



# The Stargazer

January 2006

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See EAS website at:

[http://members.tripod.com/everett\\_astronomy](http://members.tripod.com/everett_astronomy)

## EAS BUSINESS...

**NEXT EAS MEETING - SATURDAY JANUARY 28<sup>TH</sup> AT 3:00 PM AT THE EVERETT PUBLIC LIBRARY, IN THE AUDITORIUM (DOWNSTAIRS)**

January 28<sup>th</sup> meeting - Oliver Fraser of UW Astronomy – “Studying the changing period of a Pulsating White Dwarf Star”

Map to library - <http://www.epls.org/about/mlmap.htm>

2702 Hoyt Avenue  
 Everett, WA 98201

Directions to library - <http://www.epls.org/about/mldirect.htm>

## CLUB STAR PARTY INFO

Upcoming star party schedule – In hibernation for the winter.

People should send mail to the mail list to coordinate spur-of-the-moment observing get-togethers, on nights when the sky clears.

We try to hold informal close-in star parties each month during the spring, summer, and fall months on a weekend near the New moon at a member's property or a local park. (call Mike Locke at (425) 259-5995 for info or check the EAS website.) Members contact Mike Locke for scope borrowing.

**Yakima Messier Marathon – Info from Bruce Perrault of YAS**

“I am enclosing a news article on our [YVAS] Messier Marathon. Some of the Seattle members are interested in doing this, so I thought I would sent it to your [Anacortes] club also. We have held events there before and this is a nice dark site with good facilities. It can only handle 100-200 people, though.

I have included some information on the Yakima Astronomical Societies annual Messier Marathon. This should answer most of your questions about it, but feel free to ask me more. I will also send this to a couple of the other clubs in the area.

**The Messier Marathon will be held March 25th & 26th from Saturday afternoon until late Sunday Morning.** That way anyone that wants to get some sleep before leaving can.

It will be held at the Ahtanum Mission Park. The Ahtanum mission is a state historical site run by the Catholic Church. It has some 130 year old apple trees planted by missionary priests in the 1800's. They have put in a nice modern clean restroom facility with running water. The park is located next to Ahtanum Creek and joins the Yakima Indian reservation across the creek. There are plenty of trees, dark skies and room. A nice open field is on the West end where we can set up telescopes and have a fairly open view of the sky. It is quite dark out there, as you are toward the mountains from Yakima.

It is theoretically possible to view all the Messiers, except M30, but getting 100 would be a pretty good accomplishment. I have a check sheet we use on our website set up by the hour. You get a 2 hour break at midnight to let more objects rise in the East.

Directions: 17740 Ahtanum Rd, Yakima WA 98903. It is located a little East of the Tampico store. Best way to come will be to take the Valley Mall Blvd exit from the freeway and go West about a mile to the 3rd ave stoplight. Turn left and go to Ahtanum Road, then right about 12 miles to the Mission.

<http://www.perr.com/messier.html>

The Mission is a private park and does charge admission. They have 8 RV sites with power available, so let me know if you want to reserve one. Below are the admission charges which you will pay upon arrival. No pre- registration is required, except I would like to know how many RV's would like to come and if you would let me approximately how many in your club are interested, we can plan ahead.

\$1.00 per person  
 \$5.00 per tent  
 \$10.00 per RV hookup

The one rule that we need to be careful of, because it has been a wet year, is do not drive on the soft grass. In other words stay on the gravel driveways with vehicles. Normal park rules would also apply, no alcohol, guns etc. The caretaker is a really nice guy, but he is also a Yakima County Sheriff.

The weather can be quit variable in the early Spring and is usually in the 20's at night if the sky is clear, so dress warm. We have both a local weather link and sky clock on the YAS website, so keep an eye on these as the 25th approaches. So come join us and lets all have a good time viewing under dark skies” - Bruce Perrault - <http://www.perr.com/yvac.html>

**\$\$ - FINANCIAL HEALTH - \$\$**

The club maintains a \$500+ balance. We try to keep approximately a \$500 balance to allow for contingencies. .

**CLUB SCOPES**

SCOPE	LOAN STATUS	WAITING
10-INCH DOBSONIAN	ON LOAN	NO WAIT LIST
EAS members: contact Mike Locke at (425) 259-5995 or 'mlocke at lionmts.com' to borrow a scope.		

**ASTRO CALENDAR FOR 2005****January 2006**

Jan 03 - Quadrantids Meteor Shower Peak  
 Jan 04 - Earth At Perihelion (0.983 AU From Sun)  
 Jan 07 - Asteroid 4 Vesta Closest Approach To Earth (1.552 AU)  
 Jan 15 - Stardust, Comet dust sample capsule Return To Earth  
 Jan 25 - Saturn Occults PPM 125631 (8.0 Magnitude Star)  
 Jan 27 - Saturn at Opposition  
 Jan 28 - 20th Anniversary (1986), Space Shuttle Challenger Accident  
**Jan 28 - EAS MEETING - Saturday 3:00 PM at Everett Public Library**  
 Jan 29 - Chinese (lunar) New Year  
 Jan 31 - 45th Anniv. 1961 Mercury-Redstone launch Ham the Chimpanzee

**February 2006**

Feb 01 - Saturn 0.9 degrees S of M44 (Beehive cluster)  
 Feb 15-28 - Zodiacal light visible in dark skies after evening twilight  
 Feb 17 - Venus at greatest brilliancy  
 Feb 24 - Mercury at greatest Eastern elongation (18 deg.)  
 Feb 25 - Asteroid Ceres occults moon  
 Feb 27 - Cassini, Titan Flyby

**March 2006**

**Mar 04 - February EAS Meeting - 3:00 PM at Everett Public Library**  
 Mar 13 - 20th Anniversary (1986), Giotto, Comet Halley Flyby  
 Mar 14 - Penumbra Lunar Eclipse  
 Mar 20 - Vernal Equinox, 18:26 UT  
 Mar 20 - Earth Day  
 Mar 25 - 10th Anniversary Comet Hyakutake Near-Earth Flyby (0.1 AU)  
**Mar 25 - March EAS Meeting - 3:00 PM at Everett Public Library**  
**Mar 25/26 - YVAS Messier Marathon Star Party - Ahtanum Park**  
 Mar 29 - Solar Eclipse (Visible From North Africa & Central Asia)

**April 2006**

Apr 16 - Easter Sunday  
 Apr 22 - Lyrids meteor shower peak  
**Apr 29 - April EAS Meeting - 3:00 PM at Everett Public Library**

**May 2006**

May 04 - Jupiter at Opposition  
 May 05 - Astronomy Day  
 May 05 - Eta Aquarids meteor shower peak  
 May 14 - Griffith Observatory reopens

**June 2006**

Jun 21 - Summer Solstice, 12:26 UT

**UW Astronomy Colloquium Schedule**

The Astronomy Department weekly colloquium meets Thursdays at 4:00 pm in PAB A102 (the classroom part of the Physics/Astronomy Building complex).

