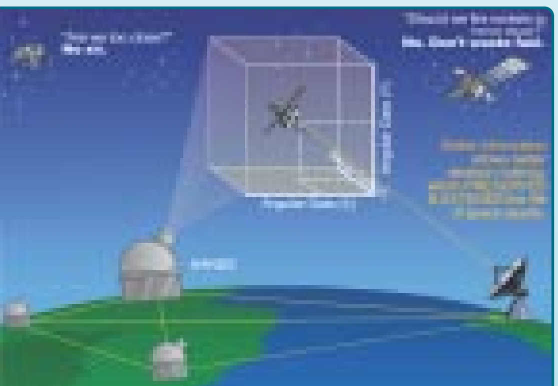
MAUI [HAWAII]
AMOS
fall 2002
Air Force Research Laboratory DETACHMENT 15

HAWAII FIRM OCEANIT WINS AIR FORCE RESEARCH LABORATORY GRANT

OCEANIT HAS BEEN AWARDED A MULTI-YEAR CONTRACT FROM THE US AIR FORCE RESEARCH LABORATORY TO PRODUCE A FULLY AUTOMATED, NETWORKED SYSTEM OF MULTI-SENSOR, REMOTE SMALL TELESCOPES TO ACQUIRE, ANALYZE, AND CATALOG SPACE-BASED ASSETS. THIS PHASE II SBIR AWARD IS THE RESULT OF OCEANIT'S BREAKTHROUGH WORK OF VERY ACCURATE SPACE OBSERVATIONS OBTAINED USING A LOW-COST TELESCOPE SYSTEM.

Typical uses for the new system will be to track satellites, and provide more precise orbital information. For example, the Air Force will be able to more accurately catalog satellites in orbit. Also, satellite owners can improve their knowledge of potential collisions with nearby space objects or debris using this data, along with collateral information. In addition, the Air Force will also be able to free up larger telescopes for more demanding tasks, by off-loading work to the Oceanit system which can track satellites just as accurately. Additional uses include surveillance of military forces and objects reentering the Earth's atmosphere. Ultimately, users of the system will be able to better identify potential problems or threats, and thus take preventive measures.



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As part of the project, Oceanit will utilize the Air Forces' award-winning "Raven" system of remote automated small telescopes built from low-cost commercial-off-the-shelf components. Oceanit's Space Systems Division played an important role in the development of Raven. Raven personnel were awarded the Air Forces' highest technology award, the "Air Force Chief Scientist Engineering Achievement Award" which recognizes outstanding contributions in research, development, or engineering.

The final "commercializable" product will be a global network of low-cost telescopes to automatically track satellites and provide invaluable supplemental data for the Air Force, other defense organizations, universities, and observatories. Oceanit's Phase II work will contribute to Hawaii's growing space capabilities and goals of a diversified economy.

A HIGH RESOLUTION IMAGING SURVEY OF A STARS

Even X-ray vision does not see everything. Despite its X-ray vision and location above the atmosphere, images from the X-ray satellite ROSAT have poor angular resolution that causes confusion in source detection. Typical uncertainties in positions are 10 Arc Seconds. By contrast, the U.S. Air Force Advanced Electro-Optical System (AEOS) 941-actuator adaptive optics system on the 3.7m telescope provides a diffraction-limited resolution of 0.04 Arc Seconds at 0.75 µm. With this superior angular resolution, a team from Lawrence Livermore National Laboratory (LLNL) led by Dr. Jennifer Patience, is conducting a survey of A stars (1.5 to 2.5 times more massive than the Sun) to resolve one of the outstanding questions raised by the ROSAT data: A stars are not expected to be X-ray sources, but some are detected by ROSAT. Different mechanisms produce the X-ray emission of higher mass

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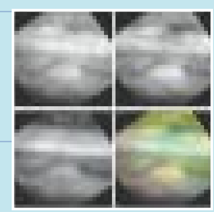
Giant Planet Imaging with the Advanced Electro-Optical System

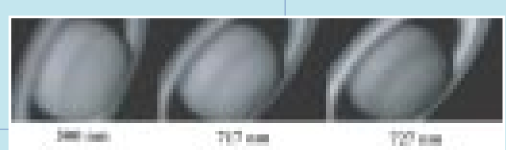
The observing team at the observation deck of Haleakala. From left to right: Takafumi Temma (NMSU graduate student, Nancy Chanover (NMSU faculty), Amy Simon-Miller (NASA/GSFC scientist), John Hillman (University of Maryland senior scientist).

