MAUI [HAWAII]

AMOS

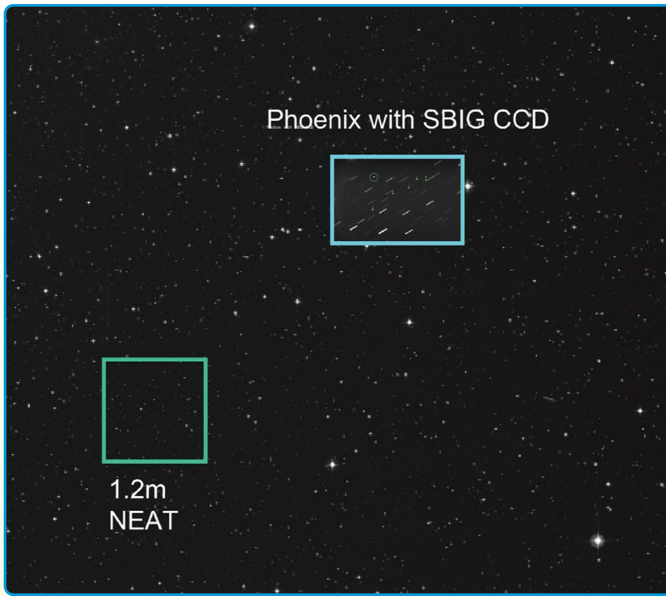
spring 2004

Air Force Research Laboratory DETACHMENT 15

AIR FORCE MAUI OPTICAL & SUPERCOMPUTING SITE

NASA/AMOS ORBITAL DEBRIS MEASUREMENT PROGRAM

OBSERVATIONS OF THE ORBITAL DEBRIS ENVIRONMENT AT THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) JOHNSON SPACE CENTER (JSC) AND AT AMOS ARE ENTERING A NEW ERA AND SPAN A WIDE RA NGE OF DEBRIS-RELATED ACTIVITIES.



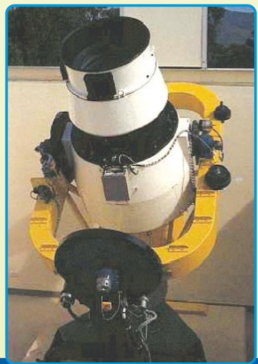
New fov for Phoenix

Advanced systems, such as the Near Earth Asteroid Tracking (NEAT) camera on the 1.2 m telescope, can support debris detection and orbit determination. Other systems at the site, such as the radiometer and the spectrographs on the 3.67 m and 1.6 m telescope, handle surface characterization and debris identification. The Phoenix system, centered around the restoration of a Baker-Nunn telescope, combines the advantages of a large field of view with new CCD technology. The unique adaptive optics system on the 3.6 m telescope can be used for the innovative observation of breakup events to track debris from their inception. These programs are all collaborations between NASA and AFRL.

The first satellite, Sputnik 1, was launched in 1957. Today, the United States Space Surveillance Network (SSN) catalogs, tracks, and maintains orbits on over 12,000 objects larger than about five centimeters in diameter. Unfortunately, active spacecraft are only a small percentage (~5%) of this population. The rest of the tracked population is orbital debris or "space junk" consisting of expended rocket bodies, dead payloads, bits and pieces from satellite launches, and fragments from satellite breakups. Understanding the evolving debris environment is essential as the human race continues to venture into space.

NASA has been making optical observations of the Low Earth Orbit (LEO) and the Geosynchronous Earth Orbit (GEO) orbital debris environment for many years. There are three main observational programs at AMOS supporting NASA's Orbital Debris program. There is an imaging program utilizing the 3.67 meter telescope adaptive optics system to image objects that have had anomalous events or breakups. There is a spectroscopic program utilizing spectrographs on the 3.67 meter and 1.6 meter telescopes to determine surface materials. There is also a program utilizing instrumentation on the 3.67 meter telescope to determine the albedo of objects based upon simultaneous visible and thermal IR photometry. AMOS is also obtaining statistical observations of the GEO debris environment supporting NASA and the Inter-Agency Space Debris Coordination Committee (IADC) activities using the Near-Earth Asteroid Tracking (NEAT) camera on the 1.2 meter telescope. In addition, a renovated Baker-Nunn telescope is available for observations.

