Williams College
Department of Astronomy
Williamstown, Massachusetts 01267

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The following report covers the Department activities from July 2000 through July 2001.

1. FACULTY AND STUDENTS

Faculty included Jay M. Pasachoff, Field Memorial Professor of Astronomy, Chair of the Astronomy Department and Director of the Hopkins Observatory; Karen B. Kwitter, Ebenezer Fitch Professor of Astronomy; Marek Demianski, Visiting Professor of Astronomy; and Stephan E. Martin, Instructor in Astronomy and Observatory Supervisor. Kwitter was on sabbatical leave during the spring semester.

The department enrolled the most astrophysics and astronomy majors ever: 8 rising juniors, 9 rising seniors, and 8 seniors graduating in the class of ’01. Graduating were Misa Cowee, Kenneth Dennison, Joel Iams, Duane Lee, Daniel Seaton, Joey Shapiro, Matthew Silver, and Darik Vélez. Rising seniors are Daniel Bissex, Gabriel Brammer, Shoshana Clark, Bethany Cobb, Rossen Djagalov, Caleb Fassett, David Gioiello, and David Glick. William Allen is an astronomy major. Incoming astrophysics juniors are Kathleen Gibbons, Christopher Holmes, Kristen Shapiro, Wei-Li Deng, Megan VanDyke, Naila Baloch, Paul Crittenden, and David Ticehurst.

2. RESEARCH

2.1 Pasachoff

A major activity was the eclipse expedition to Zambia for the June 21, 2001, total solar eclipse and the subsequent eclipse data reduction. Pasachoff is primarily interested in studies of the source of the heating of the solar corona to millions of degrees and in liaisons between eclipse observations and observations from solar spacecraft. The expedition and data reduction are in collaboration with Dr. Bryce A. Babcock, Staff Physicist and Coordinator of Science Facilities at Williams. Stephan Martin, Observatory Supervisor, led one of the experiments. Jonathan Kern, an optics designer at Caltech’s Laser Interferometer Gravitational-Wave Observatory in Livingston, Lousiana, was another senior member of the team, and helped with the design and fabrication of some of the equipment. R. Lee Hawkins of Appalachian State University led a third experiment.

This was Pasachoff’s 32nd solar eclipse. He is Chair of the Working Group on Solar Eclipses of the International Astronomical Union, for which his duties involve international coordination of information about eclipse expeditions and on eclipse observations. He is also chair of a subcommittee on public education on the occasions of eclipses of Commission 46 on Education and Development of the International Astronomical Union. See www.williams.edu/astronomy/IAU_eclipses.

The team in Zambia included 12 students: Daniel Seaton ’01, Misa Cowee ’01, Gabriel Brammer ’02, Shoshana Clark ’02, Bethany Cobb ’02, D. Michael Gioiello ’02, Kathleen Gibbons ’03, Christopher Holmes ’03, Kristen Shapiro ’03, Davy Stevenson ’04, Keck Northeast Astronomy Consortium Fellow Roban Kramer (Swarthmore ’03) and John Kildahl of Mt. Greylock Regional High School. Allan Ridgeley, retired from the Rutherford Appleton Laboratory, England, and now at the Roseland Community Observatory, along with his colleagues Dehren Mehmet and Geoff Greyer; Mitzi Adams of NASA Marshall Space Flight Center and Elizabeth Simmons, a high-school teacher on a NASA education grant; and Dr. Paul Rosenthal of the Williamstown Medical Associates, team Medical Officer, joined the group. Other Williams participants were Prof. Catharine Hill, Professor of Economics and Provost, who lived and worked in Zambia for 3 years; James Kolesar, Director of Public Affairs; and alumnus Rob Wittenmyer ’98, who had just received an MS from Boston University.

The expedition was supported by grants Pasachoff received from the Atmospheric Sciences Division of the National Science Foundation, from NASA’s Guest Investigator Program for the Solar and Heliospheric Observatory spacecraft, and from the Committee for Research and Exploration of the National Geographic Society. Additional support was received from the Massachusetts Space Grant (through M.I.T. from NASA); the W.M. Keck Foundation through the Keck Northeast Astronomy Consortium; and Sigma Xi. Further support at Williams came from the Brandi Fund, the Safford Fund (set up by his descendants in honor of the second director of the Hopkins Observatory, Truman Henry Safford), the Rob Spring ’75 fund, and the Bronfman Science Center.