IN FEBRUARY 2002, a team of planetary astronomers from New Mexico State University, University of Maryland, and NASA/Goddard Space Flight Center (GSFC) brought a specialized camera to the AFRL's 3.67-meter AEOS telescope to observe Jupiter and Saturn. The team, led by Dr. Nancy Chanover of New Mexico State University, has been studying the atmospheres of the two largest planets in our solar system for more than a decade. For this investigation, they are interested in two aspects of the atmospheres: where the cloud layers on Jupiter and Saturn are located vertically and whether they are spatially inhomogeneous, and what chemicals are coloring the clouds to render the red, orange, brown and yellow hues that we see visually on Jupiter and Saturn.

The instrument used for this investigation was developed at NASA/GSFC for high spectral resolution imaging of solar system objects. AImS, the Acousto-optic Imaging Spectrometer, employs a birefringent crystal as a tunable filter, allowing one to image in a very narrow-band, user-selected wavelength between 500-1000 nm. This provides a tremendous amount of flexibility when designing an imaging program, since one is not limited by a small number of fixed filter bandpasses. The filter is operated by the passage of an acoustic wave through the birefringent crystal (TeO_2), and the frequency of the input acoustic wave determines the wavelength of light that is diffracted through the crystal and ultimately reimaged on a CCD camera. Observations of Saturn, Jupiter, and calibration stars were made on 6, 7, and 10 February 2002 under clear and dry skies.



Three-color image of Jupiter's Great Red Spot made from a composite of red, green and blue images taken with AImS at AEOS on February 10, 2002.



Three AImS images of Saturn taken with the AEOS 3.67-meter telescope on February 7, 2002. The wavelength is listed below each image; note the change in appearance of the clouds at the polar region and in the southern mid-latitudes as the wavelength changes.

Despite several spacecraft visits and many ground-based studies, there is still much to learn about the giant planet atmospheres. With the exception of the Galileo Probe entry into Jupiter's atmosphere in 1995, which provided the first in situ measurements of a giant planet atmosphere, studies of the atmospheric vertical structure are limited to two-dimensional imaging or one-dimensional spectroscopy. When imaging, one can exploit variations in molecular absorptions in these atmospheres to "sound" to different depths, or pressure levels. In visible and near-infrared wavelengths, methane plays an important role in the quest for understanding the vertical cloud distribution of Jupiter and Saturn. The methane molecule has several absorption bands of varying strengths between 500-1000 nm. By imaging a giant planet in a wavelength corresponding to very strong absorption, one sounds high in the atmosphere. Photons at that wavelength cannot travel very far into the atmosphere before being absorbed, so any clouds that are bright and reflective in a methane absorption band are above most of the methane-absorbing gas. On the other hand, photons at a continuum wavelength can travel unencumbered through the gas until they interact with cloud particles, when they either are scattered, reflected, or absorbed. The high spectral resolution of AImS coupled with the high spatial resolution of the AEOS telescope and its tip-tilt system allow for finer vertical discrimination by imaging Jupiter and Saturn in a variety of wavelengths that step through several methane absorption bands of different strengths.

The source of the coloration of Jupiter and Saturn's cloud decks remains unknown despite many years of observations. While several trace chemicals have been proposed as the coloring agents, there is no conclusive evidence. The high spectral resolution capability of AImS allows for Jupiter and Saturn to be imaged in a very large number of colors, or wavelengths. Using a principal component analysis, information about the number of coloring agents, the spatial distribution of those agents, and the spectral characteristics of the coloring agents can be determined. High spatial resolution imaging such as that achieved at AEOS is required to separate small-scale variations in color, for example in Jupiter's Great Red Spot versus nearby smaller storm systems.

The high spectral and spatial resolution of this data set will help the team determine the vertical location of any chromophores, also providing insight into the physical processes and transport in the Jovian atmospheres. The simultaneous study of coloring agents and vertical structure in these atmospheres is important for advancing the basic understanding of the evolution of planets. Identifying which components are located at various altitudes will indicate whether photochemical production or other processes play a major role in the composition of these atmospheres. Additionally, retrieving the spectrum of a chromophore will help to identify trace species in the gas giant atmospheres.

Cadet Summer Intern Program

This past summer, AMOS hosted 3 Air Force Cadets, 1 West Point Cadet, and 1 Midshipman from the Naval Academy. Each Cadet/Midshipman spent between 3-5 weeks working on a research project at the Maui High Performance Computing Center.

