PRIME FOCUS

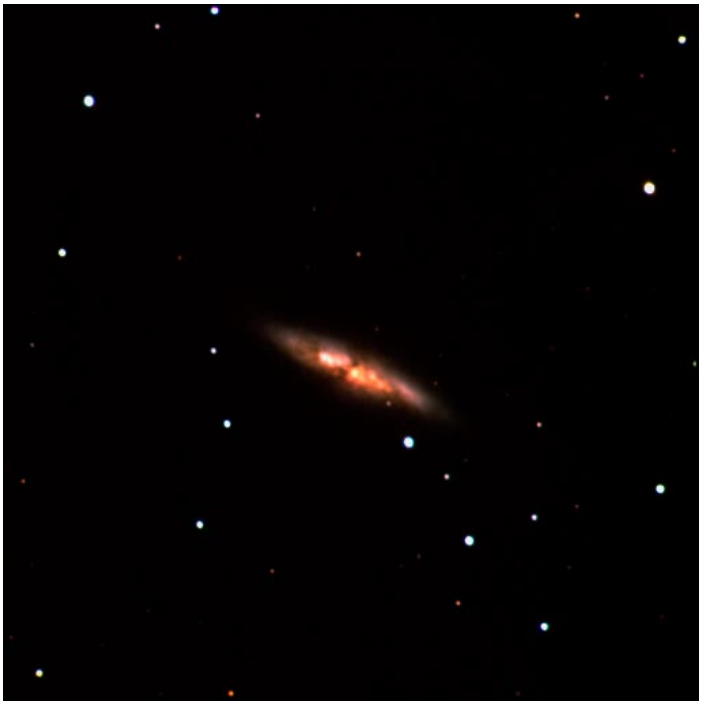
Astronomy Department Newsletter • Adler Planetarium & Astronomy Museum • No. 4, 2006.06

Department Report

INTRODUCTION

This spring, the Adler Astronomy Department stood between the long, productive observing nights of the winter and the traditionally busy tourism and conference season of the summer. Nevertheless, the months of April, May, and June were quite productive. Adler Astronomers continued to work with a wide variety of projects at the Adler, ranging from the Astro-Science Workshop to the creation of the new "Shoot for the Moon" gallery.

Outreach highlights of our past three months include the debut of José Francisco Salgado's video suite to accompany the Chicago Sinfonietta's production of "The Planets," and the international airing of the Cartoon Network's profile of Mike Smutko. The following pages provide more details of a selection of our activities.



The Cigar Galaxy in Ursa Major (M82). Also called "The Exploding Galaxy", M82 is undergoing a tremendous burst of star-formation, possibly due to interactions with its neighbor, the spiral galaxy M81. The combined stellar winds are expelling vast clouds of gas and dust. Imaged from the Doane Observatory by Larry Ciupik.

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Interview

GEZA GYUK, ASTRONOMER

Dr. Geza Gyuk has been with the Adler Astronomy Department for almost six years. His professional training includes a Ph.D in Physics from the University of Chicago and post-doctoral research positions at the University of California, San Diego and the International School for Advanced Studies in Trieste, Italy. Dr. Gyuk serves as the Director of Astronomy at the Adler, a position he has held for two years. He enjoys working with the media and high-school students and teaching classes for adult continuing education. Dr. Gyuk's research interests are very broad and include cosmology (in particular the structure and content of galactic halos), microlensing, astrobiology, asteroids, white dwarfs and high-energy gamma rays. He is a member of the VERITAS and MEGA international collaborations.

PF: *How did you first become interested in astronomy?*

GG: I've been interested in science ever since I can remember. I've always wondered about the world, sometimes to the point of distraction. My wife says that it is impossible to take a walk with me; I'm always stopping and looking at something and wondering what it is, how it works or how it came to be. When I was young, my most prized possession was a set of Time/Life books on various topics in science --Energy, Time, Light, etc. Physics always appealed to me as the most "fundamental" of the sciences, but I was also attracted to Biology. I probably became interested in Astronomy specifically because my father would take me out to look at the stars for hours when we went camping. That and science fiction, of which I've been an avid reader since grade school. In college I thought I'd be a physicist (though I almost double majored in biology). It wasn't until I was in graduate school that I realized that Astronomy was what I wanted to do as a career.

PF: *What kind of research do you do?*

GG: It might be better to ask, "what kind of research do you not do!"? Seriously, though, I have a pretty broad range of interests which spreads me very thin. I'm involved in research projects in at least five different areas: the search for dark matter through gravitational microlensing, the observation

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of very-high energy gamma rays, the search for fragments of differentiated asteroids, the study of the exospheres of planets, and the search for ultra-cool white dwarfs in the Galactic halo. These are a mixture of observational projects and theoretical projects so I get a chance to go observing, but also can do astronomy happily with only a computer. With the possible exception of the asteroid work, I doubt any of these will ever have any practical application.

