PLANETARY SCIENCE INSTITUTE

NEWSLETTER

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Puzzling Craters on Titan

By Charles Wood (our Man in Managua)

On February 15, 2005, the Cassini spacecraft made a close flyby of Titan (Saturn's largest moon), acquiring a second radar image of the moon's surface, while using the flyby to tweak its orbit for upcoming studies of the Saturn system. Some radar team members were at JPL's California laboratory to get a first view of the new portion of the cloud-swathed moon. Other team members, like me, were waiting at home. But, *my* new home is Managua, Nicaragua.

Following a 30-year career teaching at universities and working for NASA, I had taken semi-retirement in January and moved, with my family, to Nicaragua. We chose Nicaragua because it is a beautiful land with many active volcanoes — perhaps my volcanological experience can help Nicaraguan scientists monitor their volcanoes. And as a planetary geologist, I have always been interested in terrestrial volcanoes, not only for their beauty and power, but also to understand their formation and modification processes, so that these could be applied to interpret eruptions on other worlds. Also, politically stable now — the three presidential elections since 1990 saw power transferred peacefully from the revolutionary Sandinistas to a business-oriented conservative government — Nicaragua is beginning to attract tourists and new residents.

I call it "semi-retirement" because I still work part-time on my Cassini grant, trying to interpret the history of the 5,150-km-wide Titan from the radar images that Cassini will acquire over the next 3.5 years. Also here in Managua, I continue to write my Lunar Photo of the Day web page (http://www.lpod.org) as part of another NASA grant to promote space science to the public. But now, and every few months, as more Cassini flybys provide new looks at Titan, I collaborate with my colleagues, including Ralph Lorenz and Jonathan Lunine at the University of Arizona, to decipher this amazing world.

Titan is larger than the planets Mercury and Pluto, and was briefly imaged in 1980 as the Voyager 1 spacecraft whizzed through the Saturn system on its way to Uranus, Neptune and beyond. However, Titan is covered by a thick orangeish haze that kept Voyager from seeing its surface. Cassini was designed to carry a radar instrument whose signals would penetrate the thick haze to record Titan's surface. Our first radar pass on October 26, 2004, revealed a weird terrain unlike most other planetary surfaces. We saw no impact craters, and much of the surface was an even, dark hue that provided little clue as to what geologic processes operated there. But we did see a 100-km-wide feature that we think is a giant volcano, and a few smaller craters with long, white flows that we tentatively interpret as volcanic calderas with water ice lava flows. ***Continued on page 2***

This 80-km-wide impact crater was seen on the second radar pass of Titan by Cassini, February 15. The crater has a dark zone of ejecta around it, but more interesting is a broad, bright area that looks like the parabolas around some impact craters on Venus. If this bright patch on Titan is associated with the crater, it was probably formed by the projectile's interaction with Titan's atmosphere. (NASA/JPL)

Inside this issue:

Puzzling Craters on Titan *continued*

The February 15 Cassini pass greatly widened our perspective of Titan. The radar provided us with a thin noodle (3000 km long, 300 km wide) view of Titan's surface. This time we discovered two large impact structures. One looks very fresh, is about 440 km wide and appears to be a twin-ring impact basin, such as Bill Hartmann and I studied on the Moon 30 years ago. The other crater (see image on previous page) is about 80 km wide and seems to be surrounded by a radar-bright halo of presumed ejecta. It is peculiar that so far only two craters — one large and the other gigantic — have been seen on Titan. Have smaller craters been destroyed by ice eruptions and a drizzle of ethane from the atmosphere? The existence of the 440-km-wide basin is puzzling — in most of the solar system, craters that large were formed earlier than about 3.9 billion years ago, but the basin on Titan is probably much younger. Where did the projectile that formed it come from?

Over the next 40 or so months, the Cassini spacecraft hopefully will continue to perform flawlessly, giving us periodic new views of Titan's surface. For some of these encounters I will fly to JPL to be an onsite part of the radar team, but for most encounters I will download the new images from the Internet and participate in email discussions with my colleagues on what the new data mean. And, at the end of the day while they fight freeway traffic to get home, I will step out to our verandah and contemplate the meaning of Titan and the rest of the cosmos while using my oscillatory suspension facility — which here in Nicaragua is known as a hammock!

