

University of Hawaii
Institute for Astronomy
Honolulu, Hawaii 96822

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This report covers the period from 1 October 2001 through 30 September 2002, and was compiled in October 2002.

1. INTRODUCTION

The Institute for Astronomy (IfA) is the astronomical research organization of the University of Hawaii (UH). Its headquarters is located in Honolulu on the island of Oahu near the University of Hawaii at Manoa, the main UH campus. It also maintains offices in Waiakoa on the island of Maui, and in Hilo on the island of Hawaii. The IfA is responsible for administering and maintaining the infrastructure for the Haleakala High Altitude Observatory Site on Maui and for Mauna Kea Observatories (MKO) on Hawaii.

More information is available at the Institute's World Wide Web site: www.ifa.hawaii.edu.

2. STAFF

The scientific staff during this report period consisted of Joshua E. Barnes, Ann M. Boesgaard, Fabio Bresolin, Schelte J. Bus, Kenneth C. Chambers, Paul H. Coleman, Antoinette Songaila Cowie, Lennox L. Cowie, Harald Ebeling, Christ Ftaclas, Donald N. B. Hall, James N. Heasley, J. Patrick Henry, George H. Herbig (emeritus), Klaus-Werner Hodapp, Esther M. Hu, David C. Jewitt, Robert D. Joseph, Nick Kaiser, Rolf-Peter Kudritzki (Director), Jeffrey R. Kuhn, Barry J. LaBonte, Jing Li, Haosheng Lin, Gerard A. Luppino, Eugene A. Magnier, Eduardo L. Martín, Robert A. McLaren, Karen J. Meech, Roberto H. Méndez, Donald L. Mickey, Tobias C. Owen, Andrew J. Pickles, John T. Rayner, Bo Reipurth, David B. Sanders, Theodore Simon, Alan Stockton, István Szapudi, David J. Tholen, Alan T. Tokunaga, John L. Tonry, R. Brent Tully, Richard J. Waincoat, Jonathan P. Williams, and Gareth Wynn-Williams.

Postdoctoral fellows included Hervé Aussel (James Clerk Maxwell Fellow), Pierre Baudoz, Yanga R. Fernández, Michael Liu (Parrent Fellow), Andisheh Mahdavi (Chandra Fellow), Jana Pittichová (NATO-NSF Postdoctoral Fellow), and Norbert Przybilla.

Three students, Robert Whiteley, Robert Thornton, and George Bendo, completed requirements for the Ph.D. degree. The other graduate students during the report period were Sean Andrews, James Armstrong, Elizabeth Barrett, Brian Barris, James Bauer, Sandrine Bottinelli, Peter Capak, Michael Connelley, Michael Cushing, Scott Dahm, David Donovan, Henry Hsieh, Catherine Ishida, Yuko Kakazu, Dale Kocevski, Sebastien Lefranc, Elizabeth McGrath, Megan Novicki, Maria Pereira, Daniel Potter, Barry Rothberg, Scott Sheppard, Brian Stalder, Wei-Hao Wang, Kathryn Whitman, and Mark Willman. For more information about the graduate program, see www.ifa.hawaii.edu/gradprog.

Visiting colleagues included Amy Barger, Olivier Guyon, Fred Lo, Sebastien Matte, and Ralph Timmermeester.

2.1 New Faculty

Visiting Astronomer Reipurth arrived in December 2001 on a three-year appointment. He studies star formation and molecular clouds. He has initiated the Center for Star and Planet Formation while at IfA. Coleman, Ftaclas, and Méndez joined the staff in January 2002. Coleman's research interests are primarily the large-scale structure of the universe. He also is an advocate for fractal mathematical methods in the analysis of astronomical objects. Ftaclas is interested in instrumentation, extrasolar planets, and brown dwarfs. Méndez is primarily interested in planetary nebulae. Williams joined the staff in September 2002. He studies the molecular interstellar medium and star-forming regions using millimeter- and submillimeter-wavelength telescopes.

