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Total Lunar Eclipse Draws Attention Back to the Moon

By Laura Spector

As August draws to an end, watchers of the night sky were treated to some of nature's magic. In the early morning hours of August 28, sky watchers across much of the world looked on as the Moon crossed into the shadow of the Earth, becoming completely immersed for 1 hour and 30 minutes—a period of time much longer than most typical lunar eclipses. In fact, this eclipse was the deepest and longest in seven years. The event began 54 minutes past midnight PDT (3:54 a.m. EDT) on August 28. At first, there was little change. The outskirts of Earth's shadow were as pale as the Moon itself; an onlooker might not even realize anything was happening. But as the Moon penetrated deeper into the Earth's shadow, a startling metamorphosis occurred. Around 2:52 a.m. PDT (5:52 a.m. EDT) the color of the Moon changed from moondust-gray to sunset-red. This is "totality," and it lasted for almost 90 minutes.

With the Sun blocked, you might expect utter darkness, but instead, the ground at your feet appears to be aglow. Why? Look back up at Earth. The rim of the planet seems to be on fire. Around the Earth's circumference you will witness every sunrise and sunset in the world—all at once. This incredible, colorful light beams into the heart of Earth's shadow, transforming the Moon into a landscape of copper moondust and golden hills. The eclipse was visible from Australia, parts of Asia, and most of the Americas, but not from Africa or Europe. The view is different from each location on the planet. Here in the United States, Pacific observers are favored. For them, the entire eclipse unfolded high in the post-midnight sky, however, on the East Coast, totality was cut off early by the sunrise.

While sky watchers focused their attention on the eclipse, NASA scientists and engineers were looking at the Moon for a different reason. NASA is getting ready to take its first steps back to the Moon, nearly 40 years after the first human Moon landing.

Next year, NASA will launch the Lunar Reconnaissance Orbiter (LRO) to compile the first all digital, next-generation maps of the Moon, which will measure topography, temperature, resources, and hazards.

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Photo of the Month

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Correction: In Vol 3 Issue 10, Page 6 Nicole Quenelle's name was misspelled.

Cover caption: Astronaut F. Story Musgrave, anchored on the Space Shuttle Endeavor's robotic arm, prepares to be elevated to the top of the *Hubble* Space Telescope during *Hubble*'s first servicing mission in 1993. *Hubble* was specially designed to be repaired and upgraded by astronauts while in orbit.

Photo Credit: NASA

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Deadlines: News items and brief announcements for publication in the *Goddard View* must be received by noon of the 1st and 3rd Wednesday of the month. You may submit contributions to the editor via e-mail at alittle@pop100.gsfc.nasa.gov. Ideas for new stories are welcome but will be published as space allows. All submissions are subject to editing.

Our Journey Back to *Hubble*

By Susan Hendrix



Photo credit: NASA

Caption: The Hubble Space Telescope hovers at the boundary of Earth and space in this picture, taken after Hubble's second servicing mission in 1997. Hubble drifts 353 miles (569 km) above the Earth's surface, where it can avoid the atmosphere and clearly see objects in space.

Since its launch in April 1990, NASA's *Hubble* Space Telescope (HST) not only continues to excite astronomers around the world with its discoveries, but has become a familiar icon to millions of people from Cincinnati to Singapore.

Just a few of *Hubble's* accomplishments include: measurement of the current rate of expansion of the universe (the *Hubble* Constant), the shocking discovery that the expansion of the universe is speeding up, and the determination of an accurate age of the cosmos of 13.7 billion years. *Hubble* showed that titanic gamma-ray bursts first observed by Air Force satellites originate in distant galaxies. *Hubble* made the first accurate measurement of the mass of a super-massive black hole and performed the first demographic survey of super massive black holes that exist at the centers of nearly all galaxies. *Hubble* made the first observations of the chemical makeup of the atmosphere of a planet orbiting another star, and provided the first high-resolution maps of the structures of planet-forming disks of dust and debris around ordinary stars like the Sun.

Not surprisingly, many of these discoveries would not be possible if engineers had not designed *Hubble* to be serviced in space. Thanks to four previous service calls to *Hubble*—Servicing Mission 1 in 1993, Servicing Mission 2 in 1997, Servicing Mission 3A in 1999, and Servicing Mission 3B in 2002—the telescope's capabilities have progressed along with advancements in technology.

Next summer, astronauts will visit this old friend to service it one last time. During the five planned Extra Vehicular

Activities, or spacewalks, the crew will replace aging gyroscopes, install two new science instruments called the Wide Field Camera 3 and the Cosmic Origins Spectrograph, swap out *Hubble's* original batteries, and install a Fine Guidance Sensor.