PF: *What is a typical day like for you?*

GG: Well, I don't spend all my time in front of a telescope, that's for certain. A typical day starts by catching up with the latest astronomy research papers while taking the train into work in the morning. Once at the Adler I take a look at my email and perhaps follow up on one of the interesting papers I read on the ride in. I usually go to a meeting or two dealing with administrative duties. If I'm lucky I'll have a media question or other opportunity to do some outreach. Much of the rest of the day (if there is any at this point) is spent in working on one or the other of the outreach and education projects I'm involved in. At some point in the day I try to talk with my fellow Adler Astronomers about research and also get a bit of research work in. If not, I bring my research work home with me. I consider it a particularly enjoyable day if I can get in both educational and research activities. Most of my work is done in front of a computer, so I try to make sure I also have the chance to talk with people in person.

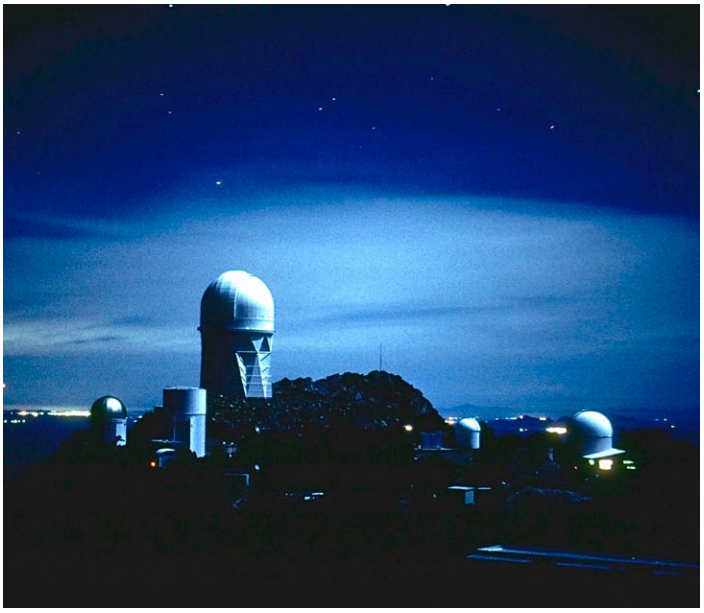
PF: *What's the best part of being an astronomer?*

GG: I get to do what I love and make a living out of it. I still am amazed and gratified that society values Astronomy enough to support our quest to understand our place in the Universe. The most enjoyable specific part to me is travelling to mountaintop observatories to gather data. There is something almost spiritual about travelling to a place dedicated to observing the heavens. The location of the observatories is always pretty remote, the people I am surrounded by are diverse but all share the same basic love of Astronomy, and night and day are switched. This combination makes me feel as if I am journeying to another world.

I also enjoy working with people and trying to communicate my love of and enthusiasm for Astronomy. I particularly enjoy working one-on-one with members of the public. Seeing the light in someone's eyes when they "get it" and understand something that I am explaining is a thrill!

PF: *What do you enjoy the least about your work?*

GG: I get less time to do science and outreach than I would like to. I spend rather too much time doing administrative tasks and paper work. On the other hand, all jobs have aspects that one could do with less of. I think that I'm lucky that even in the parts I enjoy the least I get to interact with interesting people.



Eighteen stories tall, the Mayall 4-meter telescope dominates this picture of Kitt Peak National Observatory at night. Adler Astronomer Geza Gyuk travels to Arizona to use the Mayall for his microlensing research. Image credit: NOAO/AURA/NSF

PF: *Do you have any advice for kids interested in Astronomy?*

GG: Most importantly, you don't have to be really good at math to enjoy thinking about the Universe. All you need is an open mind and a willingness to read a lot. You might want to start just by reading magazine articles, such as those in "Sky and Telescope," or learning about the night sky. The book "365 Starry Nights," by Chet Raymo, is a great place to start.

If you want to be a professional astronomer, that's another story. In addition to taking a lot of science courses, you'll need to get at least reasonably comfortable with mathematics. But don't neglect the other sides of your education. To be successful, astronomers need to communicate their ideas to other people, so skills in writing are also important. It is also helpful to have some idea of the context of discoveries, so don't forget about history.

PF: *What would you do if you weren't an astronomer?*

GG: I don't know. It's cheating to say that I'd be a physicist, because these days an astronomer is pretty much a physicist who studies the Universe. If I were to do something completely different, I'd probably choose something like biology or archaeology. What would be perfect would be something that gave me a chance to explore new things and hopefully that kept me outdoors - at least some of the time.