2.2 Honors and Awards Received

Dr. François Roddier, former head of the IfA Adaptive Optics Group, received the 2002 Maria and Eric Muhlmann Award of the Astronomical Society of the Pacific. This award honors scientists who have made important discoveries based on their work in developing new instruments and techniques. Graduate student Brian Barris won the 2001 Helen Jones Farrar/ARCS Scholarship for his work on the extragalactic distance scale and the properties of high-*z* supernovae.

3. MAUNA KEA OBSERVATORIES

The telescopes in operation during the report period were the UH 2.2-m and 0.6-m telescopes; the 3-m NASA Infrared Telescope Facility (IRTF), operated by the UH under a contract with NASA; the 3.6-m Canada-France-Hawaii Telescope (CFHT), operated by the Canada-France-Hawaii Telescope Corporation on behalf of the National Research Council of Canada, the Centre National de la Recherche Scientifique of France, and UH; the 3.8-m United Kingdom Infrared Telescope (UKIRT), operated in Hawaii by the Joint Astronomy Centre (JAC) based in Hilo on behalf of the Particle Physics and Astronomy Research Council of the United Kingdom; the 15-m James Clerk Maxwell Telescope (JCMT), a submillimeter telescope operated by the JAC on behalf of the United Kingdom, Canada, and the Netherlands; the 10.4-m Caltech Submillimeter Observatory (CSO), operated by the California Institute of Technology for the National Science Foundation (NSF); the Hawaii antenna of the Very Long Baseline Array (VLBA), operated by the National Radio Astronomy Observatory (NRAO); the 10-m Keck I and Keck II telescopes of the W. M. Keck Observatory, which is operated by the California Association for Research in Astronomy for the use of astronomers from the California Institute of Technology, the University of California system, NASA, and UH; the 8.3-m Subaru Telescope, operated by the National Astronomical Observatory of Japan (NAOJ); and the 8.1-m Gemini North Telescope, built by an international partnership and managed by the Association of Uni-

versities for Research in Astronomy. At the Submillimeter Array (SMA), installation and commissioning of the eight 6-m antennas continued. The SMA is a collaborative project of the Smithsonian Astrophysical Observatory and the Institute of Astronomy and Astrophysics of the Academia Sinica of Taiwan.

4. HALEAKALA OBSERVATORIES

4.1 Mees Solar Observatory

Mees Solar Observatory supports IfA solar scientists in data acquisition by running diverse observational programs with its telescope cluster. The observatory regularly co-observes with the satellites *Solar and Heliospheric Observatory (SOHO)*, *Transition Region and Coronal Explorer (TRACE)*, and *Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI)*. It also participates in special satellite and ground-based observatory campaigns. The observatory's complement of instruments includes the Imaging Vector Magnetograph (IVM), Haleakala Stokes Polarimeter, Mees CCD Imaging Spectrograph (MCCD), Mees White Light Telescope, and Coronal Limb Imagers.

4.2 Solar-C

The Solar-C instrument is a 0.5-m off-axis coronagraphic reflecting telescope adjacent to the Mees Solar Observatory. This instrument (1) allows coronal observations that have not been realized, even from space, (2) develops technology that IfA scientists believe will be used for future satellite observations, and (3) supports several long-term coronal observing platforms that extend intermittent coronal space observations. Unlike most telescopes, light strikes the Solar-C mirrors off axis, at an angle to their surfaces. No light is blocked, reflected, scattered, or diffracted by the mirrors or their support structure aside from the superpolished optical surfaces.

4.3 LURE Observatory

LURE is a satellite laser ranging (SLR) observatory. LURE utilizes a high-powered pulsed laser to obtain distance measurements to satellites in Earth orbit. LURE is funded by the Space Geodesy Networks and Sensor Calibration Office of NASA Goddard Space Flight Center. The missions of the target satellites include monitoring of Earth resources and climate parameters, measurements of ocean levels and temperatures, plate tectonics, and the improvement of the Global Positioning System (GPS), as well as special missions related to the physics of tethered satellite systems. LURE is capable of providing data 21 hours per day, 7 days per week. It routinely ranks in the top 5 of the 39 ILRS (International Laser Ranging Service) satellite ranging stations in both quality and quantity of data.