Other collaborating scientists joining the expedition in Zambia included Mazlan Othman from Indonesia, now at the United Nations in Vienna; Vojtec Rusin and Peter Zimmerman of the Slovakian Academy of Sciences, Slovakia; Arvind Paranjpye of the Inter-University Centre for Astronomy and Astrophysics, Pune, India; and Sujata Virdhe of Indian Space Research Organization, Bangalore, India. They were aided in Lusaka, Zambia, especially by Jacques Hillinger; by Prof. H. Mweene, Chair of the Department of Physics of the University of Zambia; and by Troy Fitrell of the American Embassy.

The team observed from Lusaka, Zambia. Totality lasted 3 minutes 14 seconds at that site. Two of the experiments deal with the still open question of how the corona, the outermost layer of the sun’s atmosphere, can reach a temperature of 2 million degrees Celsius, even though the everyday surface of the sun below it is only 6,000 degrees Celsius. One of those experiments and a third experiment are in liaison with scientists in charge of the Large Angle Spectroscopic Coronagraph (LASCO) experiment, the Extreme-ultraviolet Imaging Telescope (EIT), and the Ultraviolet

Coronal Spectrometer (UVCS) experiments on the Solar and Heliospheric Observatory (SOHO) spacecraft. Pointing was done in coordination with scientists of the Transition Region and Coronal Explorer (TRACE) spacecraft.

The first eclipse experiment is a search for rapid oscillations in the corona, with periods of about 1 second. Pasachoff and his colleagues and students have developed techniques over the last two decades to observe in the coronal green line, with time resolution so fast that such short periods can be detected. Oscillations with periods in that range are predicted by some theories that hold that the extreme coronal heating is caused by vibrations of magnetic loops. Daniel B. Seaton ’01 wrote his senior thesis on analysis of the 1999 eclipse data and then participated with Babcock and Brammer in operating the equipment on site. Unfortunately, a computer problem prevented collection of data during this eclipse. A paper on results from the 1998 expedition, with Pasachoff, Babcock, Russell, and McConnochie appeared in the journal *Solar Physics*. A paper on the 1999 eclipse data with Seaton as an additional coauthor is in preparation. Seaton used the Interactive Data Language (IDL), comparing measured data with modeled data that he constructed, continuing work began by Kevin Russell ’00, who spent the year as a Fulbright scholar in Australia, where among other things he investigated the prospective site for the 2002 total solar eclipse observations. The results from the 1999 eclipse indicate the presence of excess oscillatory power at the locations of coronal loops, endorsing a certain class of models of coronal heating. The experiment in Zambia was supported by the grant from the Atmospheric Sciences Division of the National Science Foundation.

The second experiment is to map the polarization and temperature of the corona, using a technique of comparing electronic images of the corona taken at special ultraviolet wavelengths chosen to include two at which the difference between the shape of the photospheric spectrum and coronal spectrum is especially large. The experiment was supported by a grant from the Committee for Research and Exploration of the National Geographic Society. Lee Hawkins supervised the experiment on site. A late addition to the observational plan for the 2001 eclipse was made in liaison with Peter L. Smith and John Kohl of the Harvard-Smithsonian Center for Astrophysics. Their UVCS experiment on SOHO also measures polarization, but they had a substantial discrepancy at 2.5 solar radii in the corona in their polarization measurement as compared with LASCO measurements. The Williams group attempted to measure polarization at that location, farther out than they usually worked, using a filter that overall matched the UVCS 2000-angstrom-bandpass filter.

The third experiment is to image the solar corona during the eclipse to compare with observations of the corona seen with EIT on board SOHO, in collaboration with scientists at NASA’s Goddard Space Flight Center, and with the LASCO experiment, in collaboration with scientists at the Naval Research Laboratory. The features seen at the eclipse outside the solar disk can be matched up with their bases on the solar disk observed with EIT. Further, the experiment uses a lens that gives an image at the same scale and with a green filter that matches a filter in one of the telescopes in the coronagraph system on SOHO that operated for the 1998 eclipse but is no longer working. This observation was originally in collaboration with the late Guenter Brueckner of the Naval Research Laboratory in Washington, D.C., principal investigator, LASCO, and is now in collaboration with Russell Howard and Dennis Socker at NRL. Daniel Seaton ’01 worked on the data and produced excellent composites. The comparison of the 1998 eclipse image with an image taken with one of LASCO’s coronagraphs will provide a calibration of how much light was scattered in that coronagraph. The data from the 1999 eclipse have been interposed between EIT observations of low solar levels and LASCO observations of the outer solar corona. (See images and descriptions at www.williams.edu/astronomy/eclipse99/eclipseimages.) Stephan Martin is the collaborating Williams College staff member. The experiment at the 1999 eclipse was funded by a grant from NASA’s Guest Investigator program for the SOHO spacecraft. Pasachoff, Seaton, Babcock, and Martin presented a paper on the results at the joint meeting of the American Geophysical Union and the Solar Physics Division of the American Astronomical Society, in Boston, in May 2001.