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the Cassini-Huygens mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The radar instrument team is based at JPL, working with team members from the United States and several European countries.

The Colors of Clouds: Cloud Coronae

By David J. Lien

This is the first in a series of short articles dealing with the different ways in which clouds can display colors.

Rainbows — created when falling raindrops are lit by the sun —are not the only way in which colors show up in the sky. We see the blue of the sky and the orange-red hues of the setting sun reflected on passing clouds. Less often noticed, yet still very common, are colors created when sunlight (or moonlight) passes through the clouds themselves. Not only aesthetically beautiful, the scientific study of these colors can yield useful information about the size of the particles in the cloud and even if the cloud is made of ice crystals or water drops!

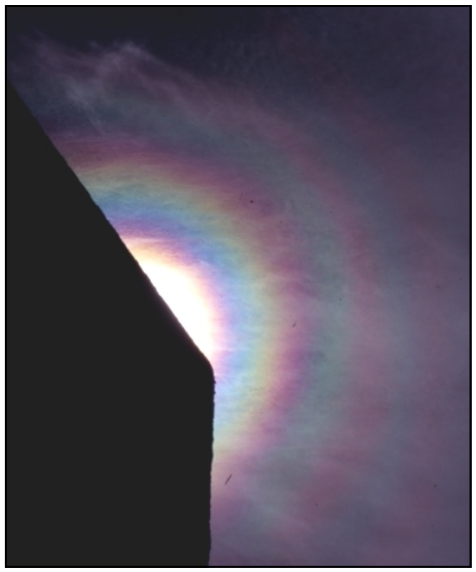
Despite the wide range of colors which can be found in the sky, they are all produced by one of two mechanisms: light r*efraction* or light *diffraction*. Light refraction occurs when light passes from one medium (like air) into another medium (like water), and is the cause of rainbows (more of which will be said in another article). Light diffraction is due to the wave properties of light, and is usually most apparent when light passes through small openings (the best example of this is to look at a distant streetlight through a window screen — the spreading of the light and the colors you see are due to light waves interacting with each other as they pass through the screen).

Light which passes through the small water droplets in clouds is also diffracted, and we usually see this diffracted light as a small, faint red ring around the moon (and around the sun, if you look carefully). This ring is called a "cloud corona" (or sometimes just a "corona").

If you look carefully, you will see this faint red ring around any cloud which passes in front of either the sun or the moon. CAUTION: be sure to block out the direct sunlight and wear sunglasses when looking for the cloud corona around the sun!

The diameter of the red ring tells us about the size of the water drops — the smaller the droplet, the larger the ring. A red ring which is just 2 moon widths in diameter has water drops which are about 20 microns in diameter (the width of a human hair is about 100 microns). A red ring which is about 20 moon widths in diameter is made from water drops which are about 6-8 microns in diameter.

The diffraction of sunlight from a single water drop actually creates a series of concentric rings of all colors around the light source. However, most clouds are made of water droplets of many sizes, which causes all of the colors to blend together except for the innermost red ring from the largest water droplets.



Some clouds are made of water droplets which are all about the same size, and in these rare cases the concentric rings of colors can be seen easily. Such was the case last January in Tucson when I took this photograph of a cloud passing in front of the sun.

The black structure is the edge of a building which I used to block out the bright sun. This picture was taken with a 35mm camera using Fujichrome 100 slide film. The brightness and contrast of the scanned image were modified to improve the image, and except for the vagaries associated with the reproduction process, the colors have not been enhanced or modified from the original.

Major Grant from National Science Foundation Awarded to PSI

Kortenkamp to direct newly-created, PSI Center for Interdisciplinary Research

By Frank Chuang

In the late morning of February 1, 2005, I heard cheering down the hall from my office at PSI, and suspecting it had to do with an award announcement we were waiting for, I went to investigate. I ran into our new Financial Officer, Bruce Barnett, who confirmed my thoughts — we had been awarded the grant! After many months of anxious anticipation, PSI was officially notified by the National Science Foundation (NSF) that we had been selected for an Advanced Technology and Instrumentation (ATI) equipment grant, effective immediately.