Both the High Performance Computing Modernization Office (HPCMO) and Air Force Research Lab (AFRL) funded this program to give Cadets/Midshipman the opportunity to get experience with high performance computers and work alongside experienced professionals on current research projects.

The program is designed so that Cadets/Midshipmen are matched with different projects that interest them. In December of last year, white papers were generated at AMOS discussing potential research projects, length of time, location, and prerequisites to enable the Cadets/Midshipmen to understand the level of work. The Academies then allow the Cadets/Midshipmen to compete for projects based on class rankings, locations, and the field of interest.

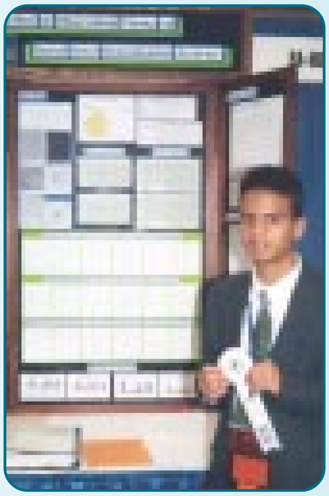
Cadet/Midshipmen had both a military and technical sponsor. The military sponsor took care of any needs that they had along with some professional development. They received a tour of the facilities and were introduced to their technical sponsor who was their day to day supervisor while working on the research project. The Cadets/Midshipmen were briefed on their responsibilities along with what to expect from both sponsors.

At the end of every week, each Cadet/Midshipman submitted an activity report to the sponsors detailing the work that was accomplished throughout the week. A final paper and presentation was required at the end of the work period. These presentations were given to a broad audience of military, technical, and management personnel.

West Point Cadet Robert Irizarry preformed regression and benchmark testing on Power 3 Tempest system. Naval Academy Midshipman Matthew Ahlert worked on passive millimeter wave imaging. Air Force Academy (AFA) Cadet Jonathan Wentzel aided high performance visualization and data set analysis. AFA Cadet Doug Ericson supported the Linux cluster scaling and performance analysis. AFA Cadet Aaron Granger calibrated MSSS mounts at the Haleakala site.

The program has provided the AMOS research community with an excellent source of talent for research projects and allowed the Cadets/Midshipmen stationed here an excellent opportunity to gain practical knowledge of high performance computers, state of the art observatories, the Air Force Research Laboratory, and Maui.

Maui Youth Research Asteroids



Matt Jachowski, a junior at Maui High School in Kahului, recently garnered several awards at the Hawaii State Science and Engineering Fair, as well as the International Science and Engineering Fair in Louisville, Kentucky, for his science project entitled “Effect of Observation Timing on Initial Orbit Determination Accuracy.” His project examined how the accuracy of asteroid orbit determination is related to the uniformity of the time intervals separating successive observations.

Jachowski’s project began while he attended the Summer Science Program (SSP) in Ojai, California. At SSP he learned physics, calculus, and astronomy. While there he also had the opportunity to use a 10-inch UCLA telescope to collect observations of asteroid 2 Pallas. Eventually, he used his new astronomy knowledge and observations of the asteroid to calculate the orbit of Pallas to less than 1% error.

Captivated, Jachowski continued examining asteroid orbit determination. Using different combinations of asteroid data, he was surprised to find that the asteroid orbits he calculated would vary from less than 1% to greater than 600% error. Intrigued, he decided to conduct a formal study of the relationship of orbit determination accuracy to the time intervals separating observations. He thought that an asteroid’s orbit could be determined most accurately if the observations used were all separated by equal time intervals. His preliminary study proved him right. He noticed a strong linear increase in orbital element error as the asteroid observations became spaced less evenly.

Eager to share his results with the public, Jachowski submitted his research to the Maui Schools’ Science Fair. He walked away from the competition “Best in Show,” an Air Force Research Award, and a trip to the Hawaii State Science and Engineering Fair as Maui’s top representative. But his research also led to another fortunate occurrence. His Physics teacher, Keith Imada, has worked with MSSS personnel for many years, and recognized his potential. Keith put him in touch with Daron Nishimoto of Oceanit. With Daron’s help, Jachowski was soon using the AFRL telescope at the RME facility in Kihei to collect observations of additional asteroids for his project. While there, he gained valuable insight and assistance from Jake Barros, Paul Sydney, and Brian Africano. They taught him how to use the telescope to obtain asteroid observations and how to reduce his information to a usable form.