The adaptive optics (AO) system installed on the 3.67 m Advanced Electro Optical System (AEOS) telescope is a state-of-the-art system that can be used to image objects in Low Earth Orbit (LEO). The Visible Imager, which makes use of the AO compensated light, has 3 fields of view ranging from 10 arcseconds to 60 arcseconds, a spectral response from 700 nm to 1100 nm, and has the potential for application to the study and tracking of orbital debris. One concept for the use of the AO system would be to image the breakup of low earth objects, and to guide follow-up observations by other metric instruments such as the 1.6 m and 1.2 m telescopes located at the site. This could contribute significantly to the identification and accurate tracking of debris objects from their initial creation, and could therefore serve to reduce the amount of untracked orbital debris.



Baker-Nunn Telescope

Spectroscopy can be a valuable tool in determining the composition of an object, whether it is a functional

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Orbital Debris Measurement Program (cont)

satellite, or space debris. Categories of orbital debris include mission-related debris (such as exhaust products, refuse, and objects released during deployment), nonfunctional spacecraft, fragmentation debris (breakup fragmentation and products of deterioration), and rocket bodies. Current optical observations of orbiting objects, including orbital debris, assume a material type and albedo in order to determine their size. However, space objects have varying compositions and thereby, varying albedos. Remote spectral observations can be used to determine the material type of payloads and orbital debris and thus obtain a more accurate albedo. This albedo can be used then in modeling efforts of the future space debris environment.

To determine if spectroscopy could be used for this purpose, spectral observations of rocket bodies as well as observations of payloads are compared to laboratory samples of common spacecraft materials in order to determine the material type of the object. Distinctions between different rocket bodies, payloads and rocket bodies, and different payloads, are apparent through these spectral observations. The data was collected at AMOS utilizing the spectrometer, Spica, which resides on the rear blanchard of the 1.6 m telescope. The telescope mount features three control axes: a polar axis, a declination axis, and an azimuth-table axis that allow a wide variety of motions and orientations. The 1.6 m mount is capable of tracking objects traveling up to 3 degrees per second.

As commercial, military/government, research, and academic agencies discover new ways to exploit the use of our Earth's space environment, the number of orbiting satellites and the associated debris increases. The importance of protecting manned and unmanned space-based assets becomes more evident. The most straightforward method to preserve the safety of on-orbit assets is to keep them from colliding with other assets and debris in the environment. Thus, it is imperative to have the ability to measure, determine, and catalog, with high accuracy, the orbits of all objects in the space environment. With this heightened awareness of the space environment, AMOS has initiated a project to develop and integrate a suite of wide field of view (WFOV) sensor systems, fields of view (FOV) that are greater than one degree. There are currently three WFOV telescopes in that arsenal: 1) Phoenix Sensor System, 2) Near Earth Asteroid Tracker (NEAT) and 3) GEODDS auxiliary.

This Phoenix sensor system, based on one of the original Baker-Nunn camera sensor systems, is the widest FOV optical sensor systems at AMOS. It is being developed and integrated at the Remote Maui Experimental (RME) site in Kihei. Because the original Baker-Nunn camera was based on curved photographic plates, retrofitting it with a flat-faced CCD was not trivial. Special optics were designed to flatten the field. The new CCD allows for digital imagery with very high sensitivity (~90% quantum efficiency). The Fairchild Imaging CCD is a 4k x 4k chip with a FOV of almost 49 square degrees. This telescope and CCD system are being tested and are available for international GEO debris campaigns.