Research Notes

DATA MINING THE SLOAN DIGITAL SKY SURVEY AND NATIONAL VIRTUAL OBSERVATORY

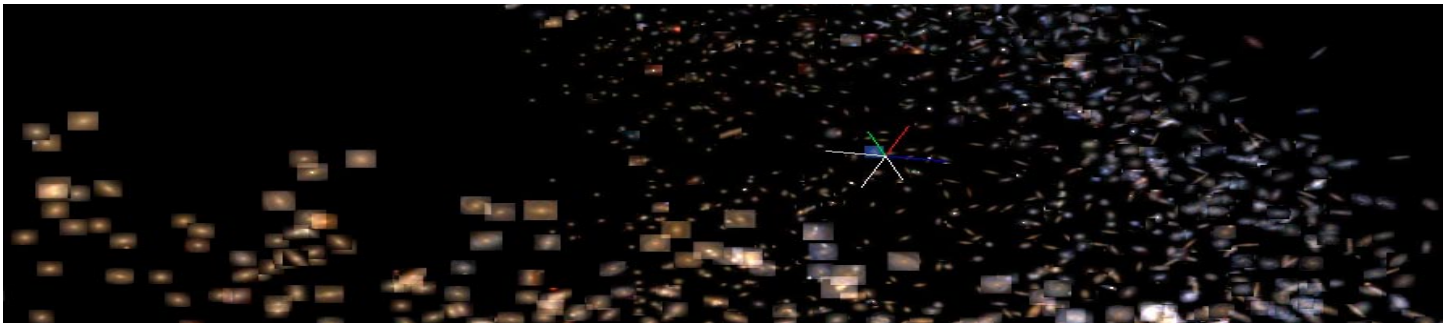
Improvements in detector technology have revolutionized the ability of astronomers to collect data. The steady march of computer technology has likewise expanded our ability to process this data and to run the simulations that allow us to understand the underlying physics. Similar revolutions are affecting the other sciences as well. This new brand of data-intensive science that is emerging has been given a name: "eScience."

Mark SubbaRao has spent the last eight years working on data processing and analysis for the Sloan Digital Sky Survey (SDSS). The SDSS is six years into an ambitious eight-year plan to survey one quarter of the sky. The survey is divided into two parts, an imaging survey and a spectroscopic survey. The imaging data, taken in five different colors, will contain a few hundred million objects, each of which has hundreds of measured parameters. Out of the imaging database, one million objects will be selected to have their spectra taken for the spectral survey. Each spectrum consists of 4000 separate values giving the intensity of the light at each of 4000 different wavelengths, and a few hundred measured parameters. The object databases alone, not counting the raw image data, will consist of hundreds of gigabytes of data.

The databases and web services developed by the SDSS project have formed the basis of the National Virtual Observatory (NVO). The NVO now enables astronomers to synthesize and compare data across different projects and wavelengths. The SDSS can be thought of as ushering in the "eScience era" for Astronomy. Future projects such as the Large Synoptic Survey Telescope (LSST) will produce vastly greater volumes of data.

Once we have all this data, how do we make sense of it? Data-mining techniques attempt to extract useful pieces of knowledge from mountains of data. An astronomical example is finding rare objects, such as the most massive galaxies (see the publications section), or very cool stars. By studying the spectra of more than half a million galaxies in the SDSS database the SDSS Spectroscopic Supernovae Search has characterized very accurately what galaxy spectra look like. SDSS astronomers then look for unusually-shaped spectra, which may indicate that the galaxy in question contains a supernova. Astronomers use a technique called Principal Component Analysis (PCA) to check to see if a spectrum has an unusual shape. Much as a wine expert might sum up a complex aroma as "fruity with a hint of oak and spice", instead of giving an extended chemical analysis, PCA looks for the "essential" components that make up an object. Instead of considering the spectrum as a set of 4000 numbers, PCA attempts to reconstruct it as the sum of a small number of differently shaped spectra. Every spectrum is checked to see if the difference between the principal component reconstruction and the actual spectrum looks like a supernova. So far, roughly one hundred type "I-a" supernovae have been found using this technique. These supernovae are important because they are "standard candles", which help us refine the relationship between distance and red-shift. This helps answer fundamental questions about the nature of our universe, such as the amount of Dark Energy.