In his eclipse work, Pasachoff was busy not only on scientific tasks but also on educational tasks relevant to the safe observing of the eclipse by populations across Africa, through his roles as Chair of the Working Group on Solar Eclipses of the International Astronomical Union (IAU) and as Chair of the Subcommittee on Public Education through Eclipses of the Commission on the Teaching of Astronomy of the IAU. (See www.williams.edu/Astronomy/IAU_eclipses.)

Another set of observations in which Pasachoff has been involved is the study of interstellar deuterium. Pasachoff has been working for some years with Donald A. Lubowich of the American Institute of Physics and Hofstra University on studies of 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 known in the universe was formed during that interval. Pasachoff and Lubowich brought in Tom Millar and Helen Roberts of the University of Manchester Institute of Science and Technology to provide models of the chemical fractionation that makes the D/H ratio different from the DCN/HCN ratio. The team observed during May 2001 at the Nobeyama Radio Observatory in Nobeyama, Japan. Gabriel Brammer ’02 joined Pasachoff, Lubowich, and Roberts at the telescope. They observed clouds near the galactic center, in the circumnuclear ring, and near the Galactic anticenter, to try to map abundances of deuterium and other isotopes at various locations in our Galaxy. In May and June 2001, Pasachoff and Lubowich obtained additional observing time at these millimeter wavelengths, concentrating near 72 GHz, at the 12-m telescope on Kitt Peak, Arizona, now administered by the Steward Observatory of the University of Arizona. Brammer conducted the observing run himself, advised and assisted by Aldo Apponi of the University of Arizona and the telescope operators.

Pasachoff continued his collaboration with Roberta Olson

on the overlap of art and astronomy. Olson moved from Wheaton College to the New York Historical Society. Pasachoff and Olson delivered an invited paper on Renaissance images of comets at the 400th anniversary symposium of the Galileo Academy of Sciences, Letters and Arts in Padua, Italy, during November 2000.

2.2 Kwitter

Kwitter and her colleagues continue their studies of planetary nebulae. In addition to the evolutionary history of their progenitors, planetary nebulae as a class offer an opportunity to study the properties of the surrounding interstellar medium and the chemical evolution of the Galaxy as a whole. Kwitter and Prof. Richard Henry of the University of Oklahoma are working on a multi-faceted project to study planetary nebulae as individual objects and as probes of chemical evolution in the Galaxy (and possibly in other galaxies as well). Their work is funded by an NSF grant. They are studying the abundances of sulfur, chlorine, and argon in planetary nebulae. These elements are particularly interesting because their amounts are not altered by the nucleosynthesis in the progenitor stars, and therefore these amounts should reflect those in the gas out of which the progenitor star formed billions of years ago. This allows us to evaluate predictions of the buildup of these elements over time in the Galaxy and to assess the various contributions, particularly from Type Ia supenovae, which come from the incineration of white dwarf stars too massive to withstand gravitational collapse.

During the summer of 2000, Gabe Brammer ’02 (supported by NSF), and Sun-Mi Chung (Wesleyan ’02, Keck Northeast Astronomy Consortium Fellow) worked with Kwitter on abundance analyses of planetary nebulae, and presented their results at the annual Undergraduate Symposium on Research in Astronomy, sponsored by the Keck Northeast Astronomy Consortium held at Middlebury College in October, 2000. Roger Cohen (Wesleyan ’02) worked with Kwitter during the summer of 2001 as a Keck Northeast Astronomy Consortium Fellow. He analyzed data for about 50 planetary nebulae, deriving chemical abundances and investigating trends. He presented his results at the 2001 Keck Undergraduate Symposium, hosted by Williams in November.

2.3 Demianski

Marek Demianski continued his interest in the process of formation and evolution of large scale structure of matter distribution in the universe. In collaboration with A. Doroshkevich, Demianski proposed a new approach to the process of structure formation stressing the role of perturbations of the gravitational potential. Predictions of this theory were compared with results of three different numerical simulations. In all these simulations, it was assumed that the average mass density of the universe is dominated by the dark matter. From theoretical considerations and numerical simulations it follows that initially large wall-like condensations appear. Walls are quasistationary structures with a long lifetime. They slowly break into much smaller dense clouds. Demianski and his collaborators analyzed the spatial distribution of Lyman α clouds which are responsible for formation of absorption lines in the spectra of distant quasars. It turned out that the clouds can be identified with elements of filaments – long cylindrical structures which are formed during the process of fragmentation of walls.