If all goes as planned, the astronauts will also attempt the first ever on-orbit repair of two science instruments—the Space Telescope Imaging Spectrograph, which stopped functioning in August 2004, and the Advanced Camera for Surveys, which stopped working in January 2007. The fifth shuttle mission to *Hubble* is scheduled for August 7, 2008. Three of the seven astronauts selected for this mission will be making a return visit to *Hubble*, and all are rigorously training to prepare for what could be their most challenging mission yet.

Please join us for this amazing ride. Check back each month for a “behind-the-scenes” look at just what it takes to successfully test instruments and other hardware. Gain insight into difficult tasks the astronauts must successfully accomplish here on Earth in order to master those seemingly simple spacewalks.

As always, for more information on the *HST* and the upcoming servicing mission, visit: www.nasa.gov/hubble

For further details on *Hubble's* servicing mission, join Mike Weiss, HST Deputy Program Manager—Technical at the next “About Goddard” on Thursday, September 6 at 10 a.m. in Bldg. 3 Goett Auditorium. ■

In Search of Interstellar Dragon Fire

By Bill Steigerwald

Ancient explorers set sail expecting to encounter dragons on the world's unknown oceans. NASA's twin *Voyager* spacecraft are searching for dragons of a different sort as they enter the boundary of our solar system—cosmic “dragons” that breathe a strange fire of high-speed atomic fragments called cosmic rays.

Just as mythical dragons were expected to inhabit stormy seas, these cosmic dragons could be found among turbulent magnetic fields powered by the colliding winds of stars, including our Sun. The winds clash at the edge of our solar system, and space physicists wonder if these dragons may be found there, or if they are even more distant in interstellar space.

“Does a great dragon, in the form of a cosmic-ray accelerator, lurk within the turbulent boundary of our solar system to breathe out the fire of cosmic rays, or do these rays arise from even more powerful dragons somewhere in deep space?” asks Dr. John Cooper of Goddard.

Cosmic rays can cause cancer in unprotected astronauts, and a better understanding of where and how cosmic rays are accelerated will improve predictions of how many will be encountered as astronauts set sail on the new ocean of space.

This ocean is not empty. The Sun exhales a thin, hot wind of electrically conducting gas, called plasma, into space at many hundreds of miles per second. This solar wind forms a large plasma bubble, called the heliosphere, in space around the Sun. Beyond the orbit of Pluto, the solar wind gradually slows as it interacts with inflowing neutral gases from interstellar space, and then abruptly drops in speed to about 30 miles per second (50 kilometers per second) at a thin, invisible boundary around our solar system, called the termination shock. A simple kitchen experiment illustrates how this shock forms. When water runs at high speed from a kitchen faucet down to the bottom surface of the sink, the water hitting this surface first flows quickly and smoothly away from the impact point, but then runs into a circular boundary with slower, more turbulent flow beyond this boundary.

In the kitchen sink experiment, the circular boundary is the termination shock. The turbulent region beyond the shock boundary corresponds to a layer in the outer heliosphere of turbulent plasma flows and magnetic fields, called the heliosheath. The boundary of this turbulent layer with the interstellar plasma environment, not so easily seen in the kitchen sink experiment because of the turbulence, is called the heliopause.

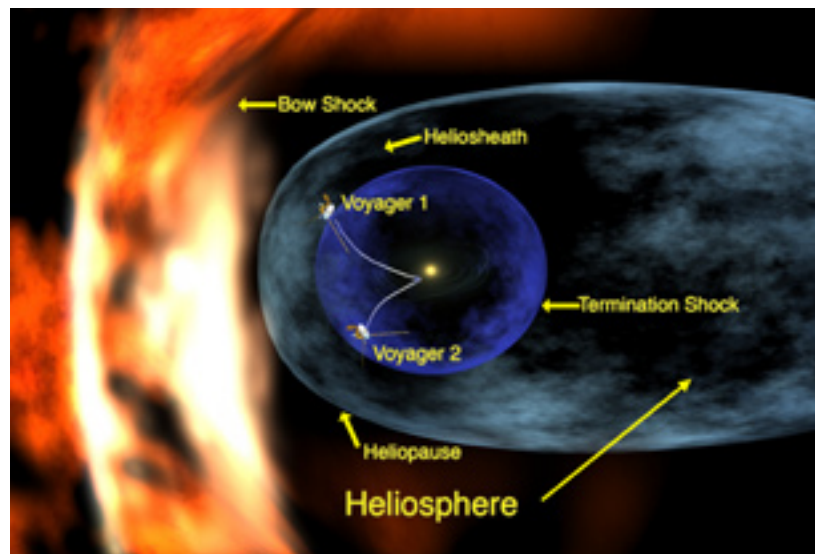
Our solar system is engulfed in a “dragon fire” of cosmic rays with a wide range of energy levels (the faster the cosmic ray, the greater its energy). Some are from known dragons like explosive flares on the Sun. Astronomers believe the rays with the highest energy come from the largest dragons in the universe, including exploding stars, called supernova; fast-rotating collapsed objects, called neutron stars, with incredibly strong magnetic fields; the heaviest collapsed stars, called black holes, which voraciously feed on infalling matter and spit out accelerated particles; and huge magnetic shock structures ejected far into interstellar space from these stellar sources. The energy for cosmic ray acceleration in all these sources comes from twisting,