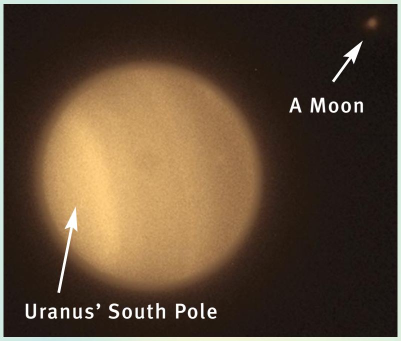
AMOS also collaborates with NASA's Jet Propulsion Laboratory on the Near-Earth Asteroid Tracking (NEAT) program. These observations are complementary to space debris observations, in that NEAT is searching for debris that is not man-made. NEAT searches for potentially hazardous asteroids (PHAs) and comets, that may impact the Earth in the future. Because one of the goals of each program is similar, searching the sky for unknown objects, there is an efficiency to be gained by combining both searches. One can take observations from one program, and scan that existing data for additional observations. One can also modify the search routines optimizing telescope time by making observations compatible with both search goals. Both of these approaches are being studied. The NEAT system consists of a 4k x 4k CCD camera mounted at prime focus of one of the twin 1.2 meter telescopes. The field of view of the telescope is 1.4 degrees square. It appears that approximately 20% of the NEAT images taken in support of the asteroid program also include satellite images. These images are particularly useful for detecting debris in geosynchronous orbit. Similarly, observations made in support of the space debris program can be scanned for asteroids and comets.

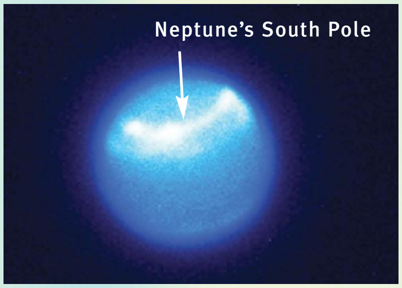
The Air Force Office of Scientific Research (AFOSR) and the National Science Foundation's Division of Astronomical Sciences manage a joint initiative for scientific research at the 3.67-meter Advanced Electro-Optical System (AEOS) telescope. This joint program makes the AEOS telescope, with its sophisticated adaptive optics, available to U.S. astronomers for a total of 50 six-hour observing nights. This program began in late 2000 and has been very successful. The recent solicitation has resulted in 5 new programs being funded.

AEOS Observations of Uranus and Neptune. *Principle Investigator is H. Hammel.*

AEOS will provide valuable imaging data for Uranus and Neptune in the very important 891 nm methane band, otherwise accessible only by very infrequent HST imaging. The 0.7-1.0 micron wavelength coverage of the AEOS facility dovetails nicely with the Keck AO system in the 1-2.4 micron region. Annual observations with AEOS and Keck AO systems will be very valuable for understanding the atmospheres of Neptune and Uranus as they approach seasonal milestones in the next few years.

Uranus & Neptune Observations





New AFOSR/NSF Astronomy Awards

Spectral and Polarimetric Imaging of Solar System Bodies. *Principle Investigator is N. Chanover.*

A new NMSU-built acousto-optic tunable filter camera was used at AEOS in January 2004 to obtain high spectral and spatial resolution images of Saturn's largest moon, Titan. These images, which were taken at wavelengths between 600-960 nm, will probe a range in altitudes on Titan between the surface and 120 km, and will be used to constrain the vertical distribution of the haze in Titan's atmosphere.

The haze distribution has implications for Titan's radiative balance and global circulation.

Spatial and Temporal Variations in the Atmospheric Aerosol Content of Mars Jupiter and Saturn. *Principle Investigator is J. Murphy.*

Sequences of AEOS images of the planet Mars obtained over two martian years are being used to characterize changes in the surface refelectivity pattern resulting from the occurrence of a global dust storm. Absolute brightness as a function of latitude: longitude on the disk (available from some, though not all images of interest) is determined, and quantified time variations of this field are then input in to a global atmospheric model to study the impact of the changes upon potential dust lifting in subsequent years. This has been accomplished regionally thus far (no significant dust lifting response is noted), and we are proceeding to a more global characterization.