During the last twenty years, large progress has been made in observing and analyzing the matter distribution on a large scale. New effective numerical codes were prepared for numerical simulations and new statistical methods of identification of different elements of the large scale structure have been proposed. Demianski and his collaborators from the Theoretical Astrophysical Center in Copenhagen, University of Durham and Astronomical Institute in Potsdam compared the efficiency of different statistical methods. New statistical methods were proposed for large deep galactic surveys which will be used to analyze data from the 2dF and the Sloan Digital Sky Survey. In collaboration with a group of astrophysicists from the Universita di Napoli, Demianski analyzed the influence of local non-homogeneities of matter distribution in the universe on light propagation. Local non-homogeneities can change the distance estimation. This effect has been applied to study gravitational lensing of distant quasars and to estimate the error of the Hubble constant determination from observations of Type Ia supernovae.

Demianski has also been active in the European Planck consortium where he is a Co-principal Investigator in the Low Frequency Instrument and in the CMBNET program where he is a Principal Investigator responsible for studying the topological signature of the universe in cosmic microwave background radiation data.

2.4 Martin

Martin participated in the Williams College Eclipse Expedition to Lusaka, Zambia. He supervised an experiment carried out during the total solar eclipse to image the corona at the same scale and with the same filter as one in the C1 coronograph on board SOHO.

Martin continued his responsibilities for maintaining the World Wide Web pages for the Astronomy department and, sponsored by Harcourt College Publishing, for Pasachoff On-Line, a site devoted to Pasachoff’s introductory astronomy textbook, *Astronomy: From the Earth to the Universe* and for the site for Pasachoff’s other textbook, coauthored with Alex Filippenko of Berkeley, *The Cosmos: Astronomy in the New Millennium*. Martin also develops and maintains web pages for some of the astronomy courses and the observatory (see www.williams.edu/astronomy). These pages contain links to useful astronomy sites and provide a forum for students to display images that they have taken with the observatory’s CCD system and photographic cameras as part of their observing projects.

2.5 Students

Joey Shapiro ’01 wrote a senior thesis with Prof. Demianski and with Prof. Colin Adams of the Mathematical Sciences Department on ‘‘If Space is Flat – the Topology of a Euclidean Universe.’’ Recent astronomical observations suggest that the geometry of the universe is flat. If this turns out

to be true, then the shape of space is restricted to only eighteen different possible topologies. Her thesis classifies and discusses the eighteen possible topologies for a flat universe, and then begins the observational search for the shape of the universe with an analysis of the spatial distribution of gamma ray bursts.

The thesis of Misa Cowee ’01, supervised by Prof. Demianski, concerned the large-scale structure of galaxies in the universe. It involved numerically simulating the process of structure formation since the early universe, and considering a nonzero cosmological constant (a repulsive force causing the expansion of the universe to accelerate, has been observationally detected through studies of distant supernovae) as the primary force affecting structure formation.

Matthew Silver ’01, a double major in astrophysics and art, wrote an art thesis relating the theories of Cubism in the arts and Special and General Relativity in physics. Starting from a consideration of the similarities between Renaissance art and science, he explored the differences between this older tradition and the Modern/Postmodern paradigm. He paid special attention to the shifting understanding of the relationship of human knowledge to the world that occurred during the nineteenth century. He concluded with a comparison of Renaissance and Modern art works, and a discussion of our ‘‘Postmodern’’ age.

Darik Vélez ’01 wrote a thesis about his observations of the ionosphere based on radar studies he made during his summer program at the National Atmospheric and Ionospheric Observatory at Arecibo, Puerto Rico. He worked with Sixto Gonzalez there and during the year. Pasachoff was his local thesis advisor.

Bethany Cobb ’02 did research off-campus during the summer of 2001 at Caltech’s Jet Propulsion Laboratory in Pasadena, CA, working with Dr. Bonnie Burrati on light curves of Triton. Cobb will present a paper on her results at the DPS meeting in New Orleans in November 2001.

