University of Hawaii
Institute for Astronomy
Honolulu, Hawaii 96822

This report covers the period from 1 October 2002 through 30 September 2003, and was compiled in October 2003.

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, Mark R. Chun, 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, Robert Jedicke, David C. Jewitt, Robert D. Joseph, Nick Kaiser, Rolf-Peter Kudritzki (director), Jeffrey R. Kuhn, Barry J. LaBonte, Jing Li, Haosheng Lin, Michael Liu, 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, Eric V. Tollestrup, John L. Tonry, R. Brent Tully, Richard J. Wainscoat, Jonathan P. Williams, and Gareth Wynn-Williams.

Postdoctoral fellows included Hervé Aussel, Fabrizio Bernardi, Crystal Brogan (James Clerk Maxwell Fellow), Gayoung Chon, Yanga R. Fernández (SIRTF Fellow), Pablo Fosalba, Michael Liu (Parrent Fellow), Andisheh Mahdavi (Chandra Fellow), Jun Pan, Jana Pittichová, Paul Price, Norbert Przybilla, and Luca Rizzi. In June, Aussel's term as James Clerk Maxwell Fellow ended, and he began working for the Pan-STARRS project. In September, Liu completed his term as Parrent Fellow and was hired as an assistant astronomer.

James Bauer and Daniel Potter completed requirements for the Ph.D. degree. The other graduate students during the report period were Sean Andrews, James Armstrong, Elizabeth Barrett, Brian Barris, Sandrine Bottinelli, Peter Capak, Li Hsin Chien, Michael Connelley, Michael Cushing, Luke Dundon, Scott Dahm, David Donovan, Hai Fu, David Harrington, Henry Hsieh, Catherine Ishida, Yuko Kakazu, Jeyhan Kartaltepe, Dale Kocevski, Elizabeth McGrath, Nicholas Moskovitz, Megan Novicki, Maria Pereira, Mark Pitts, Steve Rodney, 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 (University of Wisconsin-Madison), Akiva Bar Nun (Tel Aviv University, Israel), Troelz Dencer (Danish Technical University), Miwa Goto (Subaru Telescope), Tim Kendall (Observatorio Astronomico de Lisboa, Portugal), and Andreas Siefahrt and Alexander Szameit (from Germany).

2.1 New Faculty

Robert Jedicke joined the faculty in March to help guide the search for near-Earth asteroids as part of the Pan-STARRS project. Eric Tollestrup became IRTF deputy division chief (Hilo) in June.

2.2 Honors and Awards Received

Henry received a Humboldt Research Award for Senior U.S. Scientists from the Alexander von Humboldt Foundation.

The publishers of Science Citation Index named four IfA scientists, L. Cowie, Henry, Sanders, and Tully, ''highly cited authors.'' The ISIHighlyCited.com Web site lists them among 249 of the world's most cited and influential researchers in the space sciences, the top one-half of one percent of all publishing researchers in this field.

Sheppard was selected as the 2003 Helen Jones Farrar Achievement Rewards for College Scientists (ARCS Scholar). Rothberg and Kocevski received NASA fellowships.

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 cooperative agreement 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 Frederick C. Gillett Gemini Telescope (Gemini North), built by an international partnership and managed by the Association of Universities for Research in Astronomy.

At the Submillimeter Array (SMA), installation and commissioning of the eight 6-m antennas were close to completion. The official dedication of the facility will be on November 22, 2003. 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 coobserves 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 SOLARC

The SOLARC (Scatter Free Observatory for Limb Active Regions and Coronae) 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 SOLARC 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.

Two new infrared spectrometers were implemented in 2003. The first is a 1–5 μm high-background differential spectrograph designed primarily for use in the thermal infrared, and the second is a multifiber spectrograph that is designed for the 1–2.2 μm regime. Both spectrographs will be used for measuring coronal magnetic fields.

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. See koa.ifa.hawaii.edu/Lure/.

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 merope.mtk.nao.ac.jp/~yuki/magnumhp/index.htm.

4.6 Faulkes Telescope

First light occurred on the night of August 7–8, 2003. For more information about this project, see the Outreach section of this report.

4.7 HiVIS Spectrograph

The HiVIS visible and infrared high-resolution spectrograph was commissioned for use on the AEOS telescope.

This facility instrument operates from a wavelength of 0.39 μm out to 2.2 μm with spectral resolution of between 10,000 and 40,000. It is the highest resolution widest wavelength coverage spectrograph on a 4-m-class telescope anywhere in the world. It is being routinely used for high-resolution stellar spectroscopy.