Astronomy has a long history of discovering purely empirical relationships between observed quantities. While very frequently a deeper understanding of these relationships then leads to physical insight, they are also useful in their own right. Another class of data-mining techniques attempts to find new empirical relationships. One such relationship which has proved to be very important in the last five years is the photometric redshift. While the precise redshift for a galaxy can only be obtained by careful analysis of a high resolution spectrum, it turns out that a reasonable guess can be made based only on the photometry, the galaxy's brightness in the five colors of the imaging survey. For many purposes, the much greater number of redshifts available in this way (the imaging survey is hundreds of times larger than the spectroscopic survey) more than makes up for their lack of individual precision. Mark SubbaRao is working with a group of other scientists to develop a photometric - metallicity relationship for stars. One use of this relationship will be to search for the lowest metallicity stars, which may be remnants of the second generation of stars to form after the Big Bang. – *Mark SubbaRao, PhD*



Art or Science? This visualization of galaxy data from the Sloan Digital Sky Survey is both! The positions of and types of galaxies are taken from the SDSS data and displayed in a manner that enables scientists to explore the data in ways that were previously impossible.

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CARTOON NETWORK COMES TO ADLER

A Cartoon Network segment featuring the Adler began running internationally in June. A film crew spent two days at the Adler recording the activities at the February 2006 "Far Out Friday" and interviewing Astronomer Michael Smutko about his work and research at the Adler. The interview covered many topics in astronomy, from life on other worlds, to the research done with the Adler's Doane Observatory, to supernovae and the origins of life. Everyone who has seen it has been very pleased with the results. If you can't catch the interview on television, the clip is available for viewing and downloading from the Adler's website (www.adlerplanetarium.org).

HOLST'S "THE PLANETS"

José Francisco Salgado produced and directed a suite of seven high-definition videos to accompany two performances by the Chicago Sinfonietta of Gustav Holst's composition, "The Planets." Each of the videos includes awe-inspiring images of the featured planet, historical illustrations from the Adler Collection of Works on Paper, NASA and European Space Agency animations, as well as some animations produced by Salgado. The videos are art pieces that aim to inspire audiences and encourage them to learn more about our Solar System and the Universe in which we live.

The performances took place at Lund Auditorium in River Forest on May 14 and at Symphony Center in Chicago on May 15. Both performances were preceded by a panel discussion with Salgado and violin soloist Daniel Bernard Roumain. More than 2,000 people attended both performances. This multi-disciplinary event was the first of several forthcoming collaborations between the Chicago Sinfonietta and the Adler Planetarium and will help both institutions to broaden their audiences.

BROADENED AUDIENCE

On April 6, the Adler hosted a group of middle school students from the Youth Technology Corps (YTC). Their visit included a tour of the museum and a 3D presentation on Mars, the VERITAS telescope and Sloan Digital Sky Survey (SDSS). José Francisco Salgado gave a lecture in Spanish to the group, with the help of Mark SubbaRao and Doug Roberts, who set up the new portable Geowall projection system in the Universe Theater.

Grace Wolf-Chase presented an invited talk on Astrobiology to the "Alliance for Faith, Science, and Technology", a consortium of scientists, clergy, and lay people who advocate for science literacy in the Evangelical Lutheran Church in America.

The Cartoon Network segment profiling the Adler began running mid-June. Introduced by "The Robot" and featuring Adler Astronomer Michael Smutko the segment is about 2 minutes long. Image credit: Cartoon Network.

Grace Wolf-Chase gave a Career Day presentation to a roughly equal mix of about 50 eighth grade girls and boys at Lincoln Junior High School in Naperville, IL.

Michael Smutko gave a presentation on the structure of the Sun and an observatory tour to 30 members of the Osher Lifelong Learning Institute (OLLI) in the School of Continuing Studies at Northwestern University on July 12.

Geza Gyuk spoke with a group of about 20 middle school students (and five adults) at a "Take Your Child to Work" day in Bannockburn, IL. Topics ranged from what it is like to go observing, to the latest news about the solar system.

On May 5, Chicago Sinfonietta guests joined Adler visitors and members in the Universe Theater for a special "Far Out Friday" lecture on Holst's "The Planets", featuring José Francisco Salgado and Reneé Baker, Chicago Sinfonietta's principal violist.

José Francisco Salgado and Univisions's Ligia Ganados conducted a special one-hour edition of "Nuestra Galaxia" in the Universe Theater. The audience of approximataely 40 bilingual visitors and teachers asked varied questions about astronomy.

Larry Ciupik visited a career day at Chicago's South School , to speak with 16 4th graders on being an astronomer.

OBSERVING

Larry Ciupik, Lucy Fortson and David Steele went to the VERITAS site in southern Arizona at the end of April to observe using the two existing VERITAS gamma-ray telescopes and the 48" optical telescope on Mt. Hopkins, and to perform additional R&D work to aid in the design of a pointing monitor system for VERITAS. Using the 48" optical telescope, Ciupik imaged more than a dozen objects, including Markarian 421 and 501, as part of a multi-wavelength blazar observation

campaign involving the Whipple 10-meter and VERITAS telescopes and other instruments from around the globe. On two separate nights, VERITAS looked at Markarian 421 in conjunction with the X-ray monitoring XMM, and the gamma-ray monitoring SWIFT satellite telescopes. Steele was also present during the first two Gamma-Ray Burst (GRB) alerts received this year from satellite monitors.