writhing motions of lower-energy charged particles in turbulent magnetic fields.

Nearer our solar system, Cooper is seeking the smaller dragons that breathe out lower-energy fire, the so-called “suprathermal” cosmic rays. This suprathermal zone of fire spans a huge range in energy between that of the flowing plasma and the higher-energy cosmic rays. These suprathermal cosmic rays have been measured

within the known heliosphere and theoretically modeled by Dr. Len Fisk and his collaborators at the University of Michigan.

Cooper's new idea is that similar energy distributions of such particles may be found in interstellar space. If the *Voyager* spacecraft eventually cross the heliopause and find this same suprathermal fire in interstellar space, it would mean that the fire breathers live outside the heliosphere.



Caption: This is a diagram showing the regions of the heliosphere. It also shows the approximate locations of Voyagers 1 and 2. Voyager 1 is traveling faster and has crossed into the heliosheath.

Photo credit: NASA

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Joint Technology Gets Patients Up and Walking with SAM

By Nicole Quenelle



Photo provided by Fluentek

Caption: Adult SAM Walker.

Enduro Medical Technology used NASA Goddard Space Flight Center's cable-compliant joint (CCJ) technology and compliant walker to develop the Secure Ambulation Module (SAM). SAM is a revolutionary rehabilitative walker that enables patients to stand and ambulate without the aid of a physical therapist. The walker is currently being used to help soldiers and other patients with a variety of injuries at Walter Reed Army Medical Center gain strength to stand and walk on their own. SAM is also being used to help severely overweight patients at Kindred Hospital in Greensboro, N.C. support their own body weight to enable exercise programs. Enduro has also built and tested a prototype of a youth version of the walker (SAM-Y).

Benefits of Technology Transfer

The technology invented at NASA and developed for commercial use by Enduro Medical Technology enhances the quality of care and safety for both patients and therapists, and also offers the potential to drastically aid equine rehabilitation:

- **Reduced patient injury:** The security provided by SAM reduces patient injuries from falls and boosts confidence during therapy.
- **Earlier rehabilitation:** Because they do not need to support their own weight, many patients can begin ambulatory rehabilitation earlier in their treatment.
- **Better positioning:** Freeing the patient's arms allows the upper extremities to be properly positioned during therapy.
- **Longer and specialized sessions:** SAM enables patients to have longer therapy sessions or more specialized treatment.
- **Reduced therapist injury:** SAM dramatically reduces the back injuries sustained by therapists in bringing patients to a standing position and assisting them during gait therapy.
- **Cost and resource savings:** Because SAM eliminates the need for a physical therapist to hold a patient upright during therapy sessions, therapists can serve multiple patients simultaneously, reducing costs for medical facilities.
- **Reduced number of deaths and shorter rehab time following equine surgeries:** The veterinary community supports Enduro's proposed application of SAM for horses, stating that the device may help reduce the number of deaths following medical procedures and the need to euthanize animals following a leg fracture by enabling the horse to stand in a safe, controlled environment.

About Enduro Medical Technology

Headquartered in South Windsor, Conn., Enduro Medical Technology was founded in 2002 as a small company focused on designing and manufacturing custom wheelchairs. In 2003, the company narrowed its focus to concentrate fully on SAM and other CCJ technology-based rehabilitative devices.

Technology Origins

In the 1980s, NASA required a technology that would facilitate mechanical isolation of sounding rocket assemblies, as well as provide compliance for robots to grip or join objects. As part of this robotics research, the late James Kerley developed the CCJ technology, which provided customizable structural connections and selective, subtle cushioning, twisting, and alignment in six directions, allowing contact surfaces to be joined together.

