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Experiment Aims To Study Effects Of Martian Gravity

By Rosamund Combs-Bachmann and Ryan McLinko

As NASA turns its attention towards exploration of the Moon, Mars, and the worlds beyond, we move closer to the day when a crew of astronauts will stand on Martian terrain, the first humans to gaze upon the rust-colored sands and rocky outcroppings of Mars without the aid of a camera. The mission of the Mars Gravity Biosatellite Program is to aid those first critical steps towards human expeditions to Mars and beyond.

Before astronauts set foot on Mars, we must know more about the results of exposure to Martian gravity. The Mars Gravity program is a university-led effort to develop and operate a ground-breaking biosatellite to study the effects of Mars-level gravity (0.38g) on mammals. Mars Gravity team members at MIT and Georgia Tech are designing a biosatellite to carry 15 mice in low Earth orbit for a 5 week mission. As it orbits, the satellite will spin to generate artificial gravity of 0.38g and thus supply the first data on long-term mammalian exposure to such an environment.

Astronauts lose significant amounts of bone and muscle mass when they live in a microgravity environment for long periods of time. Currently, it is not known if gravity on Mars is strong enough to avoid or minimize these health problems. The voyage of the 15 ‘mouse-tronauts' will provide a more thorough understanding of how the body adapts to the weak level of gravity on Mars, and may also contribute to our understanding of osteoporosis-related bone loss.

At MIT, the Mars Gravity Biosatellite Program is a hub for the Bus team, the Payload team, and the Systems team. The Bus team is in charge of designing the Bus system of the satellite, which provides power and other necessities to the mice while in orbit. The Payload team is designing the actual payload module for the mice, including the cages, atmospheric modules, and other life-support. The Systems team is responsible for integrating the different systems to make sure that the entire satellite meets the science requirements. The Systems team also maintains a CAD model in order to facilitate the interfacing of the different systems of the satellite. Georgia Tech is in charge of designing the EDLS, which is responsible for the entry, descent, and landing of the satellite.

Students from around the world have joined the Mars Gravity project to advance our understanding of partial gravity environments, and to share their love of space with the scientists and explorers of tomorrow. To advance this goal, Mars Gravity reaches out to a variety of local educational groups and to the global community as well. To date, over 450 hundred students from 17 countries have contributed time, energy and enthusiasm to the Mars Gravity Program – sustaining research in a largely unexplored area of the gravitational continuum. Engineers, biologists, business students, physicists, and others work towards a common goal of discovery and deeper knowledge of space physiology.

The Mars Gravity Biosatellite Program is a collaboration between the MIT Aeronautics and Astronautics Department and the Georgia Institute of Technology Guggenheim School of Aerospace Engineering. The biosatellite is tentatively scheduled to launch in 2010 aboard the Falcon 1 launch vehicle.

ISDC Is Wildly Successful But Lacks Student Input

By Matt Cruce

The 25th International Space Development Conference (ISDC) was one of the most successful and exciting space conferences to date. With over 1300 conference attendees it was the largest ISDC in its 25 year history. Held in Los Angeles, California from May 4 thru May 7, ISDC 2006 featured dozens of presentations, interactive exhibits, panel discussions and activities spanning the entire spectrum of space related issues such as tourism, technology, policy, science, exploration and commerce. The roster of speakers at the conference was one to make anyone remotely interested in space drop their lower jaw in awe: two Apollo astronauts (Rusty Schweikart and Buzz Aldrin), founder of the X-Prize and SEDS (Peter Diamandis), the most innovative aircraft/spacecraft designer of our time (Burt Rutan), SpaceX CEO (Elon Musk), the heads of the "BIG 3" (Boeing, Lockheed Martin and Northrup Grumman), FAA administrator for commercial space transportation (Patricia Grace Smith), the science teacher who sparked the flame of love for science in many people of our age (Bill Nye the Science Guy), founder of the Mars Society (Robert Zubrin). This can barely be called a sampling of all the guests that were at ISDC.