Grace Wolf-Chase and Michael Smutko have continued their survey of star-forming regions with a series of seven half-nights using the Apache Point Observatory (APO) 3.5-m telescope during the spring quarter. They were also granted time on the University of Hawaii 2.2-meter and CFHT telescopes on Mauna Kea, which they used to obtain wide-field and faint near-infrared images to complement their APO observations of the active star-forming cloud L1340. Additionally, Grace Wolf-Chase was Co-Investigator on a successful Palomar Observatory proposal to obtain mid-infrared observations to help determine the evolutionary stages of young stellar objects in this cloud.

Mark Hammergren, Geza Gyuk and Andy Puckett continued their asteroid characterization project observing during the spring, with four half-nights on the APO 3.5-meter telescope. Although one half-night was cancelled due to poor weather, spectra of about a dozen asteroids were taken during the remainder of the nights.

The Adler has joined a small consortium managed by the University of Utah to build and operate a robotic, one-meter class telescope in Southeastern Utah. Funding is from the Eccles Foundation, the State of Utah, and the University of Utah.

CI-TEAM TEACHER WORKSHOPS

The CI-TEAM project, led by Lucy Fortson, held its first teacher workshop at Yerkes Observatory June 27-30. Adler educators Michelle Nichols and Amanda Quick lent their vital expertise along with team members from Northwestern University, Berkeley, Johns Hopkins and Yerkes to engage teachers in learning to use the Sloan Digital Sky Survey to search for Variable Quasars. The CI-TEAM grant and the START Collaboratory grant awarded to Northwestern University allows the team to create web-based software applications that allow teachers and their students to search astronomical databases, analyze the data and request follow up data from a network of telescopes. Twelve teachers spent the three days learning science by doing science and will be back in August for a follow-up workshop before they take their projects to their students in the 2006-2007 school year.

GRANTS

Department members have submitted proposals for and received a variety of grants over the past quarter. These include:

Grant Applications:

• Grace Wolf-Chase is a participant on a University of Chicago IGERT "Emergent Multiscale Phenomena" pre-proposal that received a "High Priority" panel recommendation.

• Mark SubbaRao is a Co-Investigator on an NSF Informal Science Education proposal from the National Virtual Observatory. The proposal is entitled "MyVOICE: My Virtual Observatory for Informal Collaborative Education in Science"

• Mark SubbaRao is a Co-Investigator on an NSF proposal to continue the Interactions in Understanding the Universe project.

• Lucy Fortson is a Co-Investigator on an NSF proposal with Northwestern University to continue the CI-TEAM project (see CI-TEAM this page).

• Lucy Fortson is a Co-Investigator on a NSF Math-Science Partnership proposal with the University of Chicago to provide Chicago Public School teachers with leadership training in teaching math and science.

• Mark Hammergren submitted an EPO request , "Touch the Solar System" that would enable the Adler to purchase and display touchable samples of at least four solar system objects: the Moon, Mars, Vesta and of course, the Earth.

Grants Awarded:

• Grace Wolf-Chase was awarded observing time on the Spitzer Space Telescope and grant money as Co-Investigator on the program "IRS Scan Mapping of IRAS16253-2429: A Textbook Example for Unlocking the Secrets of Proto-stellar Outflows.".

APPOINTMENTS & AWARDS

Michael Smutko was elected to Northwestern University's Faculty Honor Roll for 2005-2006. The Honor Roll was established by Northwestern's Associated Student Government as a way for students to recognize excellence in teaching and to award faculty for their positive work in affecting students' lives. Only 45 out of approximately 1000 full-time undergraduate faculty are elected to the Faculty Honor Roll each year.

Daniela Rosner won a trip to the TeraGrid06 Conference (and an iPod nano) for her work in creating a marketing campaign to inspire others to learn about the TeraGrid and cyber-infrastructure. She also received a scholarship to attend the Image and Meaning Workshop in North Carolina, and was asked to return as an assistant leader at the next workshop in Chicago.

MEDIA INTERACTIONS

In addition to the previously mentioned Cartoon Network segment and Jose Francisco Salgado's ongoing weekly appear-

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ances on Univision, the department had more than a dozen media interactions. Of particular note were appearances in New Scientist, Chicago Magazine and WGN radio.