**OVER THE AIRWAVES**

"Our group of radio script writers now consists of EAS and SAS members Jim Ehrmin, Greg Donohue, and Ted Vosk, who are now regularly writing and helping to produce our astronomy radio show, "It's Over Your Head" on radio station **KSER, FM 90.7**. The six-minute segment is broadcast **every Wednesday morning at approximately 7:20 A.M.** and gives a weekly look at what's up in the sky over Snohomish County, with other information. If you are a listener to the program, show your support by giving the program director of KSER a call!" Web page with lots of archives and other info is available at <http://www.itsoveryourhead.org/>

KPLU 88.5 FM National Public Radio has daily broadcasts of "Star Date" by the McDonald Observatory of the University of Texas at Austin, Monday through Friday at about 6:05 pm. The short 2 minute radio show deals with current topics of interest in astronomy. The University of Washington TV broadcasts programs from NASA at 12:00 AM Monday through Friday, 12:30 AM Saturday, and 1:30 AM Sunday on the Channel 27 cable station.

**EAS LIBRARY - BOOK & VIDEO LIST**

The EAS has a library of books, videotapes, and software for members to borrow. We always value any items you would like to donate to this library. You can contact a club officer or **Librarian Mike Locke**, phone (425) 259-5995, email mlocke at lioninc.com, to borrow or donate any materials. See list here: [http://members.tripod.com/everett\\_astronomy/eas\\_library.htm](http://members.tripod.com/everett_astronomy/eas_library.htm)

**MEMBERSHIP BENEFITS & INFORMATION**

Membership in the **Everett Astronomical Society (EAS)** will give you access to all the material in the lending library. The library, which is maintained by Mike Locke, consists of several VCR tapes, many books, magazines, and software titles. Membership includes invitations to all of the club meetings and star parties, plus the monthly newsletter, *The Stargazer*. In addition you will be able to subscribe to *Sky and Telescope* for \$7 off the normal subscription rate, contact the treasurer for more information. Link to registration form: [http://members.tripod.com/everett\\_astronomy/application.htm](http://members.tripod.com/everett_astronomy/application.htm)

(When renewing your subscription to *Sky & Telescope* you should send your **S&T renewal form along with a check made out to Everett Astronomical Society to the EAS address**. The EAS treasurer will renew your *Sky and Telescope* subscription for you. **Astronomy** magazine offers a similar opportunity to club members.)

EAS is a member of the **Astronomical League** and you will receive the Astronomical League's newsletter, *The Reflector*. Being a member also allows you the use of the club's telescopes, an award winning 10 inch Dobsonian mount reflector. Contact Mike Locke (425) 259-5995 to borrow a telescope. EAS dues are \$25.

Send your annual dues to the **Everett Astronomical Society**, P.O. Box 12746, Everett, WA 98206. Funds obtained from membership dues allows the Society to publish the newsletter, pay Astronomical League dues and maintain our library.

**OBSERVER'S INFORMATION...****LUNAR FACTS**

Jan 06	First Quarter Moon
Jan 14	Full Moon
Jan 22	Last Quarter Moon
Jan 29	New Moon
Feb 05	First Quarter Moon
Feb 13	Full Moon
Feb 21	Last Quarter Moon
Feb 28	New Moon
Mar 06	First Quarter Moon
Mar 14	Full Moon
Mar 22	Last Quarter Moon
Mar 29	New Moon

## Digital Lunar Orbiter Photographic Atlas of the Moon

The Lunar and Planetary Institute has created a digital version of the Lunar Orbiter Photographic Atlas of the Moon, and Consolidated Lunar Atlas available online at:

<http://www.lpi.usra.edu/research/cia/menu.html>

[http://www.lpi.usra.edu/research/lunar\\_orbiter](http://www.lpi.usra.edu/research/lunar_orbiter)

### UP IN THE SKY -- THE PLANETS

Object	Rises	Transits	Sets	Con	Mag
Sun	7:41 am	12:22	17:02	Cap	-27
Mercury	Daylight	Daylight	Daylight	Cap	--
Venus	05:58 am	Daylight	Daylight	Cap	-4.3
Mars	Daylight	18:56	2:20 am	Ari	+0.1
Jupiter	1:40 am	6:41 am	Daylight	Lib	-1.7
Saturn	16:60	12:25 am	Daylight	Can	+0.2
Uranus	Daylight	Daylight	19:47	Aqr	+5.8
Neptune	Daylight	Daylight	17:49	Cap	+7.9
Pluto	04:30 am	Daylight	Daylight	Ser	+14.0

(times local time for Everett PST)

### Transit times for Jupiter's Great Red Spot in 2005

[http://skyandtelescope.com/observing/objects/planets/article\\_107\\_2.asp](http://skyandtelescope.com/observing/objects/planets/article_107_2.asp)

### NOAA SUN CALCULATOR

Need to know exactly what time the sun will set on Sept. 26, 2065? Or when it rose in 565 BC? How about the length of daylight a week from Tuesday in Albuquerque, N.M.? Just go to NOAA's solar calculator, now available on the Web.

<http://www.srb.noaa.gov/highlights/sunrise/gen.html>

### INTERNATIONAL SPACE STATION – VISIBLE SEATTLE PASSES

#### ISS Visibility –

<http://spaceflight.nasa.gov/realdata/sightings/SSApplications/Post/SightingData/Seattle.html> or also see link <http://www.heavens-above.com/PassSummary.asp?lat=47.979&lng=-122.201&alt=0&loc=Everett&TZ=PST&satid=25544>

### MEMBER NEWS

#### Seattle Astro Society Trying To Get a Dark Sky Site

*"We feel that we need to raise \$25,000 in order to buy something appropriate on the other side of the mountains. We are making good progress within SAS. The deal basically is \$250 for dark sky membership, and some relatively nominal sum for annual dark sky dues. One would have to be a SAS member to do this, but that is a rather nominal charge. We were wondering if anyone in your club would be interested in taking part. I personally think that the dark sky site is a necessary thing for SAS to do; otherwise, the club really has little tangible to offer its members. With a dark sky site, even city-bound members would have a place within a few hours where they could view from a dark site; even us suburban folks would benefit, I think. Thanks for your consideration."*

-- Mark de Regt, SAS.

### CONSTELLATIONS OF THE MONTH: GEMINI & TAURUS

**AURIGA:** "The Charioteer". This very famous and easily recognized constellation (the "upside-down crown") borders on the constellations of Camelopardalis, Gemini, Lynx, Perseus, and Taurus. It ranks 43<sup>rd</sup> in overall brightness, containing 47 visible stars brighter than magnitude 5.5. Its central point is located at RA=6h01m and Dec.= +42 degrees. It is completely visible from latitudes North of -34 degrees, and completely invisible from

latitudes South of -62 degrees. This constellation ranks 21<sup>st</sup> in overall size, taking up 657.44 square degrees, or 1.594% of the sky. Auriga has several bright, named stars, including the famous and beautiful Capella (alpha; a yellow giant spectroscopic binary with a high lithium content), the sixth brightest in all the sky (its apparent magnitude is 0.08; absolute magnitude is 0.1; and distance is 45 light years). Other bright, named stars in Auriga include Almaaz and Maaz (epsilon; an eclipsing binary system) and Hasseleh (iota). Auriga contains, or is part of, more than one asterism, including Capella and "the Kids", and the Winter Oval, and has one known meteor shower (the Aurigids), which peak on September 1. This easy to spot fall/winter constellation has three well known Messier objects (M36, 37, and 38), all of which are beautiful open (or galactic) clusters. The midnight culmination date of Auriga is December 21<sup>st</sup>. An interesting fact about epsilon Aurigae is that approximately every 27 years, the system undergoes an eclipse which darkens it by almost one full magnitude, for nearly two years in duration. The most probable explanation for this phenomenon is that the system has a large, darker flat disk companion, (which is probably a pre-stellar cloud of matter), passing in front of the system every 27 years. The next eclipse is expected to start in January, 2010. Take a pair of good binoculars, or your telescope, and try to enjoy the wonders of beautiful Auriga at least once every winter.