Our newly-awarded, three-year grant, totaling over $224,000, began with a proposal put together in January, 2004, by PSI research scientist Steve Kortenkamp, with input from many other PSI research scientists and staff who will utilize these funds. The proposal sought support from the NSF to establish a new Center for Interdisciplinary Research (CIR) at PSI. This grant award is a significant step forward for the Institute, as it provides the resources to perform research at the highest level, and, a less tangible, but nonetheless important goal of increased visibility for PSI. Because many of the groups performing research at PSI have interests that overlap, or need people with scientific expertise outside of their own, the establishment of our new CIR is only natural.

Part of the grant will be used to acquire a high-performance computer cluster from Sun Microsystems. This computer cluster will enable the Planetary Origins and Impacts Group to run complex simulations of planet formation, dynamics of small-bodies such as asteroids and comets, and impacts on planetary surfaces and their effects on planetary environments.

A second portion of the grant will be used to purchase additional computers, software, and peripherals (such as printers) needed by the Planetary Geosciences Group. The hardware and software will provide the resources for image processing, developing Geographic Information Systems databases, and digital mapping of planetary surfaces. A large-format printer will allow output of high resolution letter-to poster-sized prints for various meetings and conferences (see picture).

Surrounding our new HP large-format printer (our first major grant purchase) are the happy Principal Investigator (PI) and Co-Investigators (Co-I's) of the NSF major equipment grant. From left: Elisabetta Pierazzo, Steve Kortenkamp (the PI), Mary Bourke, Stu Weidenschilling, David Crown, Les Bleamaster, and Frank Chuang. Co-I's not shown: Don Davis and Nader Haghighipour.

For terrestrial field studies, the grant will be used to purchase Global Positioning System devices, a laser rangefinder, an industrial-strength laptop, and other tools to measure and document geologic features of interest. The grant also contains support for personnel to help maintain the future computer cluster.

Special thanks to everyone — science and administrative staff— who helped PSI win this award!

PSI Welcomes New Financial Officer, Bruce Barnett

Bruce Barnett joined PSI on January 5, 2005, as our new Financial Officer. He has a Bachelor of Science in Accounting and Finance from Northern Illinois University and also earned his C.P.A. in Illinois. Bruce also has a wealth of knowledge from 20 years of financial management experience and a career background that seems tailor-made for our Institute's finance needs as well as our non-profit culture.

Prior to PSI, Bruce worked for another non-profit, scientific enterprise — Biosphere 2. Bruce was the CFO for Columbia University's Biosphere 2 Center, north of Tucson, for 5 years ending in 2004, when Columbia ceased managing the program. At the 250-acre Biosphere 2 Center, he was directly responsible for the Finance, Human Resources, Purchasing and Warehouse departments. Bruce joins Chuck Wood and James Ward as Biosphere 2 alumni at PSI.

From 1994 to 1999, Bruce worked for another Tucson original — Lisa Frank, Inc., a privately-held company and national leader in children's consumer products, with annual sales of $70 million. There he held the position of CFO, and later, the Director of Business Development. Interestingly, Lisa Frank began her company at 620 N. 6th Ave. — the former home of PSI.

Bruce spent 10 years with the Packaging Corporation of America, EZ Por Division in Wheeling, Illinois, ending as Director of Operations. Also, before college, he spent 4 years in the U.S. Navy, active duty; then 9 years in the Navy reserves.

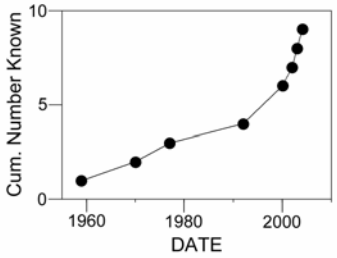
Bruce's family includes his life partner, Tammi, and his three grown daughters, including twins. Two of his children live in Tucson, and one in Phoenix — attending Arizona State University as a junior in the Walter Cronkite School.

PSI is very fortunate to have Bruce heading our finance and grants administration and we look forward to a long, harmonious association.