Aside from the speakers there were many events taking place at the conference worth a person’s time. The space art symposium was a creative and unique feature that I think everyone would like to see again in the future. Artists from all over showcased their space related artwork. Several gave lectures on how they create artwork from raw data collected by NASA satellites and orbiters. The Space Venturing Forum in its third year brought together senior business leaders from all sectors of space exploration and gave attendees a chance to pose tough questions to them. NASA announced its centennial challenges and held development workshops on them. Tours of various aerospace facilities in southern California were given. Elon Musk served as tour guide of his own facility, SpaceX!

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The list goes on and on of the events that took place in those short four days. There was far too much for one person to take it all in. I saw all sectors of space exploration represented there and given a voice -- all except one. There were no students in any of the panel discussions giving a voice to our generation. We were often referred to by the speakers and other guests as the people who are going to do the work to take humans to Mars and beyond and give all people the opportunity to travel in space. As one of the few college students at the conference, I was often asked questions about what others my age felt about space exploration, about NASA, or if what Burt Rutan says is taken as gospel by all aerospace students. I met all kinds of interesting people with interesting questions for a student. Why not pose those questions to a student in a forum like ISDC where everyone can hear the answer? This is part of what SEDS should strive for -- a representation, a voice of the next generation.

The National Space Society and the Planetary Society did an amazing job of bringing all those amazing minds together and it was an inspiring event for all those that attended. I would recommend that more SEDS members make the trip to ISDC and other events like it. Lets show the world that we are ready and willing to take on the challenges set by those that came before us to push the envelope of space exploration and technology to better the human race altogether.

Most Powerful Camera Yet Arrives At Red Planet

By Aaron Wilcox

New pictures are added to our view of Mars every day due to NASA's successful constellation of craft both on the surface and in orbit around the Red Planet. The number of these craft has been increased by one as Mars Reconnaissance Orbiter (MRO) settles into its final orbit. This new craft will build upon the discoveries of previous craft. It may answer the question as to whether Mars has liquid water beneath its surface. It will also scout for landing sites for future missions such as the Mars Phoenix Lander and the Mars Science Laboratory.

This last task falls largely to the High Resolution Imaging Science Experiment, or HiRISE camera. HiRISE will give a view of Mars with unprecedented detail. The principal investigator and originator of the HiRISE instrument, Dr. Alfred McEwen, was kind enough to give us an interview to discuss HiRISE and its place in the MRO mission.

While many of today's planetary scientists can trace their interest in other planets to the inspiration of the moon landings, Dr. McEwen's developed in a more roundabout way. While his colleagues dreamed of Apollo, his dreams remained Earthbound, "I wanted to be inspired by the environmentalist movement on Earth and went that route, and later changed to study geology and went to Northern Arizona University in Flagstaff." His search for employment led him to space exploration, "I thought I needed a job and managed to get one at the USGS Center for Astrogeology where they do planetary science…I got interested in it (planetary science) at that point in time." Since then Dr. McEwen has been involved with many different spacecraft including Voyager, Galileo, Clementine, Cassini, and with the Mars Reconnaissance Orbiter's predecessors Mars Global Surveyor and Mars Odyssey, both of which are still in operation.

The Mars Reconnaissance Orbiter is a mission that will build on NASA's previous Mars missions, answer some of the mysteries they uncovered and ask a few questions of its own. MRO will study Martian weather, climate, and geology. It will search for evidence of water, past and present. And it will aid future missions by searching for future landings sites and acting as a communications relay. Its power systems allow it to run an impressive array of instruments to achieve these objectives. Its communications system allows it to transmit data twenty times faster than previous missions. This means its array of instruments is more powerful and sophisticated then previous missions. Its imaging spectrometer will analyze different spectra of the Martian surface to identify water-related minerals. Shallow Subsurface Radar will penetrate Mars' surface to map its underground geology and to search for subsurface liquid water. Mars Climate Sounder will analyze the Martian atmosphere to study Mars' weather and climate. The Context Camera and Color Imager will take large-scale images to analyze larger features. Other instruments will study weather and perform other studies. Arguably, however, the centerpiece of Reconnaissance Orbiter is HiRISE. With its unprecedented resolution, the images it takes will likely be the public face of the mission.