**GEMINI:** The Twins, as this winter constellation is also known, borders on the constellations of Auriga, Cancer, Canis Minor, Lynx, Monoceros, Orion, and Taurus, and ranks 26<sup>th</sup> in overall brightness among the constellations, containing 47 stars brighter than magnitude 5.5. Its central point is located at RA=7h,1m and Dec.= +22.5 degrees. It is completely visible from latitudes North of -55 degrees, and completely invisible from latitudes South of -80 degrees; this constellation ranks 30<sup>th</sup> in overall size. Gemini's most famous bright stars are Castor (Alpha) and Pollux (Beta), better known as "The Twins". Gemini has two associated meteor showers: the Epsilon Geminids (19 Oct.), and the Geminids (14 Dec.), and one Messier object: the open cluster M35 (NGC 2168). Two of the planet "discoveries" took place within this constellation. In 1781 William Herschel found the planet Uranus near Eta Geminorum; in the first half of this century (1930), Clyde Tombaugh (working at Flagstaff's Lowell Observatory), discovered Pluto near Delta Geminorum. Castor, appearing as one star to the naked eye, is officially designated as a triple star, but is in reality six stars, each of the three having a companion. Studies indicate that star systems containing more than six stars will more rapidly become unstable and separate. Gemini's midnight culmination date is January 5<sup>th</sup>, so try to enjoy the beauty of this constellation, and its beautiful and interesting neighbors, on the next clear night.

**MONOCEROS:** Monoceros, or the Unicorn, is an interesting constellation which borders on many of our familiar winter star groupings, including Orion, Canis Major and Minor, Gemini, Hydra, Lepus, and Puppis. The constellation's central point is at RA=7h01m, and Dec.=+0.5 degrees; its overall brightness is listed at a magnitude of 7.476, and it contains 36 visible stars brighter than magnitude 5.5. Its midnight culmination date is January 5<sup>th</sup>, which makes it well placed for winter observing, and the grouping has one associated meteor shower (the Monocerotids), which peak on or about December 10<sup>th</sup>. This constellation ranks 35<sup>th</sup> in size, and is completely visible from latitudes +79 degrees to -78 degrees. Monoceros also contains one Messier object, M-50, which is a magnitude 6.3 galactic (open) cluster. Perhaps more famous than the Messier object however, are a trio of objects well known to many astronomers. The first is Plaskett's Star, which is in reality a pair of extremely massive stars, among the most massive pairs yet identified. This

duo sits almost directly on the Galactic Equator, and the total mass of the system is more than 100 times that of the sun. Also in Monoceros is "Hubble's Variable Nebula", a fan-shaped reflection nebula which has been seen to undergo changes in brightness, size, and shape, (but no regular period of variability has been found for the nebula). It is illuminated by the star R Monocerotis, a very young infrared-emitting stellar object surrounded by a disk of dust which is ejecting a bi-polar flow; this flow causes the variability in the nebula. Lastly, and most famous of all, is the beautiful emission nebula known as the Rosette. It surrounds an open cluster of stars containing the star 12 Monocerotis, and is an H-II region heated and ionized by this centrally located group of hot young stars. Try to enjoy the beauties of this well-placed constellation during these winter months; your time will be well spent.

**YOUNG ASTRONOMER'S CORNER, ASTRONOMY AND TELESCOPE LINGO, PLANETARY FOCUS, ASTRONOMY FUN FACTS, AND MIRROR IMAGES – WILL RETURN IN FEBRUARY**

These columns are not available this month, due to computer failure and computer replacement / upgrade process for our associate editor. He looks forward to being back on line next month, equipped with the latest in technology...

**ASTRONOMICAL NOTES -- ON & OFF THE WEB...**

**DR. BROWNLEE'S STARDUST CAPSULE PARACHUTES TO SOFT LANDING IN UTAH WITH DUST SAMPLES FROM COMET WILD 2**

Nearly seven years after setting off in pursuit of comet Wild (vilt) 2, the Stardust return capsule streaked across the night sky of the Western United States, making a soft parachute landing in the Utah desert southwest of Salt Lake City. Special helicopter-borne teams secured and recovered the capsule, containing tens of thousands of comet grains and as many as 100 bits of interstellar dust, shortly after it landed. The capsule was moved to a clean room at the Dugway Proving Ground, where a canister containing the collector grid was extracted and shipped to the Johnson Space Center in Houston.

**Donald Brownlee, a University of Washington astronomy professor who is Stardust's principal investigator**, or lead scientist, believes the comet dust carries evidence, preserved in the deep-freeze of deep space, about how the sun and the solar system formed more than 4 billion years ago. *"What's really exciting to me is that we soon expect to have this cosmic library in the laboratory so that we can try to read those records of our earliest history,"* Brownlee said. *"Our seven-year journey actually went back in time 4.5 billion years to gather these primitive samples."*

Stardust, launched on February 7, 1999, encountered Wild 2 (pronounced Vilt 2) on Jan. 2, 2004, beyond the orbit of Mars. It flew less than 150 miles from the comet's nucleus to capture tiny grains of dust and snap close-up photographs of the comet's main body. Though the grains were traveling faster than rifle bullets, they were not appreciably altered because the spacecraft's collector used a remarkable substance called aerogel that is as much as 99.9 percent empty space. The aerogel, Brownlee said, greatly reduced the effects of impact. The collector's reverse side was used to capture bits of interstellar dust streaming into the solar system from other parts of the galaxy.

On its voyage, Stardust traveled 2.88 billion miles -- the equivalent of more than 1 million trips from Los Angeles to New York. The mission became a quest for Brownlee, after Wild 2

had a close encounter with Jupiter in 1974. The giant planet's gravitational tug deflected the comet away from its previous path that went beyond Uranus, and brought it to the inner solar system where it could be reached by a spacecraft such as Stardust. Other spacecraft have visited comets, but Stardust is the only one to bring comet dust samples back to Earth.