4.4 AEOS Haleakala Atmospheric Characterization Project

Haleakala Observatories is under contract to the Air Force Research Laboratories to conduct a research program known as the AEOS Haleakala Atmospheric Characterization

(AHAC). This program supports the U.S. Air Force Advanced Electro-Optical System (AEOS) Telescope on Haleakala by providing comprehensive atmospheric characterization and timely prediction of inclement weather conditions at the observatory site. The instrument suite that supports these site measurements includes a daytime/nighttime optical seeing monitor and a network of remote meteorological systems linked by radio modems. The optical seeing monitor captures star image data at high frame rates and uses a differential image motion technique to allow the computation of seeing statistics over intervals of a few seconds. Data from the remote meteorology stations are processed using an artificial intelligence program to generate locally specific predictions of adverse weather events on a time horizon of 30 minutes. For more information, see the Web site at banana.ifa.hawaii.edu.

4.5 MAGNUM Telescope Project

The 2-m Multicolor Active Galactic Nuclei Monitoring (MAGNUM) Telescope is dedicated to studying the variation of light from active galactic nuclei (AGNs). The project is a collaboration between the University of Tokyo and UH. The main scientific objective of MAGNUM is to measure distances to AGNs and quasars up to $z=1$. The telescope is designed to be operated remotely and to conduct observations autonomously. For more information, see <http://merope.mtk.nao.ac.jp/~yuki/mage-html>.

4.6 Faulkes Telescope

See Sec. 7.2.

5. INSTRUMENTATION

Both the visible and the infrared arms of the AEOS spectrometer are now working. The main focus for the remaining work on the spectrometer is on control software and the user interface.

Work continued on the 85-actuator curvature-sensing adaptive optics system Hōkūpa'a-85 under Dr. Christ Ftacis, who assumed direction of the project in January 2002. A new design for the optical layout features all-reflective wavefront sensing optics, and the instrument design is now much more compact than the previous design was. The instrument is scheduled to be completed in the first half of 2003 and will become a user instrument on the Gemini South Telescope.

Instrumentation work at Mees and Solar-C during the past year included a filter wheel with improved blocking filters that was installed in the IVM, and an upgrade to the MCCD camera and data system that will permit both faster cadence and increased field of view for observations of solar flare spectra.

A near-infrared spectropolarimeter is being built by Lin for installation on the Solar-C telescope. It is intended for studies of magnetic fields in the solar photosphere and corona.

A mid-infrared spectrograph, also for use at Solar-C, is being fabricated. It will be used primarily for coronal line searches in the 2- to 5- μm wavelength range.

The IfA Solar Group is an active participant in planning for a new 4-m solar telescope called the Advanced Technology Solar Telescope (ATST). The National Solar Observatory is the PI institution. UH scientists are working on two instrumentation efforts: construction of a set of Sky Brightness Monitors to be installed as part of the site survey instrument suite at each of the six candidate sites and a conceptual design for a near-infrared spectropolarimeter. The latter is intended as an early facility instrument for the ATST.

6. PAN-STARRS

IfA has been awarded a \$3.4 million grant by the Air Force Research Laboratories to design a new observatory to survey the entire sky and detect very faint objects. The Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) is currently conceived of as an array of small telescopes, and sites on Mauna Kea and Haleakala are being considered. Planned to become operational in 2006, Pan-STARRS will be more powerful for survey work than all existing telescopes combined. Kaiser is the principal investigator.

A major goal of the project is to identify and track asteroids that might collide with Earth. Pan-STARRS will also detect large numbers of objects in the outer solar system, inventory stars in the Galaxy, and probe the structure and content of its disk and halo. It should also detect many planets in orbits around other stars. Roughly one-third of the observing time will be devoted to ultra-deep imaging of a number of selected fields. This will allow detection of galaxies, quasars, and stars to very faint magnitudes. One key application of these data will be mapping the distribution of dark matter in the Universe through the gravitational lensing effect. Such a dark-mass inventory will be invaluable for testing theoretical models for the formation of structure in the Universe.

Each of the telescopes will be equipped with a state-of-the-art electronic camera with 10^9 pixels. The use of small telescopes has the advantage of low cost, rapid construction, diversity of operational modes, a simple optical design, and a low environmental impact. The system will be able to scan approximately one-tenth of the sky in a single night.