3. LECTURES, CONFERENCES & SERVICE

At the General Assembly of the International Astronomical Union held in Manchester, England, in August 2000, Pasachoff was elected Vice-President of Commission 46 on Education and Development. In the normal scheme, he would become president at the Sydney IAU General Assembly in July 2003. Pasachoff continues as U.S. National Liaison to the Commission. Pasachoff continues on the science board of the *World Book*, became an advisor for the forthcoming *World Book Biographical Encyclopedia*, and continued as consulting editor for astronomy of the *McGraw-Hill Scientific Encyclopedia* and *Yearbooks*. He continues on the advisory board of *Odyssey*, an astronomy magazine for children. He became the Astronomy Expert for Microsoft’s *Encarta*, a CD-ROM encyclopedia. See encarta.msn.com. Pasachoff continues as science book reviewer for *Key Reporter*, the Phi Beta Kappa newsletter.

Pasachoff taught a Winter Study course on Leadership in Astronomy, as part of the Leadership Cluster. Visitors included James Voelkel ’84 of John Hopkins University, speaking on the history of astronomy, and Robert Williams of the Space Telescope Science Institute, speaking on contemporary leadership in astronomy, with partial sponsorship from the Lecture Committee and the Winter Study Committee.

Kwitter continued to serve on the Space Sciences panel of the National Research Council Associateship Programs Review. Kwitter also reviewed manuscripts for several astronomy journals. In addition she continued as a member on two committees of the American Astronomical Society: the selection committee for the Annie Cannon Award, and the Committee on the Status of Women in Astronomy. She is also on the Advisory Board of the *Encyclopedia of Astronomy and Astrophysics*, published by the Institute of Physics.

Kwitter attended meetings of the American Astronomical Society in San Diego, CA in January 2001, and in Pasadena, CA in June 2001, presenting a poster paper at the latter: ‘‘Testing Nucleosynthesis Theories of Sulfur, Chlorine and Argon with Planetary Nebulae.’’ She designed and taught a new sophomore-level tutorial on ‘‘Extraterrestrial Life in the Galaxy: A Sure Thing or a Snowball’s Chance?’’ The course combined aspects of astronomy, biology, chemistry, geology, and sociology in the investigation of the likelihood of life arising elsewhere in the Galaxy and our chances of detecting it. This course will be offered in alternating fall semesters, the next to be Fall 2002.

4. STUDENT OBSERVING & PLANETARIUM

Under the guidance of Steve Martin, the observatory continues to be used in support of the astronomy curriculum. Over 81 introductory astronomy students completed at least five observations of celestial objects over the course of the academic year. These included observations, photographs, and CCD images of the sun, moon, planets, nebulae and galaxies.

Student roof observatory TA’s responsible for operating the telescopes, participating in the research projects, and assisting introductory students with assignments, included Bethany Cobb ’02, Misa Cowee ’01, Wei-Li Deng ’03, Kathleen Gibbons ’03, David Gioiello ’02, Christopher Holmes ’03, Daniel Seaton ’01, Matthew Silver ’01, Joey Shapiro ’01, and Kristen Shapiro ’03. The Milham Planetarium was run by Misa Cowee ’01, Daniel B. Seaton ’01, Matthew Silver ’01, and Darik Vélez ’01. The fall show was ‘‘Oh Hubble, My Hubble: A Journey Through the Universe with the Hubble Space Telescope.’’ Summer shows were given by the summer research students.

5. COLLOQUIA

Eric Pilger, Hawaii Institute of Geophysics and Planetology/SOEST ‘‘Hotspot Detection: Remote Monitoring of Fires and Volcanoes Using Weather Satellites’’

James Voelkel, The Johns Hopkins University, ‘‘The Early Reception of Keplerian Astronomy in the 17th Century’’

Robert Williams, Former Director of the Space Telescope Science Institute, ‘‘Probing the Universe with the Hubble Space Telescope’’

Alphonse Sterling, Marshall Space Flight Center, ‘‘Big and Small Explosions on the Sun’’

Ted Jacobson, University of Maryland ‘‘Black Hole Entropy and the Holographic Principle’’

6. POSTGRADUATE PLANS OF ASTROPHYSICS MAJORS

Misa M. Cowee: graduate school in planetary science at UCLA; Kenneth A. Dennison: graduate school in physics at Cornell; Joel M. Iams: Marine Corps Officer; Duane Lee: teaching high-school physics; Daniel B. Seaton: Working on solar satellite data at Harvard-Smithsonian Center for Astrophysics; Joey R. Shapiro; teaching in Switzerland and preparing for graduate school application; Matthew R. Silver: Master's program at International Space University, Strasbourg, France; Darik O. Vélez: Teaching at Westminster School, Connecticut

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