Finding a New Use

While the CCJ technology answered NASA's requirements, it was readily clear that the subtle movement the technology facilitated could easily be extended to other applications. In the 1990s, researchers at Goddard integrated the CCJ technology into a patented walker that supported the pelvis and provided compliance that imitated hip joint movement. Suffering from arthritis, Kerley realized that pain management could be achieved by using the walker to alleviate weight on the legs to facilitate greater mobility.

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Why it Pays to Leave the Office

By Alana Little

On August 16, Goddard employees were tempted out of their offices by the sight of a large, grass Tiki umbrella and the sounds of something cool and sweet being blended to help stave off the heat of a typical August day in Maryland. The smoothies were being offered by Aglient Technologies—a test and measurement equipment supplier.

Aglient field engineers, like David Geeter, were onsite to remind the technologists and engineers who use their specialized equipment that they are always here to answer their real-time questions about oscilloscopes (measurement tools made to help engineers design, debug, and validate their designs), power supplies, RFM microwave equipment, power meters, and more. Aglient Technologies, one of Goddard's suppliers of oscilloscopes, also displayed hot new technology, some of which is already being used in the labs in Buildings 2, 12, and 19.

Tektronix—another provider of test and measurement equipment—was also onsite on this day. Nathan Weaver, Account Manager for Tektronix answered questions, and employees who visited the Tektronix truck got previews of their new product demo inside the cool recesses of the technology-outfitted 18-Wheeler. Visitors also got treated to fresh popcorn and cool drinks while they discussed some of their tricky product questions with Tektronix field representatives.

All in all, August 16 was a great day to leave the office and see what was happening around Center. ■

In Search of Interstellar Dragon Fire

Continued from Page 4

Most space plasma scientists had expected the termination shock, traversed by *Voyager 1* on December 16, 2004, to be the primary energy source for these suprathermal cosmic rays, but nothing was found. "I propose that the fabled dragon of the termination shock breathes no fire and is a kinder and gentler creature, more like Puff the Magic Dragon," said Cooper.

"I believe that the suprathermal cosmic rays we see within our solar system instead arise from even more powerful 'dragons' somewhere in interstellar space."

Cooper suggests that the zone of fire extends higher in energy within interstellar space and that *Voyager 1* measurements are gradually revealing this expanded energy range during outward movement through the heliosheath towards the heliopause. He recently presented a paper on his new theory at the 2007 International Cosmic Ray Conference at Merida, Mexico. This conference took place on the Yucatan peninsula where an asteroid impact ended the long earthy reign of real dragons, the dinosaurs, 65 million years ago.

Cooper's theory will be tested again as soon as the second *Voyager* spacecraft crosses the termination shock. "If *Voyager 2* also finds no evidence of local cosmic ray acceleration as it crosses the termination shock, it will strengthen the case for more remote dragons in interstellar space, perhaps very far beyond in the galaxy, as the source of suprathermal cosmic rays," said Cooper. The first direct traces of these fiercer dragons may be found when the two *Voyager* spacecraft eventually cross the heliopause into local interstellar space. ■



Embody Health—Your Personal Health Management Portal

Brought to you by the Occupational Health Office/NASA

NASA Civil Servant employees are able to access the health resources of the Mayo Clinic EmbodyHealth Web site, 24/7, by visiting <http://www.ohp.nasa.gov>.

When you register on Mayo Clinic EmbodyHealth, take advantage of the Mayo Clinic Health Risk Assessment (HRA) to identify your health risks, and link to resources and tools you can use to ensure a HealthierYou. For more information go to the NASA Occupational Health Web site at www.ohp.nasa.gov and select the HealthierYou logo.

To access the Mayo Clinic EmbodyHealth Web portal and the Mayo Clinic Health Risk Assessment, go to www.ohp.nasa.gov and click on the Mayo Clinic EmbodyHealth icon. The unique ID you need to register is "healthiernasa." For additional information or questions, please send an e-mail to Jennifer.R.Gerry@nasa.gov or Gail.a.bantugan@nasa.gov ■

2006–2007 NASA Leadership Development Program Graduates Honored

By Christine Williams



Photo credit: NASA

Caption: Deputy Administrator Shana Dale and NASA Leadership Development Program graduate Robert Cahalan.

On July 31, 2007, 17 members of the 2006–2007 NASA Leadership Development Program (LDP) celebrated the completion of their developmental year with a ceremony at NASA Headquarters. Six Centers were represented in this year’s graduating class.

In her address to the graduates, NASA Deputy Administrator, Ms. Shana Dale, told the graduating class that NASA leaders need to “create a culture that learns and educates, that communicates and listens, and that promotes diverse ideas and collaborative efforts.”