4.8 Kermit Infrared Imager

A 2048×2048 pixel 1–2.5 μm infrared imaging camera system has been commissioned for use on Haleakala. This fast readout, low-scattered light camera is designed to be used with the AEOS telescope and other infrared instrumentation at the summit of Haleakala.

5. INSTRUMENTATION

Work continued on the 85-actuator curvature-sensing adaptive optics system Hōkupa'a-85, which will be installed on the Gemini South telescope. The electronics are completely integrated, the optics have been installed and aligned, and all mechanisms, aside from the deformable mirror, have been installed and tested. A change in the deformable mirror material and a new electrode design have resulted in a slight delay, but the final deformable mirror is in hand and is currently being wired up. The new mirror material can be coated directly, avoiding the need for replication of the mirror surface on the PZT material. The predicted Strehl ratio for the entire system, assuming 0.75 arcsec seeing conditions, is $\sim$0.6 in the *H* band and $\sim$0.7 in the *K* band.

The Orthogonal Parallel Transfer Imaging Camera (OPTIC) was fully commissioned and used throughout the spring semester by UH observers, and it has traveled to WIYN Observatory twice as a visitor instrument. It offers some features beyond the standard 4096×4096 imager, such as image motion compensation, the ability to track moving objects, and point-spread function (PSF) shaping for planet detection. Howell *et al.* (2003, PASP, 115, 1340) describe some of these unusual capabilities.

The ULBCam was completed and set up at the UH 2.2-m telescope in time for its inaugural run in early September. With four working 2048×2048 arrays, this 16 megapixel camera, the world's largest format infrared imager, worked well from the outset and produced a large amount of data. It is quite heavily scheduled throughout the rest of the semester. Apart from some minor tweaking for ground-based observing, the construction phase has now been successfully completed.

6. PAN-STARRS

The Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) project will create a wide-field imaging system with an innovative design. It is supported by a grant from the Air Force Research Laboratories. Kaiser is the principal investigator.

Pan-STARRS will be composed of four 1.8-m telescopes observing the same region of sky simultaneously. Each telescope will have a 3° field of view and be equipped with a CCD focal plane mosaic with 10^9 pixels. The spatial sampling of the sky will be about 0.3 arcsec. In survey mode, i.e., searching for potential killer asteroids, Pan-STARRS will cover 6,000 deg^2 per night. The whole available sky as seen from Hawaii will be observed three times during the dark time in each lunation.

With exposure times varying between 30 and 60 seconds, Pan-STARRS is expected to reach a limiting magnitude of 24. The focal plane will employ orthogonal transfer CCDs (OTCCDs) that allow the shifting of charge along both rows and columns. This will allow the use of on-chip image motion compensation, i.e., the equivalent of ''tip-tilt'' image compensation but without any moving parts.

During the report period, there was rapid progress on science studies and the design of telescopes, detector systems, and data systems. A project management structure was established. Thomas Dombeck was hired as project manager, David Hafner as project program engineer, and Robert Jedicke as a specialist in near-Earth objects.

See pan-starrs.ifa.hawaii.edu for more information.

7. CENTER FOR STAR AND PLANET FORMATION

IfA astronomers and their colleagues at other observatories in Hawaii inaugurated the Center for Star and Planet Formation (CSPF) in 2002. Colleagues at the Hawaii Institute of Geophysics and Planetology provide additional expertise about meteorites. The CSPF strives to facilitate communication among researchers who specialize in different disciplines, each of which provides insight into important but limited aspects of how stars and planets form. Weekly seminars by IfA staff and visitors help keep CSPF members abreast of the latest research and developments in the field. The seminars take place in Manoa, with a video link to IfA-Hilo. A program to bring long-term visitors to IfA is on the drawing board, and plans are also underway for starting a summer school that will bring together, from all over the world, graduate students working on a doctorate in star or planet formation. In addition, the CSPF is in the process of organizing a major international meeting, ''Protostars and Planets V,'' to be held in October 2005. For more information, see www.ifa.hawaii.edu/CSPF.

8. UH ASTROBIOLOGY LEAD TEAM

In June, NASA announced that a group led by Meech was selected as one of six new Astrobiology Lead Teams. The award will bring over $5 million to UH over the next 5 years. Astrobiology research programs that will be supported at UH will have a special focus on water as the habitat of, and chemical enabler for, life.