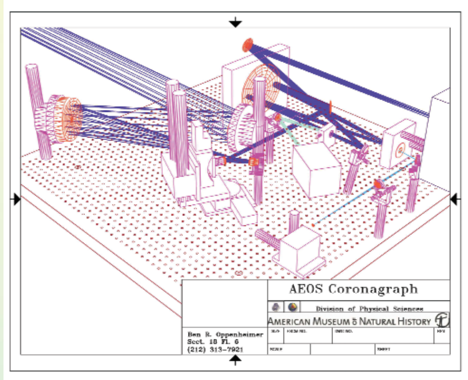
These same Mars images provide time-of-day information about the aerosol content of the atmosphere. These data, in conjuntcion with the 2 PM dust abundance provided by the Mars Global Surveyor orbiter infrared spectrometer, provide the possibility of deriving the vertical distribution of the dust as a function of time of day, which is not available from the sun-synchronous orbiting MGS observations. We hope to characterize any diurnal vertical variations in the dust to better understand the growth of small scale incipient dust storms into larger regional and/or planetary scale events. 2 PM local time dust parameters derived from the AEOS images can be 'verified' by comparison with the MGS observations, providing confidence in the AEOS image analysis results at other times of day.

Precision Imaging with Adaptive Optics Non-Redundant Masking Interferometry. *Principle Investigator is J. Lloyd.*

Imaging at the highest spatial resolution is a major thrust of modern astronomy. Until recently, high resolution imaging at visible wavelengths has been the exclusive domain of space telescopes. The advent of high performance Adaptive Optics (AO) systems, like AEOS, has opened new opportunities for astronomical research with ground based telescopes with much larger apertures than can be deployed in space. So far, AO has been compromised by the problem of point spread function (PSF) characterization. This program will investigate the PSF characterization problem and obtain precision astronomical observations by incorporating techniques from sparse aperture interferometry into an AO fed instrument.

The Lyot project: Optimized, Diffraction-limited Coronagraphy. *Principle Investigator is B. Oppenheimer*

The Lyot Project is an instrumentation program involving scientists from the American Museum of Natural History, University of California at Berkeley, Space Telescope Science Institute and the University of Hawaii. The project is bringing the world's first diffraction-limited coronagraph to the observatory to make observations of nearby stars to achieve the first images of planets orbiting stars other than the Sun.



Peer review of AEOS proposals is conducted jointly by AFOSR, AMOS, and the NSF, following NSF procedures. Funding opportunities and proposal deadlines are announced periodically at the NSF/MPS/AST web site: AST NEWS . To expedite the awards process, all proposals from the U.S. civilian community are consolidated at the NSF and awards are administered by the National Science Foundation. Proposals from researchers employed by the U.S. government must be sent directly to AFOSR and are administered by the Air Force Office of Scientific Research. All research published as a result of this program will include an acknowledgement in print that funding was jointly provided by the Air Force Office of Scientific Research and the National Science Foundation.

Air Force Maui Optical & Supercomputing Site is Presented Regional Outstanding Partnership Award by Federal Laboratory Consortium

Presenter and recipients of the FLC Regional Award pictured above (left to right) are Susan Sprake (FLC-MC, Coordinator), Don Forrester (Boeing LTS, Director of Maui Operations), Mike Maberry (IfA, Assistant Director), Gene Bal (UH/MHPCC, Executive Director), Jeanne Skog (MEDB, President/CEO), and Lt Col Jeffrey McCann (AFRL/Det 15, Commander, AMOS).

The Air Force Maui Optical & Supercomputing Site (AMOS) and its partners were presented with the Federal Laboratory Consortium (FLC) for Technology Transfer Regional Partnership Award at the TechEnterprise 2003 Conference (Oahu, Hawaii). The Regional Outstanding Partnership Award is an annual presentation by FLC in recognition of outstanding efforts in promoting technology transfer between federal government facilities and the private or public sectors.

The Air Force Maui Optical & Supercomputing Site is supported by five organizations, which include the Air Force Research Laboratory/Detachment 15 (AFRL/Det 15), the Maui Economic Development Board (MEDB), the University of Hawaii (UH), the Institute for Astronomy (IfA), and Boeing LTS.