Dr. McEwen is the father of the HiRISE camera. He began work on a proposal for HiRISE at the beginning of 2001 and submitted the proposal to NASA in August of the same year. NASA announced its acceptance of HiRISE in November 2001. HiRISE was launched as part of the Mars Reconnaissance Orbiter mission on August 12, 2005. Despite his wealth of experience with interplanetary missions HiRISE has been a challenge. "I had lots of experience on the active phase of missions, collecting data and analyzing it, but I'd never been involved in building an instrument before at this level of detail, working with the engineers and the actual design. It is quite a new experience for me."

Despite the challenges and setbacks, the labors of Dr. McEwen and his colleagues have had spectacular results. HiRISE will allow NASA to see images at the highest resolution ever applied to another planet. HiRISE will take color, stereo pictures of strips of the surface 3.5 miles wide and be able to resolve objects as small as one meter (40 inches) across from 190 miles above the surface.

Taking pictures of kitchen-table sized objects from almost two hundred miles up is not easy. But HiRISE must do this while orbiting Mars at a speed of 7800 mph (3.5 kilometers per second.) Though the optics are impressive, Dr. McEwen says the key to HiRISE is the processing of the data. Collecting enough photons to get a single, detailed image at that speed is nearly impossible. So HiRISE images features up to 128 times and combines them to create a detailed picture. It is a technique known as Time Delay Integration. "That was our biggest challenge, getting that to

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work properly," McEwen said.

HiRISE is also one of the most versatile instruments on Mars Reconnaissance Orbiter in that it will help to achieve several of the primary missions. A primary task for HiRISE will be engineering support. It will take pictures of potential landing sites for future missions and allow engineers to determine their safety. Dr. McEwen pointed out that a craft such as the Mars Phoenix Lander, scheduled as the next Mars lander, could be destroyed if it hit a rock just one foot (one-third meter) high as it landed. Only HiRISE has the resolution capabilities to be able to spot such an obstacle.

HiRISE will also contribute greatly to the science goals of the mission. It will be able to analyze landforms to help determine what geologic processes formed them and whether certain features may have been formed in the presence of liquid water. It will also study the deposits in Mars' polar regions to help study possible cycles in the Martian climate.

Some have suggested that HiRISE's imaging talents may enable NASA to find its lost spacecraft, Mars Polar Lander, lost in 1999. According to Dr. McEwen, this would be difficult due to the lack of information about its demise. The location and method of Mars Polar Lander's end is unknown, which leaves NASA not knowing where to look or what to look for. Add to this blowing dust and dust storms that could have buried it, and the chances for finding Mars Polar Lander are extremely remote.

HiRISE will even be looking into the famous "Face on Mars." "We will image it because people are interested," Dr. McEwen said. NASA will use the images for education and public outreach. However he does not share the opinion of many conspiracy theorists. "It already does not look anything like a face," he said.

In the spirit of Sojourner, and the Mars Exploration Rovers Spirit and Opportunity, public outreach will be important for Mars Reconnaissance Orbiter and for HiRISE in particular. "We are planning to accept target suggestions from the general public," Dr. McEwen stated. A website will be opened where people can suggest targets for HiRISE to image. They will also have access to HiRISE images and other MRO images and data. They will also have the opportunity to participate in the generation of science data. In a program called Clickworkers (http://clickworkers.arc.nasa.gov/top), volunteers helped with the classification of craters on Mars and in other projects. Similar projects will allow individuals to work with MRO and HiRISE data. While the website for suggestions is not yet open to the public, information about HiRISE can be found at the HiRISE website (http://hirise.lpl.arizona.edu).