PERSONNEL CHANGES

Daniela Rosner, the Astronomy Department's Visualization and Digital Media Developer, left in mid-July. Daniela's impeccable taste and artistic abilities were important contributions to a wide range of Adler projects, from CyberSpace and I2U2 to the recent opening of the Adler Staff Gallery. She is heading to Berkeley to further her studies of human-computer interactions. Although she will no longer work at the Adler, she will continue to collaborate with us on a number of projects.

Michael Curran has joined the Astronomy Department as Administrative Assistant. He will also be serving as Digital Media Assistant for the web and other projects, and will fill the role of Assistant to the Vice President for Research. In addition to experience in administration and web design, Michael brings skills in film and customer service.

PUBLICATIONS

During the spring, members of the Department were authors on five articles published in peer-reviewed journals:

"A Search for the Most Massive Galaxies: Double Trouble?", Bernardi, M.; Sheth, R. K.; Nichol, R. C.; Miller, C. J.; Schlegel, D.; Frieman, J.; Schneider, D. P.; Subbarao, M.; York, D. G.; Brinkmann, J., AJ, 131, 2018 (2006).

"A Multiwavelength Study of Sgr A*: The Role of Near-IR Flares in Production of X-Ray, Soft X-Ray, and Submillimeter Emission", Yusef-Zadeh, F.; Bushouse, H.; Dowell, C. D.; Wardle, M.; Roberts, D.; Heinke, C.; Bower, G. C.; Vila-Vilaró, B.; Shapiro, S.; Goldwurm, A.; Bélanger, G., ApJ, 644, 98 (2006).

"The flare activity of Sagittarius A*. New coordinated mm to X-ray observations", Eckart, A.; Baganoff, F. K.; Schödel, R.; Morris, M.; Genzel, R.; Bower, G. C.; Marrone, D.; Moran, J. M.; Viehmann, T.; Bautz, M. W.; Brandt, W. N.; Garmire, G. P.; Ott, T.; Trippe, S.; Ricker, G. R.; Straubmeier, C.; Roberts, D. A.; Yusef-Zadeh, F.; Zhao, J. H.; Rao, R., A&A, 450, 535 (2006).

"The First VERITAS Telescope", Holder, J.; et. al. (the VERITAS Collaboration - including L. Fortson, D.Steele, and G. Gyuk), APh, 25, 391 (2006)

"Optical Properties of Deep Glacial Ice at the South Pole", Ackermann, M.; et al. (The IceCube Collaboration - including D. Steele), 2006, J. of Geophys. Research, 111, D13203

Other articles are in progress.

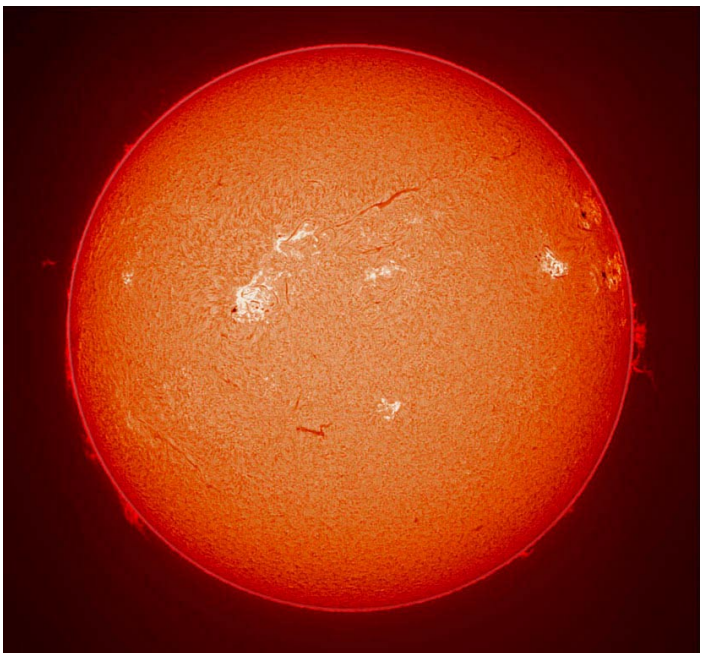
Images of Astronomy

SOLAR TELESCOPE IN THE DOANE

One of the challenges facing the Adler is increasing the number of opportunities for our visitors to look through powerful telescopes with their own eyes. Since the Adler is only open for evening observing on "Far Out Fridays" and for special events, a natural alternative is to increase our ability to do daytime solar observing.

To this end, Michael Smutko has purchased a state-of-the-art Coronado SolarMax 90 dedicated solar telescope and, with the help of Adler Technician Rich George, installed it in the Doane Observatory. The Adler is only the second institution in the Midwest to own this type of telescope.