The FLC is a nationwide network of federal laboratories organized in 1974 and formally charted by the Federal Technology Transfer Act of 1986 to promote and to strengthen technology transfer nationwide. More than 700 major federal laboratories and centers, and their parent departments and agencies, are FLC members, including organizations such as the Departments of Commerce, Defense, Energy, Labor, Justice, the CIA, NASA, NSF, and USDA.

University of Hawaii Receives an IBM Award for Genetic Mapping of Bacteria

On August 7, 2003 an IBM Shared University Research Award was presented to the University of Hawaii (UH) and the Maui High Performance Computing Center (MHPCC). UH/MHPCC scientists will receive a $1 million IBM eServer p690 system to conduct genetic research on a rare bacterium, recently isolated from waters of the Lo'ihi submarine volcano, where temperatures range from 100 to 110 degrees Fahrenheit. MHPCC announced that the advanced computing technology from IBM will help enable research that could lead to improved, longer-lasting drugs, and new treatments for diseases.

UH will use the new system for research on the ancient globin protein, which has evolved over the past 3.5 billion years to withstand extreme fluctuations in temperatures, oxygen levels, pressure, and other atmospheric changes. Through computerized modeling and analyses of these rare microorganisms and proteins, UH researchers hope to discover genetic patterns that hold the key to important new therapeutics and diagnostics and tremendous leaps in biotechnology.

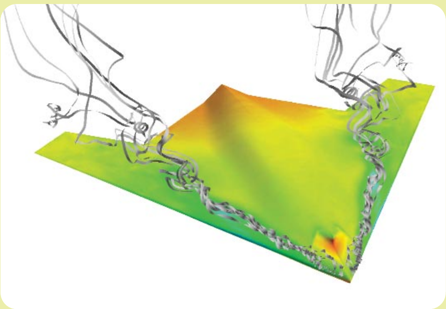
IBM and UH researchers will also collaborate on projects of mutual interest. These projects may include research into the Hawaiian Archipelago, which is home to thousands of plant and animal species, including many novel microorganisms.

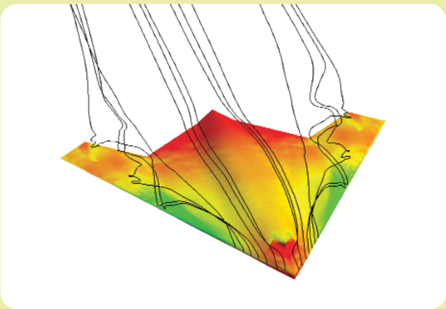
At MHPCC, Scientists using supercomputers to study the bacteria that thrive in Hawaii's inhospitable environments say mapping the genetic patterns of the microorganisms could lead to a number of medical breakthroughs, including possibly creation of a blood substitute. The research builds on work unveiled two years ago when Maqsudul Alam, a University of Hawaii scientist and his team found an oxygen-sensing protein (like hemoglobin and myoglobin in human) in a microbe that lives in inhospitable salt-marsh environments – a microbe that had been considered an unlikely host. Alam said the globin-like protein in Archaea "is probably the mother protein of the gases which were in the early era of our planet," likely evolving 3.2 billion to 3.5 billion years ago. "That means this protein could be studied to model a blood substitute for use in emergency rooms and for the enhancement of drugs that treat globin protein-related illnesses," Alam said.

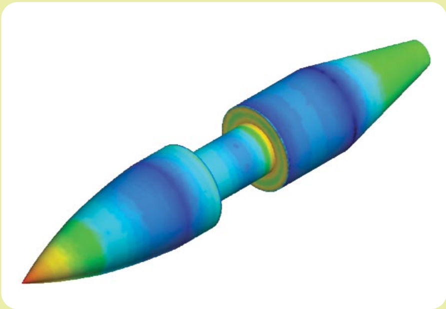
Myoglobin is used in the body to store oxygen, while hemoglobin is used to carry blood to organs. Proteins, one of the most fundamental building blocks of life, also build up bodily tissues, muscles, and organs. The researchers hope to use supercomputers to understand how the proteins in extremophiles (microorganisms that live in extreme environments) fold to produce biochemical networks that are essential for survival.