Brownlee noted that thousands of tons of microscopic comet particles blanket the Earth each year, but there is no way to pinpoint where they came from. Previously the only solid extraterrestrial samples for which a point of origin had been firmly established were moon rocks brought back during the Apollo era and meteorites that scientists know had to come from Mars. Now there will be samples of material from another known space body, and they can be compared with all the previously collected meteorites and bits of dust to see if there are similar origins. Once the canister arrives in Houston, it will be opened and work will begin extracting the comet and interstellar grains from the aerogel collector grid. The material will be parceled out to laboratories around the world for a variety of studies and experiments. One irony is that the microscopically tiny particles will be studied with some of the largest instruments. *"There's a whole variety of scientific instruments, and people all over the world are going to be investigating using the very best possible tools,"* Brownlee said. *"They will use electron microscopes, mass spectrometers and even nuclear accelerators. The largest instrument to be used that I know is Stanford University's linear accelerator, which is 2 miles long."*

Brownlee likened the mission to some of the great seafaring adventures in human history. *"A lot of great explorers didn't make it back,"* he said. *"This is the longest return voyage. Nothing has ever gone this far away and come back. In a very real sense, it is a great gift to be given the chance to do something like this."* <http://stardust.jpl.nasa.gov> or <http://www.nasa.gov/stardust>

**PUBLIC TO LOOK FOR DUST GRAINS IN STARDUST DETECTORS**

Astronomy buffs who jumped at the chance to use their home computers in the SETI@home search for intelligent life in the universe will soon be able to join an Internet-based search for dust grains originating from stars millions of light years away. In a new project called Stardust@home, researchers will invite Internet users to help them search for a few dozen submicroscopic grains of interstellar dust captured by the Stardust spacecraft which returned to Earth on January 15<sup>th</sup>.

Though Stardust's main mission was to capture dust from the tail of comet Wild 2 -- dust dating from the origins of the solar system some 4.5 billion years ago -- it also captured a sprinkling of dust from distant stars, perhaps created in supernova explosions less than 10 million years ago. *"These will be the very first contemporary interstellar dust grains ever brought back to Earth for study,"* said Andrew Westphal, who developed the technique NASA will use to digitally scan the aerogel in which the interstellar dust grains are embedded. *"Stardust is not only the first mission to return samples from a comet, it is the first sample return mission from the galaxy."*

*"Like SETI@home, which is the world's largest computer, we hope Stardust@home will also be a large computer, though more of a neural network, using brains together to find these grains,"* said Bryan Mendez. Mendez and Nahide Craig plan to create K-12 curricula around the Stardust@home project and to reach out to local astronomy groups to boost participation.

Based on previous measurements of interstellar dust by both the Ulysses and Galileo spacecrafts, Westphal expects to find

approximately 45 grains of submicroscopic dust in the collector, a mosaic of tiles of lightweight aerogel forming a disk about 16 inches in diameter -- nearly a square foot in area -- and half an inch thick. Though those searching for pieces of Wild 2's tail will easily be able to pick out the thousands of cometary dust grains embedded in the front of the detector, finding the 45 or so grains of interstellar dust stuck in the back of the detector won't be so easy.

Thanks to a grant from NASA and assistance from the Planetary Society, however, Westphal and his colleagues have created a "virtual microscope" that will allow anyone with an Internet connection to scan some of the 1.5 million pictures of the aerogel for tracks left by speeding dust. Each picture will cover an area smaller than a grain of salt. *"Twenty or 30 years ago, we would have hired a small army of microscopists who would be hunched over microscopes focusing up and down through the aerogel looking for the tracks of these dust grains,"* said Westphal. *"Instead, we developed an automated microscope to scan the aerogel and hope to use volunteers we have trained and tested to search for these tracks."* The Web-based virtual microscope will be made available to the public in mid-March, even before all the scans have been completed in a cleanroom at Houston's Johnson Space Center. In all, Westphal expects to need some 30,000 person hours to look through the scanned images at least four times. Searching each picture should take just a few seconds, but the close attention required as the viewer repeatedly focuses up and down through image after image will probably limit the number a person can scan in one sitting.

To insure that the volunteer scanners know what they're doing, each must pass a test where he or she is asked to find the track in a few test samples. To judge the reliability of each volunteer -- and to provide some reward in what for most will be a fruitless search -- the team also plans to throw in some ringers with and without tracks. *"We will throw in some calibration images that allow us to measure the volunteers' efficiency,"* Westphal said. If at least two of the four volunteers viewing each image report a track, that image will be fed to 100 more volunteers for verification. If at least 20 of these report a track, UC Berkeley undergraduates who are expert at spotting dust grain tracks will confirm the identification. Eventually, the grain will be extracted for analysis. Discoverers will get to name their dust grains.

The dust grains were collected in two phases during the Stardust spacecraft's seven-year journey to and from Wild 2 as the spacecraft turned its Stardust Interstellar Dust Collector (SIDC) into the interstellar dust stream, which courses through the solar system at a speed of about 20 kilometers (12 miles) per second. The dust grains will have made carrot-shaped trails in the aerogel, which is a novel, silicon-based sponge 100 times lighter than water.

In the early morning hours of January 15, 2006, the Stardust payload parachuted into Utah's Salt Lake Desert and was airlifted to Houston, where teams opened it so as to minimize contamination from other dust. When launched in 1999, NASA was unsure how to remove from the aerogel the micron-sized cometary grains and the nearly invisible interstellar dust grains.

*"It's amazing that Stardust flew without anyone having a clue as to how to get particles out of the aerogel after it came back,"* Westphal said. *"You have to give NASA credit for taking a risk."*

During Stardust's quiet journey to a rendezvous with a comet, however, Westphal led a team that created tools for extracting both comet grains and interstellar dust grains. Working with Chris Keller, formerly at the Berkeley Sensor and Actuator Center and now at MEMS Precision Instruments, he developed

microtweezers and what he calls micro-pickle forks to pull comet grains from the aerogel for detailed analysis of their elemental and isotopic composition. The abundances and composition within comet grains will tell scientists about the conditions in the early solar system.

These same techniques will be used to extract interstellar dust grains, but first they have to be found. Based on earlier work with glass cosmic-ray detectors on the Mir space station, Westphal developed an automated microscope to digitally photograph the entire area of the aerogel in patches -- the size of a salt grain -- that can be viewed later in search of dust particles. The lengthy but exciting search for dust grains will be conducted by Internet volunteers.

Once the grains are identified and analyzed, Westphal hopes the information will tell about the internal processes of distant stars such as supernovas, flaring red giants or neutron stars that produce interstellar dust and also generate the heavy elements like carbon, nitrogen and oxygen necessary for life.

The virtual microscope was developed by computer scientist David Anderson, director of the SETI@home project, along with physics graduate student Joshua Von Korff. Craig and Mendez are now creating a teacher's lesson guide that uses the Stardust@home Virtual Microscope to teach students about the origins of the solar system. A section of the Stardust@home Web site also will be aimed at the general public. Stardust@home website, <http://stardustathome.ssl.berkeley.edu/>

#### **INTEGRAL OBSERVATORY MEASURES SUPERNOVA FORMATION RATE FOR THE MILKY WAY GALAXY**

Using ESA's Integral observatory, an international team of researchers has been able to confirm the production of radioactive aluminium (Al 26) in massive stars and supernovae at locations throughout our galaxy, and from this determine the rate of supernovae. The team, led by Roland Diehl, determined that gamma rays from the decay of Al 26 originate from the central regions of our galaxy, implying that production of new atomic nuclei is an ongoing process and occurs in star-forming regions galaxy-wide.

Our environment is composed of chemical elements formed long ago by nuclear fusion reactions in stellar interiors and supernovae. This process of 'nucleosynthesis' leads to the emission of gamma rays, which easily reach us from all regions of our galaxy. The Integral observatory has been measuring such gamma rays since October 2002. Diehl and his colleagues were able to measure the Al 26 gamma-ray emissions along the plane of the inner galaxy. However, because the disc of the galaxy rotates about its central axis, with the inner regions orbiting faster, gamma rays from decaying Al 26 observed from these regions should be modulated by the Doppler effect in a characteristic way. It is this characteristic gamma-ray Doppler pattern that has been found by Integral.