Until the arrival of the Coronado, most of the Adler's solar viewing had been done with "white light" filters on the Adler's regular telescopes. These are filters that block out most of the light of the sun and give a safe view of the surface (or photosphere) of the Sun. White light filters are excellent for viewing sunspots and similar features on the disk of the Sun. However, sunspots are not always present on the Sun (especially now that we are in the minimum phase of the 11-year solar activity cycle) and at these times, white light filters give only a blank, featureless view of the Sun's disk.



An H-alpha image of the Sun taken in January 2006. Prominences larger than the Earth can be seen arching out along the limb of the Sun. In the disk of the Sun, intricate patterns reflect the complex magnetic field and boiling surface layers of the Sun. Image credit: Advanced Telescope Supplies, Australia

The Coronado, on the other hand, is designed to observe the Sun in one very narrow wavelength (color of light) associ-

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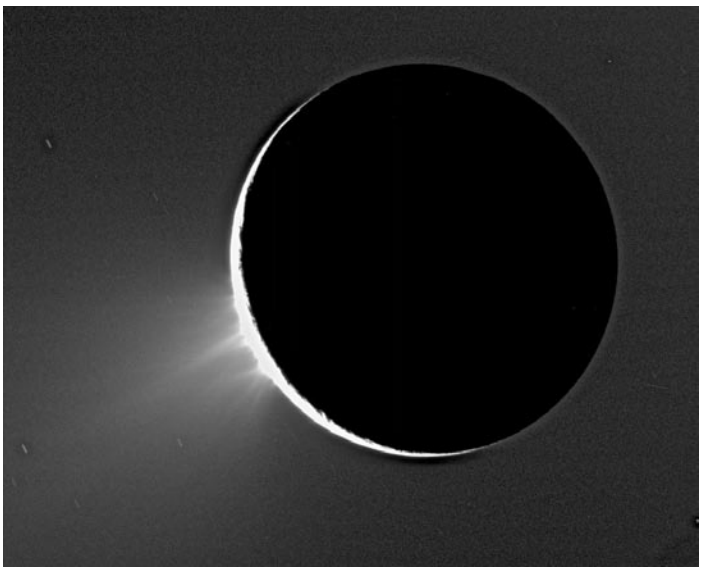
Astronomy News

LIQUID WATER ON ENCELADUS?

Last March, researchers working with data from NASA's Cassini spacecraft reported evidence that Saturn's moon Enceladus may have liquid water at or near its surface. Enceladus, the sixth-largest of Saturn's many moons, is still relatively small. It has an equatorial diameter of just over 300 miles. For its small size, however, it is very bright, implying that the surface is extremely reflective. In fact, Enceladus reflects nearly 100% of the light it receives. It is believed that Enceladus' surface is covered with some sort of frost, which accounts for its high albedo. This is consistent with its low density, which suggests that the interior must be primarily composed of ice.

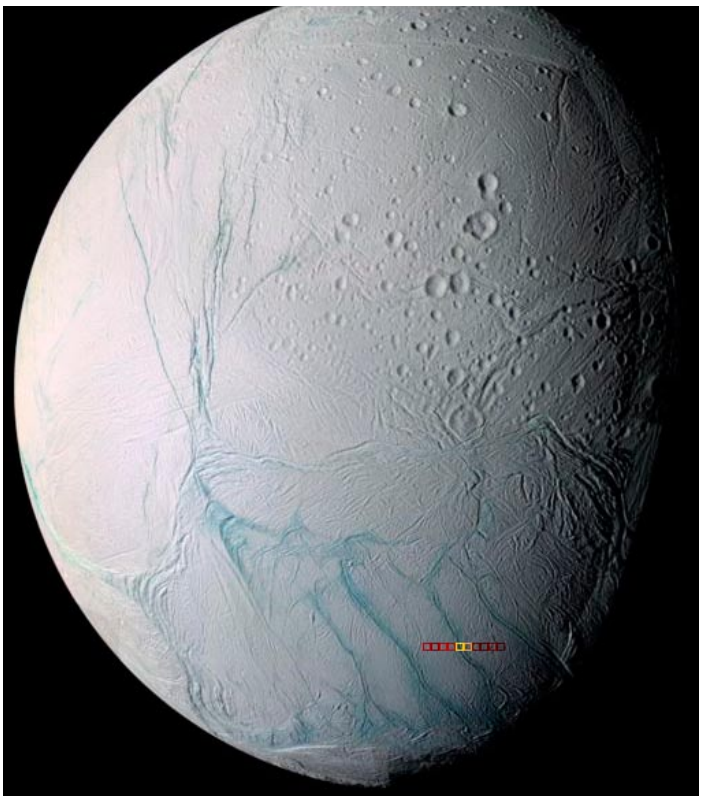
We have known since the Voyager fly-by that Enceladus shows signs of past activity. At least five different types of terrain, ranging from smooth plains with very few impacts to vast networks of fissures, provide evidence that at some point Enceladus was a geologically active world. Given the small size of Enceladus and the lack of an obvious strong heating mechanism, however, it should have cooled off rapidly. Any tectonic activity should have been limited to the very early epochs in Enceladus' history. The existence of young, less than 100-million-year-old surface regions is therefore puzzling to scientists.