A New Way To Find The Most Massive Objects In The Universe

By Andy Green

Finding the mass of something is surprisingly difficult, as anyone who has used a series of bathroom scales is likely to tell you. Measuring the mass of something the size of the earth requires some ingenuity. Cavendish did this in a very elegant way—he measured the value of Newton's constant, which relates the mass to the acceleration of gravity. Armed with the value of G, astronomers could find the mass of other planets and the sun. By calculating the length and size of the orbits of the planets, one can combine Newton's gravitation with Kepler's laws to measure the mass of the sun, and then the other planets in the solar system. Outside of our own solar system, similar methods involving Kepler's laws can be applied to only a few binary star systems which are close enough make each star individually visible. Measuring the mass of more distant and massive objects, such as galaxies and clusters of galaxies is quite difficult indeed. It was for this reason that astronomers were so reluctant to consider the presence of dark matter, an idea first proposed by Franz Zwicky at Caltech in the 1930s.

As astronomers considered various methods for measuring the mass of galaxies and then groups or clusters of galaxies, each new method was able to probe a larger scale than the previous. The estimates for the total mass of galaxies and then galaxy clusters got larger with each larger scale measurement, while the estimate of the total brightness or luminosity remained the same. The evidence suggested a large distribution of dark matter around these galaxy clusters. At first, astronomers thought that this dark matter might be ordinary matter which simply wasn't emitting any light, such as gas, dust, planets or black holes. Modern astronomers now think that this dark matter is some exotic material which only interacts with other matter in the universe through gravity. The large collections of dark matter around galaxy clusters are now called dark matter halos.

Measuring the mass and other properties of dark matter halos is important for understanding how the universe is evolving and expanding. Because dark matter halos and the galaxy clusters embedded within them are the largest gravitationally bound systems in the universe, they are also the rarest, and therefore provide good constraints on the cosmological parameters describing the evolution of the universe. Because gravity through which these dark matter halos interact is well understood, a computer can accurately model how these halos form and evolve. Finding and counting dark matter halos around galaxy clusters is important to a clear understanding of how the universe is evolving.

Many methods have been established for estimating the mass of one of these clusters of galaxies or dark matter halos. The first and perhaps most straightforward is to apply the same method used on planets orbiting around the sun. By calculating the velocity of stars orbiting the center of a spiral galaxy, the mass inside the orbit of the star can be estimated. Unfortunately this only works for spiral disk galaxies. Another method involves measuring the velocities of all of the random orbits of stars in an elliptical galaxy. In these galaxies, stars do not orbit in a uniform disk, but rather move around the center of the galaxy on randomly oriented and highly elliptical orbits. A mass estimate can be made based on these velocities. This estimate, however, is affected by the

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amount of time since the galaxy last collided or merged with another galaxy, introducing inaccuracies in the measurement. A more recent method, which also began to indicate clearly that there is much more dark matter than luminous matter, is to measure the temperature of the X-ray emitting gas which surrounds galaxy clusters. These measurements, which were conducted in the 1980's with the first X-ray space telescopes, suggested that there was as much as 200-300 times as much mass as was accounted for by stars in these galaxy clusters.

All of these methods for finding and measuring the mass of a dark matter halo depend upon detecting the light emitted by the associated normal matter. This normal matter is usually referred to as baryonic matter because it is primarily made up of fundamental particles known as baryons. This baryonic matter only represents about 20% of the total mass of the halo. A method for finding these halos by directly detecting the dark matter would avoid any problems in our understanding of how dark matter and normal matter associate. A method to do just that was also suggested by Zwicky.