From this measurement, the team found that Al 26 decay gamma rays do indeed reach us from the inner regions of the galaxy, rather than from foreground regions along the same line of sight possibly caused by local and peculiar Al 26 production. These line-of-sight regions would not have the observed high relative velocity.

From these new observations, it is possible to estimate that the total amount of radioactive Al 26 in our galaxy as is equivalent to three solar masses. This is a lot, given that Al 26 is an extremely rare isotope; the fraction estimated for the early Solar System is 5/100 000 of Al 26, in proportion to its stable aluminum isotope

(Al 27). Because astrophysicists had inferred that the likely sources are mainly massive stars, which end their lives as supernovae, they could estimate the rate of such supernova events. They obtained a rate of one supernova every 50 years -- consistent with what had been indirectly found from observations of other galaxies and their comparison to the Milky Way.

Integral's study of gamma rays will continue to operate for several more years. Astrophysicists hope to increase the precision of such measurements. Project leader Diehl said, "*These gamma-ray observations provide insights about our home galaxy, which are difficult to obtain at other wavelengths due to interstellar absorption.*" Gamma rays from decaying Al 26 were first detected in space in 1978. Because of its known half-life of 720,000 years, this provided direct proof of currently ongoing nucleosynthesis in recently-formed stars. In the mid-1990s, Diehl and his colleagues were able to show that this relatively long-lived radioactivity is present over large regions along the plane of the galaxy. Hence, production of new atomic nuclei was found to be common in our galaxy.

Many scientists were surprised, because at the end of the 1970s, traces of Al 26 decay had only been found in meteorite samples originating from the early Solar System. This was interpreted as evidence that the Al 26 radioactivity was a key ingredient in the formation of planetary bodies (radioactive heat is a necessary to melt cometary material to form rocks), and that Al 26 radioactivity was intimately related to the early Solar System. From the theories of the 1950s that all chemical elements were produced inside stars, novae, and supernovae, two competing scenarios emerged that are still debated.

Al 26 in the early Solar System could be the result of such stellar processing, occurring, with some enhancement, near the formation site of our Solar System 4500 million years ago. Alternatively, special conditions during the formation of the Solar System could have caused high-energy particle collisions, producing Al 26 locally. Although gamma rays clearly show widespread cosmic nucleosynthesis, it remains to be understood if only this, or additional local high-energy reactions, has produced the amount of Al 26 inferred for the early Solar System. One way to answer this question is the determination of the total Al 26 content of our galaxy.

### **KUIPER BELT MOONS ARE STARTING TO SEEM TYPICAL**

In the not-too-distant past, the planet Pluto was thought to be an odd bird in the outer reaches of the solar system because it has a moon, Charon, that was formed much like Earth's own moon was formed. But Pluto is getting a lot of company these days. Of the four largest objects in the Kuiper belt, three have one or more moons. "*We're now beginning to realize that Pluto is one of a small family of similar objects, nearly all of which have moons in orbit around them,*" says Antonin Bouchez. Bouchez says that the puzzle for planetary scientists is that, as a whole, the hundreds of objects now known to inhabit the Kuiper belt beyond the orbit of Neptune have only about an 11 percent chance of possessing their own satellites. But three of the four largest objects now known in the region have satellites, which means that different processes are at work for the large and small bodies.

Experts have been fairly confident for a decade or more that Pluto's moon Charon was formed as the result of an impact, but that the planet seemed unique in this. According to computer models, Pluto was hit by an object roughly one-half its own size, vaporizing some of the planet's material. A large piece, however, was cleaved off nearly intact, forming Pluto's moon Charon.

Earth's moon is thought to have been formed in a similar way, though our moon most likely formed out of a hot disk of material left in orbit after such a violent impact.

Just in the last year, astronomers have discovered two additional moons for Pluto, but the consensus is still that the huge Charon was formed by a glancing blow with another body, and that all three known satellites -- as well as anything else not yet spotted from Earth -- were built up from the debris.

As for the other Kuiper belt objects, experts at first thought that the bodies acquired their moons only occasionally by snagging them through gravitational capture. For the smaller bodies, the 11 percent figure would be about right.

But the bigger bodies are another story. The biggest of all -- and still awaiting designation as the tenth planet -- is currently nicknamed "Xena." Discovered by Mike Brown and his associates, Chad Trujillo and David Rabinowitz, Xena is 25 percent larger than Pluto and is known to have at least one moon.

The second-largest Kuiper belt object is Pluto, which has three moons and counting. The third-largest is nicknamed "Santa" because of the time of its discovery by the Mike Brown team, and is known to have two moons. "*Santa is an odd one,*" says Bouchez. "*You normally would expect moons to form in the same plane because they would have accreted from a disk of material in orbit around the main body. But Santa's moons are 40 degrees apart. We can't explain it yet.*"

The fourth-largest Kuiper belt object is nicknamed "Easterbunny" -- again, because of the time the Brown team discovered it -- and is not yet known to have a moon. But in April, Bouchez and Brown will again be looking at Easterbunny with the adaptive-optics rig on one of the 10-meter Keck telescopes, and a moon might very well turn up.

### **LARGE SURVEY OF GALAXIES YIELDS NEW FINDINGS ON STAR FORMATION PROCESS**

New findings from a large survey of galaxies suggest that star formation is largely driven by the supply of raw materials, rather than by galactic mergers that trigger sudden bursts of star formation. Stars form when clouds of gas and dust collapse under the force of gravity, and the study supports a scenario in which exhaustion of a galaxy's gas supply leads to a gradual decline in the star-formation rate.

The results come from the Extended Groth Strip Survey, a collaborative effort using major ground-based and space-based telescopes to focus on one patch of sky that offers a clear view of the distant universe. By analyzing data from a combination of powerful instruments, researchers derived information on galaxy weights and star formation rates, as well as the numbers of stars already formed, for more than 3,500 galaxies. They found that the weight (or mass) of a galaxy is an important factor determining how fast it makes stars and how the star formation rate evolves over time, said Kai Noeske. "*The picture we're getting is that heavy galaxies form stars early and rapidly, whereas smaller galaxies form their stars over longer timescales,*" said Noeske, who presented the group's findings at the AAS meeting. The study's findings shed light on ongoing debates over the physical mechanisms that activate star formation in galaxies -- in particular, the importance of starbursts triggered by mergers of similar galaxies. "*What we see is consistent with mostly undisturbed galaxies using up their gas over time, like firewood burning down,*" Noeske said.

The Extended Groth Strip collaboration consists of astronomers from 16 institutions who have pooled their data and resources to create what is now one of the most intensely studied regions of the sky, said David Koo, a member of the team.

Light from distant galaxies takes billions of years to reach Earth, giving astronomers a window into the past. The galaxies included in this study cover a wide range of redshifts (a measure of distance) and corresponding "lookback times," extending out to redshift 1.4 or as far back in time as 9 billion years, about two-thirds of the age of the universe. The study also encompassed galaxies with a wide range of masses. *"We have now been able to track star formation in galaxies out to modest distances, more than half the age of the universe, and we find that all galaxies, big or small, seem to be fading gradually so that they are less active today than they were further back in time,"* Koo said.