Ms. Dale praised the class on the completion of their Agency-wide project and their significant contribution to NASA’s strategic communications. Ms. Dale noted that this class helped fulfill the Space Act mandate to “provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof” by:

- Developing a template, to map NASA’s activities and their associated benefits and by identifying and documenting these activities and benefits; and by
- Assessing communication challenges and compiling materials for NASA communications and speakers to deliver messages easier and more effectively.

Participants Dave Young, Langley Research Center (LaRC); Chris Steffen, Glenn Research Center (GRC); and Steve Helland (GRC), were elected as the graduation speakers. Each shared their reflections of the year, their

thoughts on leadership, and how the LDP helped them strengthen their ability to be more effective leaders.

The vision of the LDP is to create powerful leaders who align with NASA’s vision, mission, and values and who create results that matter to the American people. Program elements include developmental assignments, a class project, individual coaching, training, and briefings by NASA and outside leaders. Participants must be grades 13–15 and are competitively selected at the Agency level. Key to the program is participating in developmental assignments designed to broaden participant understanding and strengthen their leadership skills. This year’s participants engaged in assignments at NASA Headquarters (HQ), Johnson Space Center (JSC), Kennedy Space Center (KSC), two industry locations, Office of Management and Budget (OMB), the State and Energy Departments, National Science Foundation, the National Oceanic and Atmospheric Administration (NOAA), and State Government. ■

2006–2007 NASA Leadership Development Program Graduates

- José M. Davis, GRC**
- Stephen M. Helland, GRC**
- Christopher J. Steffen, Jr., GRC**
- Kim Allen Veris, GRC**
- Robert Cahalan, GSFC**
- Lauretta Jean Rayhle, HQ**
- Elizabeth O. Williams, HQ**
- Lawrence A. Kenyon, JSC**
- Willie J. Lyles, JSC**
- Jeffrey C. Phillips, JSC**
- Philip R. West, JSC**
- Joseph L. Williams, Jr., JSC**
- E. Jeanne Hawkins, KSC**
- Gloria Hernandez, LaRC**
- Guy T. Kemmerly, LaRC**
- Douglas A. Terrier, LaRC**
- David F. Young, LaRC**

Suitcase Science on the Moon

By Bill Steigerwald

In October 1963, two cartographers with the Air Force Aeronautical Chart and Information Center saw a strange glow on the Moon. Using the 24-inch refractor telescope at Lowell Observatory in Flagstaff, Ariz., James Greenacre and Edward Barr saw a deep, ruby-red glow coming from the crater Aristarchus. The sighting might have been glowing gas from volcanic activity; a second sighting in November of that year was verified by Dr. John Hall, Director of the observatory at the time. Throughout history, there have been many more. There have been rumbles from other areas on the Moon as well. For example, when Dr. Yosio Nakamura of the University of Texas, Austin, and his colleagues reviewed seismology data from the *Apollo* missions, they discovered there was a magnitude 5.7 moonquake near the lunar south pole, a possible site for a future lunar base.

The Moon is not dead yet, nor has it revealed all its secrets. Scientists don't even agree how it got here in the first place. As part of NASA's vision for space exploration, astronauts will return to the Moon by 2020. They plan to test new technology for human missions to more remote destinations, like Mars. However, there are still many discoveries to be made about the Moon itself, and lunar exploration is an important part of the plans.

As part of an effort to develop new opportunities to conduct important science investigations during the planned renewal of human exploration of the Moon, NASA chose 7 proposals from more than 70 submissions under the Lunar Sortie Science Opportunities (LSSO) Program.

The seven selected proposals will result in advanced development for simple, automated instrument packages deployed on the lunar surface by astronauts. Such "suitcase science" packages could open up a wide variety of research applications regarding the Moon and the lunar environment.

Two proposals from scientists at NASA's Goddard Space Flight Center in Greenbelt, Md., were chosen; one to study moonquakes, called "Seismology and Heat Flow Instrument Package for Lunar Science and Hazards," and another to search for possible frozen water deposits at the lunar south pole, called "Volatile Analysis by Pyrolysis of Regolith (VAPoR) on the Moon Using Mass Spectrometry."

Scientists are interested in establishing a lunar base at the south pole of the Moon because the possibility that a vital resource—water in the form of ice—may exist there. The depths of some craters in the polar regions

may be in permanent shadow because the Moon is only very slightly tilted from its spin axis. These regions would be very cold, and able to trap water as ice for billions of years if somehow ice was transported there.

