eclipse and TRACE Solar Observations*. James Voelkel ’84 contributed a piece about Kepler’s books to the catalogue.

Pasachoff observed the annular solar eclipse of May 31, 2003, from an airplane off the north coast of Iceland. It was his 36th solar eclipse.

## 4. OUTREACH AND INTERNATIONAL ACTIVITIES

Pasachoff continues as Chair of the International Astronomical Union’s Working Group on Solar Eclipses. He prepared a report on the Group’s work for the IAU General

Assembly held in Sydney, Australia, in July 2003. See [www.totalsolareclipse.net](http://www.totalsolareclipse.net). He also prepared a report on the forthcoming November 23, 2003, total solar eclipse that will be visible only from Antarctica for a special symposium on Antarctic astronomy held at the IAU General Assembly.

Pasachoff continued as Vice-President of the Commission for Education and Development of the International Astronomical Union. He participated in deliberations of the Scientific Organizing Committee for plans for the Commission's sessions at the General Assembly of the International Astronomical Union in Sydney, Australia, in July 2003, including a special symposium on K-12 teaching of astronomy. Pasachoff became President of the Commission at the Sydney IAU meeting. See <http://www.astronomyeducation.org>. He also continued as Chair of the Commission's Program Group on Public Education at the Time of Eclipses. See <http://www.eclipses.info>.

## 5. AWARDS

Pasachoff received the 2003 Education Prize of the American Astronomical Society. The citation reads, "For his eloquent and informative writing of textbooks from junior high through college, For his devotion to teaching generations of students, For sharing with the world the joys of observing eclipses, For his many popular books and articles on astronomy, For his intense advocacy on behalf of science education in various forums, For his willingness to go into educational nooks where no astronomer has gone before, the AAS Education Prize is awarded to Jay M. Pasachoff." The prize will be officially awarded at the meeting in Atlanta in January 2004.

Pasachoff was elected an Honorary Member of the Royal Astronomical Society of Canada, one of only fifteen such.

Kwitter was inducted into the Alumni Hall of Honor at Edison High School in Edison, NJ.

## 6. EXTERNAL ACTIVITIES

Kwitter served the final year of her three-year term as a member of the American Astronomical Society's Committee on the Status of Women in Astronomy. She was an organizer of the meeting Women in Astronomy II: Ten Years After, held at Caltech at the end of June 2003. This meeting was a decadal follow-up to the groundbreaking meeting in Baltimore in 1992, at which the "Baltimore Charter" was drafted, a document urging the astronomical community to promote "a culture in which both women and men can realize their full potential in scientific careers." On behalf of the CSWA, Kwitter undertook a comprehensive survey of the gender and rank demographics in the leading astronomical institutions and graduate departments across the country. Results from this survey were presented at the WIA II meeting and were compared with previous surveys.

Kwitter also continued on the Observatories Council of the Associated Universities for Research in Astronomy, Inc. (AURA), notably as the only representative from a liberal arts college.

The National Research Council vets applications for post-doctoral appointments at nationally-funded laboratories in their Associateship Programs Review; Kwitter has continued

as a member of the Space Sciences Panel for this thrice-yearly review process. She also continues on the advisory boards of Annual Editions: Astronomy, and Encyclopedia of Astronomy and Astrophysics.

In March 2003, Kwitter gave a presentation at Mt. Everett High School in Sheffield, MA, about her career path and research. Kwitter was also the featured speaker at the Berkshire Museum's summer program for Massachusetts teachers; she discussed her life as an astronomer and teacher along with the experiences that influenced her. The teachers then attended an on-campus session with Kwitter, exploring the worldwide web to study recent discoveries about extrasolar planetary systems. Kwitter also participated in the College's Summer Program for Teachers, conducting a class about the search for extrasolar planetary systems.

Pasachoff continued as the Williams College representative to the Massachusetts Space Grant Consortium, which is headquartered at M.I.T., and which Williams recently joined.