When backlit by the Sun the "fountains" of icy particles jetting out from the surface are clearly apparent. They are "rooted" in the "tiger stripes" of the south polar region The particles spewed into space almost certainly make up most of the tenuous E-ring around Saturn. Image credit: NASA

The new evidence presented by the Cassini team derives from data taken in 2005, when the spacecraft swept within 600 miles of the surface during three particularly close encounters. The first indications that Cassini might find evidence of current activity on Enceladus came from measurements made by its magnetometer. These measurements suggested the existence of a very thin atmosphere composed of ionized water vapor, concentrated in the regions of the south pole. Rapid confirmation came from the slight dimming of a bright star just before it was occulted by Enceladus, and, finally, from direct measurements by on-board instruments. An atmosphere such as this, even though very thin, would have a very short lifetime before escaping to space. It must be replenished somehow.

In November of 2005, images of Enceladus backlit by the Sun were taken by Cassini, clearly showing plumes of ice particles being jetted off of the surface to heights of many hundreds of miles. These plumes were centered on the south polar region as inferred from earlier data. This directly showed that some sort of ice/water cyrovolcanism was currently ongoing.



An image of Enceladus taken by the Cassini spacecraft. The prominent "tiger stripes" can be seen in the south polar regions. The area surrounding the stripes is almost crater free, indicating youth. The change in color may indicate chemicals welling up from the fissures. The band of colored squares indicates the temperature across one of the stripes. The temperature is highest right at the fissure. Image credit: NASA

Thermal maps show that the South polar regions are many degrees hotter than the rest of Enceladus, something that is in direct conflict with what we would expect if the Sun were the only source of heat. Detailed images of the region show extensive fissures called "tiger stripes". The entire region is devoid of craters, indicating that it is very young, perhaps less than 10 million years old. In addition, the "tiger stripes" show signatures of a slightly different composition from the rest of the surface of Enceladus. Finally, very detailed thermal measurements show that the "tiger stripes" are considerably warmer than the surrounding surface, indicating that they are likely

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ated with hot hydrogen gas. This wavelength is called "H-alpha" because it is the primary wavelength of visible light given off by heated hydrogen gas. H-alpha telescopes give views of the lower atmosphere of the Sun (or chromosphere) immediately above the visible surface (or photosphere) of the Sun. The chromosphere is exciting to observe because that is where amazing structures like granulation, plages, and loop prominences exist—even when there are no sunspots present on the surface of the Sun. These structures can change in the course of minutes, so an observer can watch the Sun change throughout the day. The photo above, taken last January (though not at the Doane) illustrates the type of view that can be seen in H-alpha.

With the energetic help of Master Educator Michelle Nichols, Adler staff and volunteers are being trained in the use of the Doane and the Coronado telescopes, so that the Doane can be open to the public throughout the summer. Visitors to the Doane can view the Sun in white light through one telescope and then in H-alpha light by looking through the Coronado just a few inches away. Later in the year, when the weather turns too cold for visitors' comfort outside in the Doane, the Coronado can be fitted with a video camera that will provide the potential to allow live solar images to be displayed inside the Adler: in CyberSpace, the theaters, the Solar exhibit in the Milky Way gallery, or even on the Adler's webpages. – *Michael Smutko, PhD*

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the source of the plumes.

Although other interpretations may be possible, the many mutually consistent lines of evidence strongly support the idea that Enceladus is a currently active world, most likely with pockets of liquid water. This water may have been in liquid state continuously or intermittently for hundreds of millions or even billions of years. The presence of liquid water makes it of strong interest for astrobiology, as it suggests that it may be a possible habitat. In any event, it is only the fourth known world of the solar system with tectonic activity, something of interest in its own right. – *Geza Gyuk, PhD*

About the Adler Astronomy Department

The Adler Planetarium & Astronomy Museum has taken the lead among planetaria world-wide in establishing an astronomy and astrophysics research group in a museum setting. Adler Planetarium astronomers possess rich and diverse expertise in many areas of astronomy as well as other closely related scientific fields such as particle physics and geophysics. Several members of the Adler Astronomy Department also hold joint appointments at the University of Chicago and Northwestern University. The nature of these joint appointments strengthens the integration of the Adler and its educational mission with the research community.

You can download our Annual Report published in the Bulletin of the American Astronomical Society from:

http://www.adlerplanetarium.org/astronomy/astronomers

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