Some astronomers believe vapor from comet impacts could migrate to the poles and become embedded in the lunar soil at the bottom of permanently shadowed craters. Others believe hydrogen from the solar wind could become embedded in the lunar soil and combine with oxygen there to form water molecules.

If water ice exists in the eternal shadows of the lunar poles, and it is practical to extract water from the lunar soil, the water could be used for drinking, or it could be broken down into hydrogen and oxygen for use as rocket fuel and breathable air.

Volatiles are things that vaporize easily, like frozen water, and a major part of the VAPoR volatile mission is to discover how much ice, if any, exists at the lunar poles. "Remote missions, like Lunar Prospector, have detected hints that ice may exist at the lunar poles, but the only way to know for sure is to go there and see how much is trapped in the lunar soil (regolith)," said Goddard's Dr. Daniel Glavin, Principal Investigator for the proposed mission.

The mission will use a small oven to vaporize volatiles in lunar soil. The resulting gasses will be analyzed with a mass spectrometer instrument, which uses electric fields to separate molecules by their mass. If the mission discovers water, it can also reveal its origin by analyzing isotopes, elements with similar chemical properties but different masses. For example, the isotope deuterium is chemically similar to its lighter cousin, hydrogen, a component of water. Deuterium is much less common than hydrogen, however, like hydrogen, deuterium can bond with oxygen to form water. By measuring the ratio of deuterium to hydrogen in water, scientists can tell where it came from. Water from a comet will have a higher deuterium-to-hydrogen ratio than solar-wind-implanted hydrogen or water derived from Earth contamination.

Part of the goal for the moonquake mission is to evaluate safety. "We're not sure it's a good idea to put your mobile home on the edge of Shackleton crater with all the moonquake activity," said Goddard's Bruce Milam, who is helping the team design the drill needed to bury the instruments. The mission will also measure heat flow from the Moon, which will help gauge the potential for lunar volcanic activity.

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Joint Technology Gets Patients Up and Walking with SAM

Continued from Page 5

Goddard licensed the technology to Enduro, giving birth to the SAM walker for humans. After establishing the device's use and benefits for human rehabilitation, Enduro engineers began to engage in discussions with doctors at nationally renowned veterinary hospitals. Interest among this community was high and convinced Enduro that the CCJ-based technology could also be incorporated into a rehabilitative device designed specifically for horses.

The Transfer Process

In 2003, Enduro Medical Technology learned of the compliant walker through industry peers who were using a prototype of Goddard's technology. Realizing the market potential of the device, Enduro contacted Goddard and then worked with the Innovative Partnerships Program (IPP) Office to license the technologies. The company then completed the project by modifying the cable-compliant system into an advanced walker with a flexible harness that embraces the lower torso. Doing so enabled the device to support a patient without the aid of a physical therapist. In February 2007, Enduro secured a new field-of-use license from Goddard to develop SAM-Equine.

Looking Ahead

While SAM is showing remarkable results for patients at Walter Reed and Kindred Hospital, Enduro continues to invest in further development and exploration of CCJ technology-based devices. The company also has released and tested a prototype of SAM-Y and is working to insert the youth version into the marketplace. In addition, ongoing efforts to secure funding will enable the building of a prototype of SAM-Equine, and the company currently plans to work on the equine industry requirements with the University of Georgia's School of Veterinary Medicine. ■

Suitcase Science on the Moon

Continued from Page 8

"Many moonquakes are from meteorite impacts or tidal stress from Earth's gravity, but there are these other moonquakes that we can't explain," said Goddard's Dr. Patrick Taylor, Principal Investigator for the moonquake mission.

"Our mission will help understand their cause by revealing the layers of the Moon, its composition, and how it is cooling."

Both mission proposals were awarded a nine-month contract to refine their design and evaluate alternatives, like various locations and different drill designs for the moonquake mission, or robotic versus human deployment for the VAPoR mission (NASA is not sure how risky it is to send astronauts to the bottom of a deep lunar crater).

"The proposals we received show that the scientific community is excited about the opportunity to capitalize on the nation's planned lunar outpost. The Moon has much to teach us about itself, the history of our solar system, and even the history of the Sun. In the future, more and more scientists will be able to participate in lunar research as we focus attention on Earth's fascinating satellite," said Dr. Alan Stern, Associate Administrator for NASA's Science Mission Directorate. ■

Background Image on Page 8: This is a view of the Aristarchus and Herodotus craters taken from orbit during the Apollo 15 mission. The view is toward the south. Aristarchus crater is near the center of the image, and the flooded Herodotus is to the right. Credit: NASA

Total Lunar Eclipse Draws Attention Back to the Moon

Continued from Page 1

Although it is Earth's closest neighbor, scientists still know relatively little about the Moon, aside from the six *Apollo* human landing sites.