Astronomers have found from previous galaxy surveys that star formation activity becomes more intense as they probe farther back in time. One proposed explanation has been that galaxy mergers were more frequent in the past, triggering bursts of star formation due to compression of gas clouds during the merger process. *"We are finding that mergers do not appear to play the dominant role in star formation, because we see normal-looking, undisturbed galaxies that are undergoing large amounts of star formation,"* Koo said. *"There probably are multiple mechanisms that can activate star formation. We are asking which is dominant,"* he added. *"Mergers do drive star formation; they just don't seem to be the major driver."*

Koo and Noeske are both members of the DEEP2 team, one of seven survey teams involved in the Extended Groth Strip Survey. DEEP (Deep Extragalactic Evolutionary Probe) began about 15 years ago, led by Koo and other astronomers using the twin 10-meter Keck Telescopes at the Keck Observatory and Hubble Space Telescope to conduct a large-scale survey of distant field galaxies. Phase 2 of the project began three years ago using the powerful DEIMOS spectrograph on the Keck II Telescope and has now gathered spectroscopic data from almost 40,000 distant galaxies.

DEEP2 has observed 13,000 galaxies in the Extended Groth Strip, one of four fields surveyed by the project. Joining the DEEP2 team in the Extended Groth Strip Survey is a broad consortium of other survey teams that are contributing data. Infrared data from Spitzer Space Telescope were especially important for Noeske's study, because they enable astronomers to see through the dust that obscures much of the star formation taking place in distant galaxies. *"Having the infrared data from Spitzer allows us to measure the star formation rates very accurately because we are no longer blinded by dust,"* Koo said.

The array of instruments trained on the Extended Groth Strip covers a tremendous range of wavelengths, including x-rays and radio waves, as well as infrared, visible, and ultraviolet light. *"This is an exceptional period of time for astronomy, because for the first time we are able to combine data from almost all of the important wavelengths,"* Koo said.

## **ASTEROID BREAKUP EVENT COVERED THE EARTH IN EXTRATERRESTRIAL DUST**

Scientists have made the first positive link between a breakup event in the main asteroid belt and a large quantity of interplanetary dust particles deposited on Earth. Sediments found in oceanic core samples indicate that millions of years ago, the Earth was blanketed by extraterrestrial dust. Computer simulations indicate these particles are fallout from the breakup of a large asteroid in the main asteroid belt, a population of

interplanetary bodies ranging from tiny pebbles to Texas-sized rocks located between the orbits of Mars and Jupiter.

Interplanetary dust is composed of bits of rock -- from a few to several hundred microns in diameter -- produced by asteroid collisions or ejected from comets. Interplanetary dust migrates toward the Sun, and en route some of this dust is captured by the Earth's gravitational field and deposited on its surface. Presently, more than 20,000 tons of this material accumulates on Earth each year, but the accretion rate should fluctuate with the number of asteroid collisions and active comets. By looking at ancient sediments that include both interplanetary dust and ordinary terrestrial sediment, it should be possible to detect major dust-producing solar system events in the past.

Because interplanetary dust particles are so small and rare in sediment -- significantly less than a part per million -- they are difficult to detect using direct measurements. However these particles are extremely rich in a rare isotope of helium -- helium 3 -- compared with terrestrial materials. Over the past decade, Ken Farley has measured helium 3 concentrations in sediments formed over the last 75 million years to create a record of the interplanetary dust flux.

Recently, Farley found a large excess of helium 3 in some 8.2 million-year-old sediments, indicating that the accretion rate of interplanetary dust suddenly increased by a factor of about 4 and then decreased over about 1.5 million years to pre-event levels. To assure that the peak was not a fluke present at only one site on the seafloor, two different localities were studied: one in the Indian Ocean and one in the Atlantic. The event is recorded clearly at both sites. *"The helium 3 spike found in these sediments is the smoking gun that something quite dramatic happened to the interplanetary dust population 8.2 million years ago. It's one of the biggest dust events of the last 80 million years,"* says Farley.

To find the source of these particles, Dr. William F. Bottke and Dr. David Nesvornyy along with David Vokrouhlicky studied clusters of asteroid orbits that are likely the consequence of ancient asteroidal impacts. *"While asteroids are constantly crashing into one another in the main asteroid belt,"* says Bottke, *"only once in a great while does an extremely large one shatter."*

The scientists identified one cluster of asteroid fragments whose size, age and remarkably similar orbits made it a likely candidate for the Earth-dusting event. Tracking the orbits of the cluster backwards in time using computer models, they found that, 8.2 million years ago, all of its fragments shared the same orbital orientation in space. This event defines when the 100-mile-wide asteroid called Veritas was blown apart by impact and coincides with the spike in interplanetary seafloor sediments described above. *"The Veritas disruption was extraordinary,"* says Nesvornyy. *"It was the largest asteroid collision to take place in the last 100 million years."*

As a final check, the team used computer simulations to follow the evolution of dust particles produced by Veritas breakup. Their work shows that the Veritas event could produce the spike in extraterrestrial dust raining on the Earth as well as a gradual decline in the dust flux. *"The match between our model results and the helium 3 deposits is very compelling,"* Vokrouhlicky says. *"It makes us wonder whether other helium 3 peaks in oceanic cores can also be traced back to asteroid breakups."* <http://www.swri.org/press/2006/asteroidbreakup.htm>

## **GALAXY'S NEIGHBORING SPIRAL ARM IS CLOSER THAN THOUGHT**

The Perseus spiral arm, the nearest spiral arm in the Milky Way outside the Sun's orbit, lies only half as far from Earth as some previous studies had suggested. An international team of astronomers measured a highly accurate distance to the Perseus arm for the first time using a globe-spanning system of radio dishes known as the Very Long Baseline Array (VLBA), which offers the sharpest vision of any telescope in existence. Additional VLBA measurements will help astronomers to determine the true structure of the Milky Way. *"We know less about the structure of our own galaxy than we do about many nearby galaxies like Andromeda,"* said team leader Mark Reid. *"We literally can't see the forest for the trees because we are embedded inside our own galaxy, and interstellar dust blocks our view."* Previous estimates of the distance to the Perseus arm varied by a factor of two. Studies based on the motions of stars yielded a distance of more than 14,000 light-years, while observations comparing the apparent brightness of massive, young stars with estimates of their intrinsic brightness yielded a distance of only about 7,200 light-years. The new VLBA measurements confirm with an accuracy of 2 percent that the Perseus spiral arm is located about 6,400 light-years from the Earth. *"Our neighbors are closer than we thought,"* stated author Ye Xu .

Obtaining accurate distances in astronomy is a difficult challenge. The most reliable method for measuring astronomical distances is called trigonometric parallax, a technique similar to the triangulation used by land surveyors. A trigonometric parallax is determined by observing the change in position of a star relative to a very distant, essentially fixed object like a quasar, as the Earth moves in its orbit around the Sun. Just as a finger held at arm's length appears to shift against the far wall when viewed with one eye or the other, a nearby object will appear to shift position relative to a more distant one. Mathematical calculations then yield the distance to the closer object. The parallax method is powerful but requires exceptional accuracy. *"I have spent more than a decade developing the calibration techniques we needed to obtain this result,"* said Reid. The team achieved an accuracy of 10 micro-arcseconds, which is a factor of 100 better than previous methods. That resolution is equivalent to looking from the Earth to a person standing on the Moon's surface and telling whether that person is holding a flashlight in their right or left hand. The VLBA is the only telescope able to provide such high resolution.