Pan-STARRS will be the first survey telescope to use sensitive electronic CCD detectors to image the entire visible sky at optical wavelengths. The IfA is collaborating with Lincoln Laboratories of the Massachusetts Institute of Technology (MIT) to develop the advanced CCDs. The system will be able to take images at a rate of 1 to 2 per minute.

Once operational, Pan-STARRS will generate huge quantities of data. To process these, IfA astronomers are collaborating with the Maui High Performance Computer Center (MHPCC) and with Science Applications International Corporation (SAIC), a leader in the field of massive databases.

The huge database generated by Pan-STARRS will be made available over the National Virtual Observatory so that others may use it for education and research.

7. OUTREACH

Heasley continued to serve as outreach coordinator. Monthly star charts and a quarterly newsletter continued to

be sent to members of the Friends of Hawaii Astronomy and other interested parties. An open house for the general public was held at the Manoa facility on 6 October 2001. It included lectures, tours, and displays. IfA faculty and staff also participated in AstroDay 2K2 on 20 April in Hilo. Other outreach activities included public lectures and star parties.

7.1 TOPS Teacher Enhancement Program

The summer of 2002 marked the fourth year of support under a five-year the National Science Foundation (NSF) grant for the TOPS (Toward Other Planetary Systems) teacher enhancement program. The workshops are three weeks of intensive astronomy training for teachers and high school students.

This year 25 teachers and 19 students participated in the workshop. One of the TOPS participants this year, Melissa Lambertson, was a prize recipient of the Discovery Channel Young Scientist Challenge (DYSC), which is associated with science fairs around the nation, and occurs each fall in Washington, D.C. She was one of 4,000 middle school entrants in grades 5–8 selected by their science fair directors to enter their science projects in the DYSC.

The teachers and students participated in a wide variety of hands-on activities ranging from archaeoastronomy to grinding telescope mirrors. They also engaged in observing projects that use small telescopes, including simple visual observations of the moon, planets, and nebulae, and sophisticated variable star observations using a CCD camera, photometer, and spectrographs. One of the highlights of the workshop was a tour of Mauna Kea. TOPS also benefited from a core of volunteers from the Bishop Museum (Honolulu) and the Hawaiian Astronomical Society.

TOPS integrates the humanities with astronomy to make the science interesting to a wider audience. Participants worked under the direction of Clive Ruggles, an archaeoastronomer from University of Leicester, UK. They surveyed ancient heiau (sacred sites) to determine their astronomical significance. Chief Joseph Chasing Horse, an internationally known Native American cultural consultant, and Richard Shope, the education and public outreach coordinator of the Outer Planets/Solar Probe project at NASA's Jet Propulsion Laboratory, presented talks and workshops on Lakota astronomy. Nainoa Thompson, president of the Polynesian Voyaging Society, lectured on canoe voyages from Hawaii to Tahiti and Rapa Nui (Easter Island).

Support for the TOPS workshops also comes from private donations and in-kind support from NASA. For the third year in a row, a staff member from the Astrobiology Institute at NASA Ames Research Center worked, at NASA's expense, with the TOPS teachers and students. The NASA IRTF also provided support.

Another long-standing supporter of TOPS is Janet Mattei, the director of the Amateur Association of Variable Star Observers (AAVSO). She spends two weeks each summer with the TOPS teachers and students to lecture on variable stars, to introduce them to the Hands On Astrophysics exercises AAVSO has developed, and to assist with observing projects. This year, 30 TOPS participants and staff gave presentations

at the AAVSO conference in Kona, Hawaii that followed the TOPS program.

Additional information about TOPS is available at www.ifa.hawaii.edu/tops.

7.2 Faulkes Telescope

The IfA and the Faulkes Telescope Corporation are collaborating to locate a 2-m telescope facility at the University's Haleakala High Altitude Observatory site on Maui. The Dill Faulkes Educational Trust of the United Kingdom (UK) is financing the telescope, which will be named in honor of Dr. Martin "Dill" Faulkes, the British scientist and software developer who founded the trust.