Maui High Performance Computing Center Provides Computational Resources for Key Department of Defense Programs

SCIENCE AND TECHNOLOGY ARE THE FOUNDATIONS OF THE DEPARTMENT OF DEFENSE (DOD) MODERNIZATION AND READINESS. THE OFFICE OF THE SECRETARY OF DEFENSE HAS INVESTED SIGNIFICANT FUNDING IN HIGH PERFORMANCE COMPUTING (HPC) TO MAINTAIN A TECHNOLOGICAL ADVANTAGE FOR THE U.S. MILITARY. The DOD High Performance Computing Modernization Program (HPCMP) provides the DOD research community with HPC hardware and software, which enable the development of advanced technologies that support the warfighter. HPCMP research initiatives increase the capabilities and effectiveness of new weapons systems, while reducing the design-process timeline and total life-cycle costs.







Detached Eddy Simulation (DES) with Computational Fluid Dynamics (CFD) solver (Cobalt60, Cobalt) is used for the prediction of massively separated turbulent flow around a complete aircraft.

The Maui High Performance Computing Center (MHPCC) is an Allocated Distributed Center of the HPCMP, providing resources to HPCMP researchers and other government organizations. A recognized leader in scalable computing technologies and applications, MHPCC is an AFRL Center, managed by the University of Hawaii (UH). MHPCC's computational resources are from HPC companies such as IBM, Sun Microsystems, SGI, and Compaq. MHPCC provides an innovative environment for migrating projects from research to production, and has a highly qualified professional staff to assist with application prototyping, benchmarking, and testing.

MHPCC is hosting five HPCMP Challenge Projects during FY04, allocating more than three million central processing unit (CPU) hours of computing time to support high priority research of the Department of Defense.

Towards a High-Resolution Global Coupled Navy Prediction System: A modestly high-resolution global coupled prediction system will be developed along with high-resolution ocean and ocean/ice states for evaluation and testing. This system will lead to improved weather and ocean forecasts impacting most of the Navy's operational concerns, from routine ship and aircraft operations to weapons performance and search-and-rescue guidance.

Distributed Pump Jet Propulsion (DPJP) for Submarines: Extremely intensive computations will be applied to the flow field of a distributed pump propulsor. The simulations will include the hull and propulsor interaction as well as the propulsor alone. Model- and large-scale Reynolds Averaged Navier-Stokes (RANS) calculations will be carried out for the conventional straight and level flight condition to provide data for powering predictions.

Multidisciplinary Applications of Detached-Eddy Simulation to Separated Flows at High Reynolds Numbers: Detached-Eddy Simulation (DES) with Computational Fluid Dynamics (CFD) is used for the prediction of turbulent flow around a complete aircraft. These simulations provide a more accurate accounting of turbulence and separation in the flow.

Directed High Power RF Energy: The Foundation of Next-Generation Air Force Weapons: RF weapons will be designed to work against hostile battlefield electronics. Magnetically Insulated Line Oscillator (MILO) modeling is supporting the design of RF weapons to counter hostile battlefield electronics.

3D CFD Modeling of the Chemical Oxygen-Iodine Laser (COIL): The COIL has been chosen as one of the most powerful laser weapons. The COIL program has produced improved model inputs and performance data used to validate the kinetics package.

AMOS

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Air Force Research Laboratory DETACHMENT 15

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The Air Force Research Laboratory, Detachment 15 will hold the fifth annual AMOS Technical Conference on September 13 – 17 in Maui, Hawaii.

The conference series aims to provide a stimulating and thought-provoking forum for sharing the latest technical developments and ideas in space surveillance, optics and high performance computing. It is intended for scientists, engineers, and technical managers from academia, industry, government, and military programs.

For more information visit http://www.maui.afmc.af.mil