LRO will dramatically change all that by acting like a "chart-making" Renaissance-era explorer. It will reveal the mysteries of the lunar polar regions, while also evaluating from above the changes that have taken place since humans left the lunar surface in December 1972, when *Apollo 17* blasted off to return to Earth.

LRO is the first mission in an endeavor to extend a human presence into the solar system, starting with a return to the Moon. Returning to the Moon will enable the pursuit of scientific activities that address our fundamental questions about the history of Earth, the solar system, and the universe—and about our place in them—including aspects of the search for life beyond our home planet.

For images of the eclipse see "Photo of the Month" on Page 12. ■

The Portable Planetarium Comes to Goddard

By Alana Little



Caption: Portable e-Planetarium Go-Dome.

Photo credit: e-Planetarium

Professor Patricia Reiff, Director of the Rice Space Institute at Rice University, visited Goddard Space Flight Center during the week of August 20 to preview to International Polar Year (IPY) meeting participants a new learning tool called the e-Planetarium Discovery Dome.

Imagine stepping into a Moon Bounce type-contraption The room is cool and dark. There are no chairs so you sit in the middle of the floor and wait for something to happen. Suddenly, there is an explosion of color from all sides of the dome. From above, you get a glimpse of shimmering water; from the left a shark swims by, perhaps in search of his dinner; on the right you see a few clown fish swimming by a vibrant coral reef. You have just found yourself immersed in the sea.

This is what e-Planetarium's Discovery Dome brings to eager minds. E-Planetarium is a woman-owned small business, led by Reiff. The company was formed as a way to market shows, software, and planetarium technology created by the Immersive Earth project and its partners.

The e-Planetarium Web site states that the Immersive Earth project is a partnership between the Houston Museum of Natural Science, Rice University, Carnegie Museum of Natural History, HomeRun Pictures, Elumenati, and Sky-Skan, Inc. This partnership was made possible from the "Immersive Earth," a five-year, NASA Research, Education, and Applications Solutions Network (REASoN) funded project that brings together six museums, two universities, and three companies to create and distribute full-dome digital planetarium shows nationwide.

E-Planetarium is a distributor of domes, shows, projectors, and software and the new traveling dome show. "Our planetarium shows are truly immersive because they present the viewer with images, in front, behind, above, and on both sides of their seat," said Reiff.

The planetarium shows are an excellent way for teachers to introduce students to space and Earth science. All content is age-group formatted allowing the tool to grow with a class or an entire school system.

"Unfortunately, most will never be able to visit a planetarium because of where they live and cost constraints," explained Reiff. This is where the dome becomes an extremely useful tool. This easily portable system uses an inflatable dome and a single-fish-eye projector display. (The fish eye mirror system projector is what allows the movies to wrap themselves around the dome.)

Currently, 29 school systems and museums have purchased the e-Planetarium Discovery Dome. This tool makes a lot of sense for educators. The cost of packing up a small number of students for a field trip to their closest planetarium can be enormous, and while the students are gone, they miss an entire day of other learning.

"Owning a dome and training a teacher to use the software developed by e-Planetarium will allow hundreds of children access to museum-quality planetarium shows at a much lower cost," said Reiff. "Once you own the dome and ancillary equipment you can then purchase whatever movies follow their teachers' content."

Reiff explained that the first cooperative agreement called "Museums Teaching Planet Earth," was part of the Earth Science Information Partners (ESIP) program, to use Earth Observing Satellite (EOS) data to create products that could be financially self-sustaining. Their first show, plus the "Earth Update" CD was funded from that one. Goddard helped to finance the program.

The content is very engaging. The e-Planetarium brochure explains how in "Earth's Wild Ride," the year is 2081 and a grandfather shares stories of Earth with his grandchildren who were born on the Moon. Students will get to fly through their lunar colony, soar over the lava flow of an erupting volcano, ride a river through a canyon, and visit the dinosaurs as an asteroid hits.

"Cosmic Questions" is a live-interactive program that covers the objectives students must know for the fifth grade Texas Assessment of Knowledge and Skills (TAKS) test while exploring the Sun, Moon, and planets of the solar system. Moon phases, seasons, and eclipses are all included and the content is adjustable for grade level. Some movies can also be ordered in Korean, Spanish, and Hebrew.