PSI at Meteorite Meeting in Switzerland

Continuing our participation in projects at the International Space Science Institute (ISSI) in Bern, Bill Hartmann helped organize a workshop on a rare class of meteorites. These are meteorites whose entry trajectory and behavior as a fireball in the atmosphere were videoed or recorded by other means. The interesting thing is that in all available cases, the first explosions observed in the high atmosphere occurred when the stresses and pressures on the incoming body were much *less* than the strength of the rocks collected on the ground. This seems to mean that the meteorite bodies in space had very low strength, probably because they were highly fractured from impact events prior to their arrival on Earth.

This class of meteorites may thus tell us important stories about the nature of meteoroidal bodies in space. Recoveries of meteorites from observed fireballs are rare; only nine cases are known so far. But the rate has increased very rapidly in the last few years, because of the rapid spread of amateur video cameras and surveillance equipment. As can be seen in the graph at left, this class of objects can be expected to expand dramatically in the next few years, offering new insights into interplanetary bodies.



The first meeting of the fireball working group at ISSI, October, 2004. Standing from left: Edwin Gnos, (Switzerland), Olga Popova (Group leader, Russia), Josep Trigo-Rodriguez (Spain/USA); seated: Bill Hartmann, Ivan Nemtchinov (Russia), Jiri Borovicka and Pavel Spurny (both Czech Republic).

Director's Notes: News! News! News!

Our California accounting office is now closed and integrated with the rest of our accounting and grants management operations in Tucson. Bruce Barnett has joined PSI as our new Financial Officer and we are very glad to have him on board!

The Tucson office has expanded into the "West Wing," which contains several of our scientists, programmers, our conference room and main computer operations. The "East Wing" contains more of our science staff, the administrative and financial staff, and our library. We plan to have an open house in April.

We are experimenting with VoIP phones in the West Wing (Voice Over Internet Protocol). Each phone has its own IP address; so, a person can take their phone home, plug it into their high-speed internet service, and calls to their office will ring at their home. We are working with the provider about capabilities allowing our off-site scientists to be integrated into a single system with our other VoIP phones (imagine talking over an intercom to anyone on the system regardless of where they are — for no charge — whether they are in Washington DC, Tucson or Nicaragua).

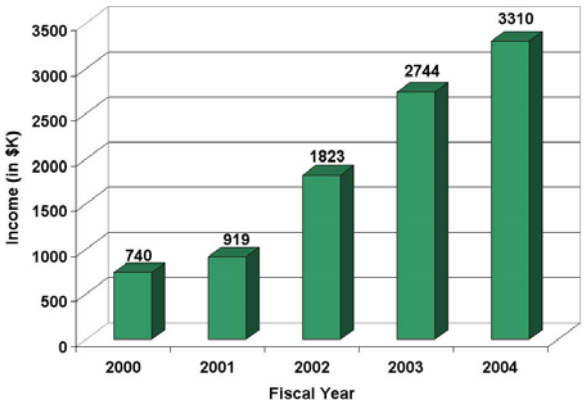
Each quarter, I have been mentioning PSI's growth. Now that we have finished our fiscal 2004, I thought I would illustrate this with the two figures below.

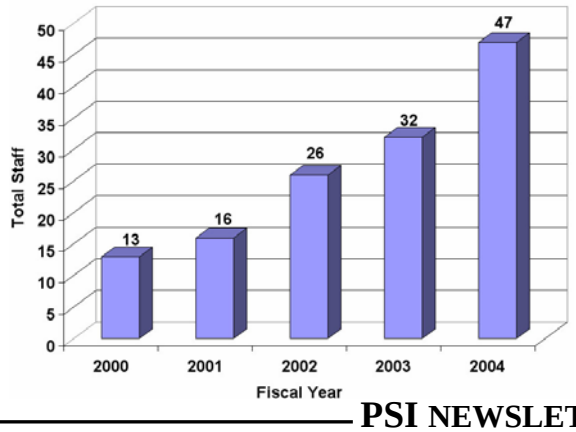
From 2000 to 2004, PSI has more than quadrupled its income (all research grants), and our staff has grown rapidly as well. Over the past couple of years, we have been joined by a number of young talented scientists who are successfully working to establish independent research programs. These are exciting times for PSI. To read about the individual research activities of PSI scientists in 2004, go to www.psi.edu, click on Research, then Annual Research Reports.