Reid and his colleagues used the VLBA to examine the region near a newly formed star in the Perseus arm called W3OH. They gathered radiation from bright, compact radio sources known as methanol masers. (Masers amplify, or strengthen, radio-wave emission the same way that lasers amplify light emission. Masers can form naturally in outer space.) With a distance in hand, the team was able to determine the motion of W3OH in three-dimensional space. They found that W3OH is orbiting the galactic center more slowly than the galaxy spins, and is "falling" toward the center of the Milky Way. Such peculiar motions can be studied to determine the distribution of mass in the Milky Way.

The team has additional VLBA observing time to measure other regions of the galaxy. Over time, such studies will help map the spiral structure of the Milky Way and determine the distribution of unseen dark matter believed to surround it.

#### **ASTRONOMERS SEIZE RARE OPPORTUNITY TO MEASURE DISTANT CHARON**

Being in the right place at the right time gave a group of Massachusetts research astronomers a unique opportunity to study Pluto's largest moon Charon. The resulting measurements,

to unprecedented accuracy, of Charon's size and possible atmosphere provide insight into the way this distant world may have formed. On July 10, 2005, astronomers observed the light from a star as it disappeared behind Charon and reappeared on the other side -- an event known as a stellar occultation. Occultations provide important information about the size of remote bodies, as well as the makeup of their atmospheres (if they have them).

According to team member Jim Elliot, observations of a stellar occultation like this one have been made only once before, from South Africa in 1980. *"We have been waiting many years for this opportunity,"* he said. *"Watching the star vanish as it was blocked by Charon was spectacular."* Although the star disappeared behind Charon for less than a minute, data from the observations provided considerable information about this tiny moon.

In a paper in *Nature*, the authors determined Charon's radius to be 606 +/- 8 km. For perspective, this radius is roughly twice the width of Massachusetts with an error of only 5 miles. The size was combined with mass measurements from Hubble Space Telescope data to establish a density for Charon of 1.72 g/cm<sup>3</sup>. This density, roughly 1/3 that of the Earth, reflects Charon's rocky-icy composition. What makes this achievement so remarkable is that the observation could only be made from a narrow, 650-mile wide region in South America. The observers were located at four telescopes in Chile and one telescope in Brazil for the event. The largest telescope employed by the consortium was the 8-meter Gemini South Telescope on Cerro Pachón. The observations utilized the Acquisition Camera, a guider instrument that is typically used for telescope pointing and target selection, as a high-speed photometer. Portable camera systems were mounted on the other telescopes: the 6.5-meter Clay and 2.5-meter du Pont at Las Campanas Observatory in La Serena, Chile, the 0.8-meter at the Observatório Cerro Armazones in Anofagasta, Chile, and the 0.6-meter at Observatório Pico dos Dias, Itajubá, Brazil. Observations were successful at all stations excluding Brazil, which was clouded out.

Jay Pasachoff, a collaborator in the effort, praised the team doing the work. *"It's astounding that our group could be in the right place at the right time to line up a tiny body three billion miles away,"* he said. *"The successful observations are quite a reward for all of the people who helped predict the event, constructed and integrated the equipment, and traveled to the telescopes."*

Observations taken at a high rate, 10 frames per second, from the 6.5-meter Clay telescope detected subtle optical effects caused when the starlight passed the edge of Charon's disk. By analyzing these effects, known as diffraction fringes, the team concluded that any atmosphere on Charon is less than one millionth the density of Earth's atmosphere. Their analysis provided very strict limits on the amounts of various gases that could be present. Three years earlier, the team previously used the technique of stellar occultation to study Pluto's thin atmosphere, showing that it was subject to slight global warming.

The results of the observations argue against the theory that Pluto and Charon were formed by the cooling and condensing of the gas and dust known as the solar nebula. Instead, astronomers think that Charon was formed in a collision between two objects early in the formation of the solar system. *"Our observations show that there is no substantial atmosphere on Charon, which is consistent with an impact formation scenario,"* said lead author Amanda Gulbis. *"We also find that Charon contains roughly 10% less rock by mass than Pluto. This difference suggests that either, or both, objects involved in a Charon-forming collision had concentrations of heavier materials in their cores."* A collisional

formation like this has a parallel in theories for the formation of the Earth-Moon system.

Pluto has recently received considerable attention, with NASA's New Horizons mission to be launched in January 2006, the discovery of two new moons, and the discovery of several Kuiper belt objects that are Pluto-sized (or even larger). The success of the team in observing the Charon occultation bodes well for their ability to observe occultations of different stars by these newly discovered objects. The so-called "10th planet" (2003 UB313), recently discovered by scientists from Caltech, is a prime candidate for stellar occultation observations. Although this object is approximately twice as far away from the Earth as Charon, it is thought to be twice as large. 2003 UB313 thus covers the same angular extent in the sky as Charon, just as the Moon and the Sun appear to be the same size although the Sun is physically larger.

"We are eager to use the occultation technique to probe for atmospheres around large Kuiper belt objects," remarked Jim Elliot, who has been observing stellar occultations by bodies in the solar system for more than three decades.

### ASTRONOMERS SPOT RARE LUNAR METEOR STRIKE

Astronomers at NASA's Marshall Space Flight Center, Huntsville, AL, have recorded a small but powerful meteoroid strike in the night on the moon's surface. On Nov. 7, using a 10-inch-diameter telescope, astronomers recorded a tiny blip northwest of Mare Imbrium, the moon's "Sea of Showers." Such impacts are not uncommon, but it was only in 1999 that scientists first recorded a lunar strike as it happened. "People just do not look at the moon anymore," said Dr. Robert Suggs. "We tend to think of it as a known quantity. But there is knowledge still to be gained here." As NASA plans to return to the moon, the agency has a need to understand what happens after lunar impacts in order to protect lunar explorers. On Earth, the atmosphere vaporizes most small meteoroids, leaving nothing behind but a brief streak of light. The vacuum environment on the moon, however, means there is nothing to slow incoming meteoroids before they strike.

"The likelihood of being struck by a meteoroid on the lunar surface is very, very small," said Bill Cooke. "The challenge is learning what happens to high-velocity ejecta, the debris kicked up by a meteoroid strike, which is not hindered by atmospheric friction or Earth gravity. What threat does that debris pose to humans or equipment?" Suggs, who heads the impact study, used commercial software tools to study the video frame by frame, and spotted a very bright flash. The burst of light diminished gradually over the course of five video frames, each 1/30th of a second in duration. Suggs called in Cooke, and both scientists agreed that the bright light was an impact flash, captured by video from some 248,000 miles away. Immediately, the team began ruling out other possible causes. Two telling characteristics won out - the gradual diminishment of the flash rather than an on-off "winking" effect, and its motionlessness. A flicker of light from a moving satellite, Cooke noted, would have appeared to shift perceptibly, even in five brief frames of video.