Einstein's general relativity showed that light is bent by any massive object which it passes near. Zwicky suggested how this effect could be measured for distant galaxy clusters, a method known as gravitational weak lensing. The method is called lensing because the effect is similar to that of a simple magnifying glass. It is weak because the effect is very small: a typical galaxy is stretched by only 1-2% of its size. This is very different from strong lensing, where galaxies deformed by very massive gravitational lenses can be stretched into long arcs or even multiply imaged. Because the weak lensing effect is small, telescopes have only become powerful enough to make this very delicate measurement in the past five years. Several groups around the world have successfully measured the weak gravitational lensing effect of individual galaxy clusters. However, the true power of this measurement lies not in individual detections, but in making the measurement on many clusters

Gravitational lensing is an important method of searching for dark matter halos not only because it is independent of baryonic matter, but also because the strength of the gravitational lens leads directly to the mass of the cluster though a simple formula. The only other unknowns in this formula are the distance to the cluster and the distance to the background (lensed) galaxies.

Our group is leveraging the power of weak lensing in the first blind survey to detect galaxy clusters. This group represents a collaboration between a group led by Satoshi Miyazaki from the National Astronomical Observatory of Japan, which has focused on the weak lensing aspects, and a group led by Richard Ellis at Caltech, which focuses on determining the distances to these clusters.

The survey covers 22 square degrees of the sky, roughly one quarter the size of a fist at arms length. The area is divided among seven separate patches of sky. This partitioning is to sample potential variance between different patches of sky. This is a blind survey, meaning that we have searched these patches without any prior assumptions about where clusters are or might be. There are, however, known clusters in our field, which have been found by previous searches. Thus we will be able to compare weak lensing as a cluster finding method to other, more traditional methods.

Gravitational weak lensing is not without its problems. Because the effect is so small, there is a lot of noise. Some of the noise is inherent in the measurement, such as the random intrinsic shapes of the galaxies. Other noise is introduced by the CCD and the way in which it is read out, by tracking problems while the image is taken, by the turbulence of the atmosphere, and by inaccuracies in the grinding of the mirror. Calibrating away these errors is very difficult. It is accomplished by looking at stars that inevitably appear in every field of the telescope. In a perfect world, these stars would occupy just a single pixel in the image. However, they are spread out for various reasons, many of which are those just mentioned. The amount by which these stars are not point-like is called the point spread function, or PSF. By assuming the star should be round, it is possible to correct the image when the star is not round. The size of this PSF is often more than 10 times the size of the weak lensing signal, so accurately correcting this problem is very important.

Because this technique is new, many of the sources of noise are not fully understood. We are working hard to gain a better understanding of these noise sources and suggest how to avoid or remove them in our own and future surveys. One such noise source is in the number of cluster galaxies which are used in the measurement of the weak lensing signal. Only the background galaxies are lensed by the foreground cluster's mass, so these foreground galaxies can dilute the signal from the background galaxies. A host of other problems have also been encountered which must be solved or explained before we will have a final catalog of clusters available.

Since the distances to these clusters are necessary to determine their mass, measuring these distances reliably is very important. For distant galaxies, this requires a spectra of the galaxy. By measuring the redshift of the galaxy, we can use Hubble's law to determine the distance. While a cluster is composed of many galaxies, a small patch of sky will contain other galaxies that are not associated with the cluster. Because collecting spectra of these galaxies is time consuming, the galaxies that receive telescope time are carefully selected among the surrounding galaxies. Even with these selections, sometimes the redshifts of the galaxies do no agree. Without at least a couple galaxies with the same redshift, it is difficult to determine if we have actually found a cluster or not. In these cases, the objects are re-observed, and often further investigation reveals the distance to the cluster.

This survey will be the first of its kind. It will demonstrate many of the problems associated with this method of cluster finding and offer solutions to those problems. There are other groups working on much larger surveys, although these will take much more time to complete. This pilot survey will suggest how our understanding of cosmic parameters can be constrained by these surveys, but the larger surveys will be necessary to provide useful constraints on these parameters.

Further Reading:

The pilot survey, which tested many of the methods, is described in:
Miyazaki, et. al. "Searching for Dark Matter Halos in the Suprime-Cam 2 Square Degree Field" Astrophysical Journal, vol. 580, pp. L97-L100, 2002.