The ceremonial blessing and groundbreaking for the Faulkes Telescope took place on 2 November 2001. By the end of the report period, the foundation had been laid, and the enclosure for the telescope had arrived on Haleakala. The telescope itself is scheduled to arrive in December 2002, and plans call for the telescope to be operational in 2003.

The Faulkes Telescope will be the largest professional grade telescope in the world dedicated to education and public outreach. The project will draw on young people's interest in astronomy to teach them what science is. It will offer students in the UK and Hawaii hands-on research experience. Students will conduct research projects under the mentoring of their teachers and professional astronomers. In Hawaii, access to the telescope will be available to public and private schools and to the science programs of the UH system and other local colleges. It will be operated remotely from control centers in the UK and on Maui.

The first instrument to be installed will be a state-of-the-art CCD camera. Later, funds will be sought to add an infrared camera to allow operation of the telescope during daylight hours. A spectrograph is also under consideration as a future instrument.

Heasley continues as the IfA project scientist for the Faulkes Telescope Project.

7.3 Research Experiences for Undergraduates and Teachers

Two outreach programs, Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET), continued for a second year. The REU program is supported by a five-year grant from NSF, which also provided supplementary funds for the RET program. Heasley is the principal investigator, and Meech is the co-investigator.

Six REU students spent 10–12 weeks in the summer as full-time research assistants under the supervision of a faculty mentor. The participating students were Jennifer Beard (Virginia Tech), Elizabeth Fernandez (New Mexico Institute of Mining and Technology), Matthew Graham (Oklahoma

State), Alaina Henry (University of Rochester), Collete Salyk (MIT), and Tiffany Titus (Illinois Institute of Technology). The students received travel money and a stipend to cover living expenses. This year the students were mentored by Barger, Boesgaard, Kuhn, Reipurth, Tholen, and Wainscoat.

The two teachers in the RET program, Jean Hamai and Clyde Kobashigawa, were both former participants in the TOPS Teacher Enhancement workshops. They worked with Heasley on the analysis of *Hubble Space Telescope* observations of globular clusters and on developing robust numerical techniques to detect faint asteroids in digital images. The purpose of this program is to develop a core of local teachers with experience in research projects who will be able to serve as resource teachers for those using the Faulkes Telescope.

The REU and RET programs received additional support from Sun Microsystems, which loaned the IfA a Sunray server and eight workstation displays for participants' use.

8. SCIENTIFIC RESEARCH

Listed below are the major areas of research at the IfA, followed by the names of those active in that area (some names are listed more than once). Further information about research activities can be found at www.ifa.hawaii.edu/research, on the home pages of individual faculty members (accessible through www.ifa.hawaii.edu/faculty), and in the list of publications (see Sec. 9). See Sec. 5 for more information about instrumentation projects.

Galactic and extragalactic astronomy: Aussel, Bresolin, Chambers, Coleman, Cowie, Ebeling, Henry, Hu, Joseph, Kaiser, Kudritzki, Luppino, Mahdavi, Pickles, Sanders, Songaila, Stockton, Tonry, Tully, and Wainscoat.

Star formation and interstellar matter: Aussel, Ftaclas, Hodapp, Liu, Magnier, Martín, Méndez, Rayner, Reipurth, Tokunaga, and Wynn-Williams.

Stellar astronomy: Boesgaard, Bresolin, Heasley, Herbig, Przybilla, Simon, and Williams.

Solar system astronomy: Bus, Fernández, Jewitt, Meech, Owen, Pittichová, and Tholen.

Solar physics: Kuhn, LaBonte, Li, Lin, and Mickey.

Theoretical studies: Barnes, Kaiser, and Szapudi.

Instrumentation: Baudoz, Ftaclas, Hall, Hodapp, Luppino, Mickey, Rayner, Stockton, Tokunaga, and Tonry.

9. PUBLICATIONS

For a list of publications for calendar year 2001, go to the IfA Web site: www.ifa.hawaii.edu/publications/annual_reports.html. More recent publications are listed at www.ifa.hawaii.edu/publications/preprints and at www.ifa.hawaii.edu/publications/2002_PubsList.html.

Rolf-Peter Kudritzki, Director