This research will have the following foci: the abundance and distribution of water in the interstellar medium and in circumstellar disks; the water content, D/H ratio, and dynamics of icy outer solar system bodies such as comets and Kuiper Belt objects; laboratory experiments related to complex molecule trapping and formation on interstellar grains; cosmochemical studies of meteorites that record the incorporation of water into silicate material in the early solar system; models of the escape of water from the atmospheres of Earth-size planets; spacecraft- and meteorite-based research and theoretical studies of the role of water in forming the diversity of rocks and sediments on Earth, Mars, and Venus;

biological exploration of ice-covered habitats in Iceland, Antarctica, and North America with application to the search for life on Mars and Europa; biological and chemical exploration of extreme aquatic habitats in and around the Hawaiian islands including the deep-sea Kauhako Lake crater on Molokai and Lake Waiau on Mauna Kea; and development of concepts and prototype hardware for instruments that could be used to detect and characterize life on other planetary bodies. See www.ifa.hawaii.edu/UHNAI for more information.

9. OUTREACH

Heasley continued to serve as outreach coordinator until the end of August 2003. 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 April 26, 2003. It included lectures, tours, and displays. IfA faculty and staff also participated in AstroDay on April 19 in Hilo and in the Hawaii County Fair in September. Other outreach activities included public lectures and star parties.

In September, Gary Fujihara became the science education and public outreach officer in Hilo.

9.1 TOPS Teacher Enhancement Program

The TOPS (Towards Other Planetary Systems) teacher enhancement program held its final summer workshops in 2003. The purpose of TOPS has been to instruct math and science teachers about how to incorporate astronomy into their curricula. The primary goal of the June workshop, held on Oahu, was to equip the participants with the necessary skills to mentor students undertaking astronomy projects during the 2003–4 school year. Because this workshop was aimed at consolidating skills acquired in previous years, all but one of the 16 participants were TOPS alumni. A major objective of the summer workshop in Hawaii was to get teachers ready to use the Faulkes Telescope on Haleakala (see Sec. 9.2).

Besides learning to mentor student projects, the TOPS teachers honed their skills for planning and executing workshops for other teachers to give the TOPS program a significant multiplier effect. The TOPS teachers presented a teacher workshop on Maui that covered included archeoastronomy, light and spectroscopy, celestial navigation, cratering, and the expanding universe.

The primary instructors for the Hawaii workshop included TOPS director Meech, T. Slater and J. Bailey (Univ. Arizona), and J. Mattei (director, American Association of Variable Star Observers).

In addition to the workshop in Hawaii, several of the TOPS leaders directed a workshop on Pohnpei at the end of July. Fourteen returning TOPS teachers from Micronesia, as well as 13 additional teachers from Pohnpei and Kosrae, attended.

Meech procured funding to send the teachers to the meeting of the Division of Planetary Sciences of the American Astronomical Society in September 2003 to share their project ideas and attend an extrasolar planet workshop.

TOPS meetings and Maui workshops will continue the TOPS initiative. Additional information about TOPS is available at www.ifa.hawaii.edu/tops.

9.2 Faulkes Telescope

The Faulkes Telescope North is a 2-m telescope facility at the 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.

First light occurred on the night of August 7–8, 2003, and the main CCD camera was installed. The telescope is undergoing testing for pointing, tracking, and optical performance. Plans call for the telescope to be operational by the end of 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.

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. For more information, see http://www.faulkes-telescope.com/.

Trained during the summer 2003 to do remote observing, TOPS teachers are now preparing students for pilot astrobiology projects. When the Faulkes Telescope is ready in January 2004, these students will obtain images needed for them. The vision is to have them produce exemplary astronomy science fair projects. This effort is being supported by the newly granted NASA Astrobiology Lead Team at UH.

9.3 Research Experiences for Undergraduates

The Research Experiences for Undergraduates program, funded mainly by a five-year grant from NSF, continued for a third year. Eight students from the mainland and one from UH spent 10–12 weeks in the summer as full-time research assistants under the supervision of a faculty mentor. The students, their home institutions and faculty mentors were Curtis Asplund (Oberlin, Coleman), Eva-Marie David (Xavier, Simon), Trent Dupuy (Texas, Reipurth), Sharon Velez Erickson (Hawaii, Ftaclas), Audra Hernandez (Colorado, Williams), Ellen Lee (Harvard, Li), Amy Livernois (Maine, Ftaclas), Jeremy Miller (Maryland, Tholen), and Yvonne Torres (New Mexico State, Heasley).

10. 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. 11). See Sec. 5 for more information about instrumentation projects.

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

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

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

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

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

Theoretical studies of cosmology and galaxy formation: Barnes, Chon, Fosalba, Kaiser, Pan, and Szapudi.

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

11. PUBLICATIONS

For a list of publications for calendar year 2002, 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/2003_PubsList.html.

Rolf-Peter Kudritzki, Director