A good introduction to gravitational lensing can be found in:
Joachim Wambsganss, "Gravity's Kaleidoscope" Scientific American, November 2001, Vol. 285 Issue 5, pp. 64

SEDS students got a chance to interview NASA's Administrator at this year's Goddard Memorial Symposium.

From left: Kirk Kittell, Mike Griffin, Megha Sharma, John Evans

Griffin Offers Students Advice

By Kirk Kittell and Megha Sharma

On March 14, Megha Sharma and Kirk Kittell spoke with NASA Administrator Mike Griffin at the American Astronautical Society's annual Goddard Memorial Symposium in Greenbelt, Maryland. After his opening presentation, he answered questions about the aerospace demographic gap, space science, and how to be where he is now.

During his presentation, Griffin spoke about the communications gap between scientists and engineers, but we asked about a different communications gap — the one between the older generation that is dominant in the NASA workforce and the needed influx of younger scientists and engineers to replace them when they retire. He suggested that a way to link incoming and outgoing employees was through professional societies, as he did when he was younger. "What I did was join professional societies like AAS, AIAA, IEEE. I did things to put myself in the company of older folks: I went to professional society meetings, I joined committees, I volunteered to work on things. In that environment, age differences will go away and they will accept you. The role of AAS is underutilized, underappreciated by many young folks."

One of the hot topics at the time of his presentation was the impending reductions in space science. When asked how students studying for careers in science should consider the cuts, he noted that the reductions are dependent on perspective. "We're flying 54 missions right now in the operational phase and dozens more coming along. We're spending $5.3 billion this year on space science missions. There are an enormous number of opportunities."

How does Griffin define success in his position as NASA Administrator? His firmly-bounded criteria included flying the shuttle safely, finishing the space station during his tenure, being well along the road to finishing CEV, and effectively preparing for a return to the moon. "If we have our architecture accepted for 'this is the way we're going back to the moon,' then I'll feel I have been successful."

Before he left, we asked him how we can follow him to the top of the ranks in the space industry. "Those are the right things to think about: 'how can I be where I want to be?' So, what you have to do right now is to be a practitioner: to do real stuff, and to do it on as broad a stage as possible. Write professional papers, go to conferences, work, join committees, get involved and you'll have the opportunity to meet international players. When you get older together, you'll have a history with each other."

Remember: when you talk to Mike Griffin in person, it's Mike, not Dr. Griffin. If you participate in the AAS Goddard Memorial Symposium in March 2007, you will have the opportunity to try this and ask him your own questions. Also, if you participate in the International SEDS Conference or the International Astronautical Conference in Valencia, Spain, in October 2006, you will also meet the NASA Administrator.

A Special Thanks To . . .

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Conference Opportunities

Space Frontier Foundation's Return to the Moon Conference
Date: July 20-23, 2006
Location: Las Vegas, Nevada
Website: http://www.space-frontier.org/

Mars Society Conference
Date: August 3-6, 2006
Location: Washington DC
Website: http://www.marssociety.org/convention/2006/

2006 AIAA/AAS Astrodynamics Specialists Conference
Date: August 21-24, 2006
Location: Keystone, Colorado
Website: http://www.space-flight.org/

X Prize Cup
Date: October 19-22, 2006
Location: Las Cruces, New Mexico
Website: http://www.xpcup.com/index.cfm
Volunteer Opportunities Available

AAS National Conference
Date: November 14-15, 2006
Location: Pasadena, California
Website: http://www.astronautical.org/

SpaceVision 2006 Conference
Date: November 2006 (Exact dates to be determined.)
Location: Orlando, Florida
Website: http://www.seds.org/

Please email Todd Romberger at vice-chair@seds.org if you or anyone from your chapter is interested in attending (or already planning on attending) any of these events. By communicating and cooperating in our travel plans we can pool resources, save money, and represent SEDS as a cohesive group.

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