For more information on e-Planetarium and the Discovery Dome, and to find out how you can schedule a free demonstration, please visit:

<http://www.e-planetarium.com> ■

NASA's Radio JOVE Puts Ears to the Universe

By Amy Pruett

On August 19, North Carolina high school students closed their eyes and employed their ears as they tuned into sound waves snagged from space using Radio JOVE telescopes. The Radio JOVE Project is an innovative scientific enterprise that challenges individuals, such as middle school, high school, and college students, to assemble a 20 MHz receiver and an antenna that will capture sounds emanating from Jupiter, the Sun, and the Milky Way galaxy. The summer day also signified an important milestone for Radio JOVE as one student attending the Pisgah Astronomical Research Institute weeklong Space Science Lab in North Carolina used the 1000th kit distributed.

Designed largely by radio astronomers from Goddard and the University of Florida in 1997, Radio JOVE telescopes can be used to study planetary and solar stellar radio emissions by listening to radio waves from Jupiter, the Sun, and the Milky Way galaxy. As energy is released from charged particles trapped in a heavenly body's magnetic field, or in a magnetic field belonging to a planet's Moon or Sun, a Radio JOVE telescope picks up the sporadic radio waves.

According to observers, the sounds that one hears while using the radio telescope could be likened to waves crashing on a beach, or at other times, the sound of popcorn popping. The study of the radio emission increases understanding of the planets and stars, most notably, their magnetic field and their charged particle interactions.

"Through radio astronomy, we want to inspire a number of people to look at the universe in a new way," said Jim Thieman, Goddard scientist and co-founder of Radio JOVE. "The two wavelength bands, optical and radio, that can be received by ground-based telescopes, reveal a lot about the universe and Radio JOVE facilitates the understanding that much can be learned through radio, as well as optical, observations."

Not only do Radio JOVE users learn about radio astronomy, but also how to build electronic devices. The radio telescopes, available for purchase online, come in kit form, so an individual must piece together the provided parts, solder wires, and erect the antenna. The manufacturing process exposes its users to science, technology, engineering, and mathematics in a creative way, enhancing the radio astronomy experience.

While describing the unique traits of Radio JOVE, Chuck Higgins, one of developers and now the distributor of the kit, said "There are lots of other ways to explore science, technology, engineering, and mathematics, but this approach has never been taken. There is no other program like this where you build it [the radio] and own it. Our goal is to not just inspire radio astronomers, but to inspire kids to pursue scientific fields in college." The Radio JOVE kits are available for purchase online and the Pisgah Astronomical Research Institute in North Carolina obtained, among others, the 1000th kit to be distributed. They used the Radio JOVE kits as part of a weeklong workshop to study the Sun for western North Carolina area high school students.

Christi Whitworth, Science Educator at the Pisgah Astronomical Research Institute, believes that Radio JOVE is a valuable, multifaceted learning tool.



Caption: Students assembling a Radio JOVE kit.

Photo credit: NASA

"Radio JOVE provides the student participants the opportunity to work with an instrument, as well as conduct observations needed for the study of the Sun," said Whitworth. "The entire process of the study falls into the hands of the students who will be conducting it. Participating as scientists from the beginning of the study gives ownership to the results and conclusions developed from the study

being conducted. In addition, Whitworth is certain that Radio JOVE generates enthusiasm in its users for the sciences.

"Students have repeatedly mentioned their appreciation for the skills required to build the instrument and some have expressed their desire to pursue careers that involve those types of skills. The excitement they show when they use their instrument for the first time is palatable."

The fact is, Radio JOVE's users learn a lot about radio astronomy, but the knowledge gained doesn't end there. The enhanced understanding continues into other realms of science, technology, engineering, and mathematics. The process of assembling and operating the instrument teaches, inspires, and excites individuals as it presents the study of Jupiter, the Sun, and the Milky Way galaxy in an innovative, creative way. Radio JOVE is an established, respected radio astronomy tool that will undoubtedly continue to facilitate increased understanding as students assemble and operate the kits that put their ears to the Universe.

For additional information on Radio JOVE or to purchase a kit, visit: <http://radiojove.gsfc.nasa.gov/> ■

Photo of the Month

The Lunar Eclipse as Seen on August 28, 2007



Photo credit: Dylan O'Donnell in Albury, New South Wales, Australia.

Caption: This image shows the lunar eclipse as a series of images of the Moon.



Photo credit: Anthony Arigo/SpaceWeather.com

Caption: This image shows a star emerging from the limb of the Moon during the eclipse on August 28, 2007.



Photo credit: Anthony Arigo/SpaceWeather.com

Caption: This image shows the Moon during the eclipse on August 28, 2007.