Unfortunately, Jachowski was unable to completely analyze his new information in time for the state science fair, but his previous analysis did benefit from the valuable insights and experiences he had gained from his experiences at the telescope. Despite the absence of the new data, he project was stunningly successful at the state competition. He won the Hawaii Astronomical Society Award, UH School of Ocean and Earth Science and Technology (SOEST) Award, Office of Naval Research Award, Best in Category (Earth and Space Science), Best Public School Project, and Fourth overall. In all, he won over $5000 in cash awards and scholarships.

At the Intel International Science and Engineering Fair, Jachowski had the best finish of any Hawaii student, finishing 3rd in the category of Earth and Space Science ($1000), competing with 50 other students in this category. He also won the Bart and Priscilla Bok First Place Award in Astronomy from the American Astronomical Society and the Astronomical Society of the Pacific ($5000 and his research to be published in the IAPPP Communications).

Matt has been extremely grateful for the help and support he has received from the various people and agencies at the Maui High Tech Park, but he hopes too that his research can benefit them. He hopes that some of the various organizations that track satellites can use his results to more accurately carry out their calculations. His information could very well be useful, because the topic of orbit determination accuracy and its relationship to observation spacing is glossed over in even the most authoritative texts on orbit determination. Ultimately, Jachowski hopes that his research will be of real benefit to orbit determination practitioners in the real world.

Ultimately, Matt hopes that his research will be of real benefit to orbit determination...

Kawailehua Kuluhiwa, a twenty-year old Maui woman, was hired by Boeing in March of 2001 as an observer and investigator for the MSSS Data Analysis Group, supporting NASA's Near Earth Asteroid Tracking (NEAT) program. The NEAT program, (covered in the Fall 2000 AMOS Newsletter and also mentioned in the Winter 2002 Newsletter) utilizes a camera on the 1.2-meter telescope at MSSS to search the sky for previously unknown near-Earth asteroids and comets. The NEAT program is a collaboration between AMOS and the Jet Propulsion Laboratory (JPL).

This summer, Kuluhiwa was granted the opportunity to participate in a four-week internship at JPL in Pasadena, California, where she would be able to inspect NEAT images captured from the other NEAT telescope, a 1.2 meter telescope at the Palomar Observatory. This literally gave her the chance to look at the NEAT project from a different perspective.

Meeting numerous individuals with various fields of interests and knowledge were just one of the highlights of Kuluhiwa's trip. She quickly realized that this would be an unforgettable experience, as she witnessed the many amazing accomplishments and projects completed by these highly respected scientists, physicists, geologists, engineers, and astronomers. Dr. Eleanor "Glo" Helin, astronomer and principal investigator for NEAT, not only played the role of a mentor to Kuluhiwa this summer, but also acted as a "dear friend." Kuluhiwa also worked alongside JPL's Ken Lawrence, who introduced her to interesting, fun-filled tasks, which included plotting out the orbits of several near-Earth asteroids. These asteroids were named after instrumental individuals who greatly contributed to the Mars Pathfinder project. She also took part in determining the validity of observations of objects detected as near-Earth asteroids, using a special software package.

Helin had also introduced Kuluhiwa to Gilbert Clark, director of the Telescopes In Education (TIE) program, which gives students from around the world the opportunity to utilize a remotely controlled telescope that can acquire images of the sky. The TIE program uses a 24-inch telescope atop Mount Wilson Observatory, located in the San Gabriel Mountains of Southern California. This same telescope can be controlled by students in their own classroom using a special modem and astronomy software. Kuluhiwa was invited by Clark to take a closer look at the 24-inch telescope, along with a film crew from England who were doing a documentary on him and the TIE program.

Besides visiting Mount Wilson Observatory, Kuluhiwa was able to go to Table Mountain Observatory (TMO) with Dr. Michael Hicks, a scientist employed at JPL. Here she was given the chance to learn about astrometry as they both captured images of interesting objects throughout the night, using a 24-inch telescope. "I realize that I was very fortunate to have this kind of hands-on activity. It was definitely an adventurous and informational learning experience never to be forgotten."

The internship provided an opportunity for Kuluhiwa to broaden her understanding of the work she performs for MSSS, as well as to reaffirm her interest in the observations made at the MSSS, and the science behind those observations.