We always have to keep our eye on the future, and for PSI things are looking pretty expansive. Think scientific expeditions to remote locations on Earth, a PSI Discovery mission, a spacecraft instrument development program, shaping the Moon-Mars program, and more fundamental research programs.

2005 is going to be a good year!

Mark Sykes
Director





Planetary Photo of the Month: A Little Crater on Mars

By W.K. Hartmann

A shallow human-made impact crater on Mars, caused by the impact shield of the Mars Opportunity rover. The crater, photographed by the rover itself, is near the landing site in the Meridiani Planum ancient lakebed. The heavily-damaged heat shield itself is in the background. (NASA)

PSI researchers Don Davis, Elisabetta Pierazzo, Bill Hartmann, Stu Weidenschilling, and former PSI researcher Eileen Ryan have participated in many experiments and theoretical efforts to model impact craters on various planets at various speeds. The Opportunity rover, operating in the ancient Meridiani Planum lakebed on Mars, recently sent back images of a different kind of "experiment."

When Opportunity landed on Mars, the heat shield on the entry package was ejected and crashed near the landing site at moderate velocity (probably a few hundred mph). Photos from orbiters and eventually the rover itself revealed the heat shield on the ground, and Opportunity drove to that location. On the ground, the rover photographed the "crater" made when the heat shield pancaked into the ground. The image may give valuable insight into crater formation not at cosmic impact speeds (10-14 km/sec typically on Mars), but more modest speeds (few hundred 100 m/sec) such as experienced by rocks ejected from impact craters, which fall back onto the surface.

In a curious twist, Opportunity discovered the first meteorite found on Mars, only a few meters (yards) from the heat shield. It was an iron meteorite, possibly weathered out of overlying soil that once covered the Meridiani lakebed. Team leader Steve Squyres quipped to the rover team that they better get the rover out of that spot ASAP, since it is obviously a place where metal objects come crashing down out of the sky!

Friends of PSI

The ***Friends of PSI*** are people like you — folks interested in the excitement and knowledge brought about by astronomy and planetary science. The scientists at the Planetary Science Institute pursue fundamental research in planetary science, geology, and astronomy. PSI is also involved in many educational activities including school field trip programs, popular articles and lectures, research internships for undergraduates, and training and mentoring young researchers at the graduate and postdoctoral levels.

Friends receive a quarterly newsletter detailing the activities of PSI's science and education programs. Additionally, the newsletter contains new scientific discoveries at PSI, as well as features on PSI scientists and their activities.

So join us today with your yearly membership contribution, or become a supporting or sustaining member by joining at one of the tax-deductible categories listed below.

- ***Meteorite Member*** ($35): Receive the newsletter plus personal invitations to "members only" Institute events.
- ***Asteroid Member*** ($200): All of the above plus your choice of one of the following: A multicolor print of an original painting by W. K. Hartmann, or a signed copy of *A Traveler's Guide to Mars*, Bill's beautiful and fascinating overview of modern Mars research, illustrated by detailed photographs from the Mars Global Surveyor mission.
- ***Planet Member*** ($750): All of the above plus an exclusive invitation to an annual private dinner and highlights of astronomy talk with Institute scientists.
- ***Star Member*** ($5,000): All of the above plus an invitation to a night of observing at the Skywatcher's Inn, hosted by PSI scientists. This outing includes naked eye and telescopic viewing of the night sky at a prime dark-sky observatory near Benson, AZ.
- Or you can become a ***Supporting Member*** ($10,000 or more) or a ***Sustaining Member*** ($20,000 or more) and receive all of the above as well as provide additional funds to be used by PSI scientists in research and educational activities.

To make your tax-deductible donation, please complete the form on page 6 and send to the Tucson address.

Thank you!

Visit our website for information on current research projects & educational programs:

www.psi.edu

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For complete membership benefits, see page 5.

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Please mail to: **PSI,** *1700 E. Ft. Lowell, Suite 106, Tucson, AZ 85719* ***Thank you!***

Our **Science Field Trip Program** offers fun and exciting educational demonstrations for school-age children. To help us purchase supplies used in these demonstrations, please send your tax-deductible donations to the **California Science Education Field Trip Program,** at PSI, c/o Bill Schramm at Shepherd of the Hills, 30121 Niguel Rd., Laguna Niguel, CA 92677. ***Thank you!***

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