Pasachoff continues on the science board of the World Book and as consulting editor for astronomy of the McGraw-Hill Scientific Encyclopedia and Yearbooks. He is on the Council of Advisors of the Astronomy Education Review electronic journal. See <http://aer.noao.edu/>. Pasachoff continues as science book reviewer for The Key Reporter, the Phi Beta Kappa newsletter. He continues as advisor to the children's magazine *Odyssey*.

The second edition of Pasachoff's text *The Cosmos: Astronomy in the New Millennium*, with Alex Filippenko of the University of California at Berkeley as co-author, was published. See <http://info.brookscole.com/pasachoff/>. Souza was co-author of the Instructor's Manual and Test Bank. Pasachoff worked with Milos Mladenovic of the Williams College Center for Information Technology to post regular updates and press releases on a wide variety of astronomical topics on the Web at <http://www.solarcorona.net>.

Pasachoff wrote an informal book on solar physics, *The Complete Idiot's Guide to the Sun* (Alpha Books, 2003). <http://www.solarcorona.net/sun>.

The second Spanish edition of Pasachoff's *Field Guide to the Stars and Planets: Guía de Campo de las Estrellas y los Planetas* was published by Ediciones Omega S.A., Plató, 26, 08006 Barcelona, Spain.

Souza traveled to Kitt Peak National Observatory to work with J. Milingo (a collaborator of Kwitter at Gettysburg College) on spectroscopy of planetary nebulae. Souza gave guest lectures in Astronomy 402 on Interstellar Molecules and in Chemistry 304 on Magnetic Resonance Imaging. Souza is Steve #304 of the National Center for Science Education's Project Steve (<http://www.ncseweb.org>), in support of the teaching of evolution.

Souza has completed or initiated numerous improvements to the Observatory instrumentation and facilities. In particular, Souza's work enabled the 14 students in Kwitter's Astronomy 402 class on the interstellar medium to make use of the full complement of the Observatory's instruments, including the radio telescope (to measure the rotation of the Milky Way galaxy) and the spectrograph (to obtain temperatures and densities of a variety of planetary nebulae). With the assistance of students Lissa Ong '04, John BackusMayes

'05, and Ryan Carollo '05, Souza has been renovating our venerable Carroll spar solar telescope, a fine refractor well suited to high-quality H-alpha observations of the Sun. In addition to a complete teardown, cleanup, and repainting, the limb-guider is being replaced with modern detectors and electronics.

### 7. COLLOQUIA

Howard Bond, Space Telescope Science Institute, "Hubble Space Telescope Observations of the Light Echo Around V838 Monocerotis: An Astronomical CAT"; Vojtech Rusin, Slovak Academy of Sciences, "Recent Solar Eclipses"; Joris Gerssen, Space Telescope Science Institute, "A Search for Black Holes in Globular Clusters"; Martín Guerrero, University of Illinois, "X-ray Bubbles: from Planetary Nebulae to Superbubbles"; Joshua Winn, Harvard-Smithsonian Center for Astrophysics, "Measuring the Universe with Gravitational Lenses"; Norman J. Levitt, Rutgers University (public lecture in coordination with Astronomy 336, with co-sponsorship by the Lecture Committee) "Science as the Mirror of Democracy."

### 8. MILHAM PLANETARIUM

The fall 2002 show was "Dust to Ashes: The Life and Death of Stars"; the spring 2003 show featured the winter constellations and the film SolarMax. Christopher Holmes '03, Kate Gibbons '03, Jesse Dill '04, and Davy Stevenson '04 gave the shows.

In June 2004, the Spitz A3p projector had its fortieth anniversary; we are approved for fundraising for a replacement.

### 9. POSTGRADUATE PLANS OF MAJORS

Naila Baloch; Wei-Li Deng, travel; Kathleen Gibbons, M.A. at Columbia University in the philosophical foundations of physics; Christopher Holmes, Master's in history and philosophy of science at Cambridge University, England, then physics graduate school; Kristen Shapiro, working in the Astronomy Department at the University of Leiden in The Netherlands for a year, then astrophysics graduate school; Megan VanDyke.

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