AEOS

A High Resolution Imaging Survey of A Stars

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and lower mass stars – winds with shocks from massive stars and magnetic fields from the dynamo in less massive stars such as the Sun. Since A stars lack both strong winds and dynamos, their ROSAT detections were a surprise. Less massive companion stars may be the true source of X-rays in these stars. The LLNL AEOS program is designed to search within the ROSAT position error boxes of A stars for previously unresolved companions. They are also observing a control sample of A stars without X-ray detections and will compare the proportion of binary stars in each sample.

In addition to answering questions in stellar X-ray activity, the statistics of the binary stars in our data will address binary star formation. Surveys of both young and old stars have revealed that the majority of stars are binaries. The mechanism that produces multiple rather than single stars is unknown, but two possibilities include capture and fragmentation. The AEOS data, which can resolve multiple stars separated by as little as the Sun-Saturn distance, will be compared to the predictions made by the different formation models.

AEOS observations were made during two observing runs in November 2000 and April 2001 with the Visible Imager CCD camera (VISIM) on the AO bench. The observing strategy involved taking two types of images for each target. A set of 500 unsaturated narrow field exposures was recorded to search for the closest companions. Additionally, a smaller set of 10 – 30 saturated images were taken to search for wider, fainter companions.

Companion stars to many of the A stars are resolved by the AEOS images. Currently, only data from the second run have been systematically analyzed for companions. Examples of the resolved systems are shown in the Figure A. All of the primaries are X-ray detected stars and the companions are all within the ROSAT error box and could account for the X-ray detection. Among the stars analyzed thus far, there is a high fraction of binaries in the X-ray detected stars: 11 of 17 X-ray detected field or cluster stars are binary, while 3 of the 12 cluster stars without an X-ray identification have a companion. Although the sample is currently small, additional telescope time is allocated to obtain a large sample and provide a statistically significant test of the companion hypothesis.

"Companion stars to many of the A stars are resolved by the AEOS images"

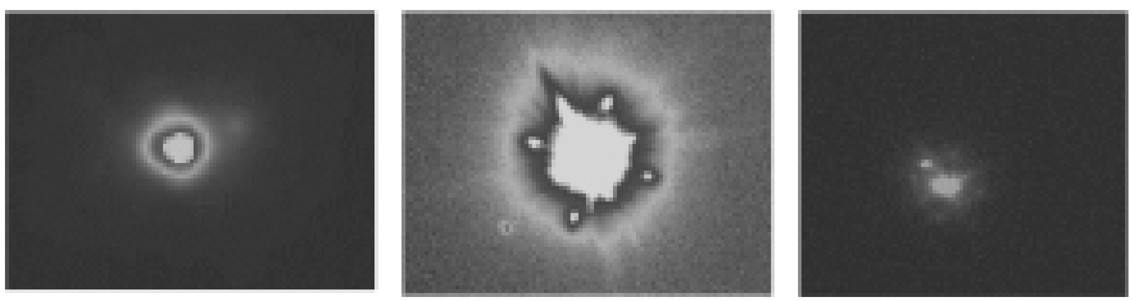

Figure A: Companion stars to many of the A stars are resolved by the AEOS images. Currently, only data from the second run have been systematically analyzed for companions.

AMOS fall 2002

AMOS expands research capabilities through the Business Research Library

IT'S OFFICIAL! The Maui Research and Technology Park's Business Research Library (BRL) is in the process of bringing a rich array of sci-tech databases, defense technical documents, and digital connections to resources from NASA, Air Force Research Laboratory (AFRL), Sandia Laboratories, Los Alamos National Laboratory, Naval Research Laboratory, and many more. The AFRL has designated the BRL of the University of Hawaii-Hilo's Small Business Development Center to be the Maui AFRL site library. Located in the Maui Research and Technology Center, the BRL is the digital front door through which scientific and technical libraries network electronically to bring a full range of library services to their users. This arrangement provides high level support for AMOS scientists who must have desktop access to the latest databases in sci-tech resources to conduct sophisticated research and compete for ongoing grants. Ruth Corn, library director, is coordinating the development of the portal connection to cyber desktop resources and putting in place the infrastructure to provide interlibrary loan services for archive materials, books, or conference proceedings that may not be digitized. A consistent search interface to multiple full text databases, indexes, electronic journals, reports, citation analysis, reference resources, and links to catalogs and collections of the nation's leading sci-tech libraries will be provided to streamline the search process and help scientists maintain their competitive edge. More information is available from Ruth at 808-875-2400.

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