Suggs and Cooke next consulted star charts and lunar imaging software and determined the meteoroid was likely a Taurid, part of an annual meteor shower active at the time of the strike. Based on the amount of light produced the object was roughly five inches in diameter, traveling more than 60,000 mph, and may have gouged a crater nearly 10 feet in diameter out of the moon's surface. The Taurids, which approach Earth from the direction of the Taurus constellation, are believed to be ancient remnants of comet Encke, which orbits the Sun every 3.3 years.

NASA scientists previously studied lunar meteor strikes during the Apollo moon program, but lacked the sophisticated video cameras and high-powered image processors to capture the tiny, telling flashes. Now, however, as NASA readies its next-generation spaceship to carry explorers back to the moon for potential long-term stays, Suggs and Cooke say lunar impact research is more vital than ever. "Large-scale lunar facilities are sure to be well-protected, using impact-resistant technologies much like those developed to shield the space shuttle and the International Space Station," Suggs said. "We want to support additional measures that safeguard personnel working in the lunar field - early-alert systems, emergency protective measures and new technologies that will mitigate risks from flying impact debris." <http://www.nasa.gov/home> [http://science.nasa.gov/headlines/y2005/22dec\\_lunartaurid.htm](http://science.nasa.gov/headlines/y2005/22dec_lunartaurid.htm)

The blast, equal in energy to about 70 kg of TNT, occurred near the edge of Mare Imbrium (the Sea of Rains) on Nov. 7, 2005, when a 12-centimeter-wide meteoroid slammed into the ground traveling 27 km/s. "What a surprise," says researcher Rob Suggs, who recorded the impact's flash. He and colleague Wes Swift were testing a new telescope and video camera they assembled to monitor the moon for meteor strikes. On their first night out, "we caught one," says Suggs. "The object that hit the moon was 'probably a Taurid,'" says meteor expert Bill Cooke. In other words, it was part of the same meteor shower that peppered Earth with fireballs in late October and early November 2005. "Fireball Sightings" - [http://science.nasa.gov/headlines/y2005/03nov\\_taurids.htm](http://science.nasa.gov/headlines/y2005/03nov_taurids.htm)

The moon was peppered, too, but unlike Earth, the moon has no atmosphere to intercept meteoroids and turn them into harmless streaks of light. On the moon, meteoroids hit the ground-and explode. "The flash we saw," says Suggs, "was about as bright as a 7th magnitude star." That's two and a half times dimmer than the faintest star a person can see with their unaided eye, but it was an easy catch for the group's 10-inch telescope.

Cooke estimates that the impact gouged a crater in the moon's surface "about 3 meters wide and 0.4 meters deep." As moon craters go, that's small. "Even the Hubble Space Telescope couldn't see it," notes Cooke. The moon is 384,400 km away. At that distance, the smallest things Hubble can distinguish are about 60 meters wide.

This isn't the first time meteoroids have been seen hitting the moon. During the Leonid meteor storms of 1999 and 2001, amateur and professional astronomers witnessed at least half-a-dozen flashes ranging in brightness from 7th to 3rd magnitude. Many of the explosions were photographed simultaneously by widely separated observers. Since the Leonids of 2001, astronomers have not spent much time hunting for lunar meteors. "It's gone out of fashion," says Suggs. But with NASA planning to return to the moon by 2018, he says, it's time to start watching again.

There are many questions that need answering: "How often do big meteoroids strike the moon? Does this happen only during meteor showers like the Leonids and Taurids? Or can we expect strikes throughout the year from 'sporadic meteors?'" asks Suggs. Explorers on the moon are going to want to know. "The chance of an astronaut being directly hit by a big meteoroid is miniscule," says Cooke. Although, he allows, the odds are not well known "because we haven't done enough observing to gather the data we need to calculate the odds." Furthermore, while the danger of a direct hit is almost nil for an individual astronaut, it might add up to something appreciable for an entire lunar outpost. Of greater concern, believes Suggs, is the spray - "the secondary meteoroids produced by the blast." No one knows

how far the spray reaches and exactly what form it takes. Also, ground-shaking impacts could kick up moondust, possibly over a wide area. Moondust is electrostatically charged and notoriously clingy. "Mesmerized by Moondust" - [http://science.nasa.gov/headlines/y2005/21nov\\_abbas.htm](http://science.nasa.gov/headlines/y2005/21nov_abbas.htm) Even a small amount of moondust can be a great nuisance: it gets into spacesuit joints and seals, clings to faceplates, and even makes the air smell when it is tramped indoors by moonwalkers. Could meteoroid impacts be a source of lunar "dust storms?" Another question for the future....

Suggs and his team plan to make more observations. "*We're contemplating a long-term monitoring program active not only during major meteor showers, but also at times in between. We need to develop software to find these flashes automatically,*" he continues. "*Staring at 4 hours of tape to find a split-second flash can get boring; this is a job for a computer.*" With improvements, their system might catch lots of lunar meteors. Says Suggs, "*I'm ready for more surprises.*"

### ASTRONOMERS DISCOVER FASTEST-SPINNING PULSAR

Astronomers using the Robert C. Byrd Green Bank Telescope have discovered the fastest-spinning neutron star ever found, a 20-mile-diameter superdense pulsar whirling faster than the blades of a kitchen blender. Their work yields important new information about the nature of one of the most exotic forms of matter known in the Universe. "*We believe that the matter in neutron stars is denser than an atomic nucleus, but it is unclear by how much. Our observations of such a rapidly rotating star set a hard upper limit on its size, and hence on how dense the star can be*" said Jason Hessels.

Pulsars are spinning neutron stars that sling "lighthouse beams" of radio waves or light around as they spin. A neutron star is what is left after a massive star explodes at the end of its "normal" life. With no nuclear fuel left to produce energy to offset the stellar remnant's weight, its material is compressed to extreme densities. The pressure squeezes together most of its protons and electrons to form neutrons; hence, the name "neutron star." "*Neutron stars are incredible laboratories for learning about the physics of the fundamental particles of nature, and this pulsar has given us an important new limit,*" explained Scott Ransom, an astronomer at the National Radio Astronomy Observatory and one of Hessels' collaborators on this work.

The scientists discovered the pulsar, named PSR J1748-2446ad, in a globular cluster of stars called Terzan 5, located some 28,000 light-years from Earth in the constellation Sagittarius. The newly-discovered pulsar is spinning 716 times per second, or at 716 Hertz (Hz), readily beating the previous record of 642 Hz from a pulsar discovered in 1982. For reference, the fastest speeds of common kitchen blenders are 250-500 Hz. The scientists say the object's fast rotation speed means that it cannot be any larger than about 20 miles across. According to Hessels, "*If it were any larger, material from the surface would be flung into orbit around the star.*" The scientists' calculation assumed that the neutron star contains less than two times the mass of the Sun, an assumption that is consistent with the masses of all known neutron stars.

The spinning pulsar has a companion star that orbits it once every 26 hours. The companion passes in front of the pulsar, eclipsing the pulsar about 40 percent of the time. The long eclipse period, probably due to bloating of the companion, makes it difficult for the astronomers to learn details of the orbital configuration that would allow them to precisely measure the masses of the pulsar and its companion. "*If we could pin down these masses more*

*precisely, we could then get a better limit on the size of the pulsar. That, in turn, would then give us a better figure for the true density inside the neutron star,*" explained Ingrid Stairs, another collaborator on the work.

Competing theoretical models for the types and distributions of elementary particles inside neutron stars make widely different predictions about the pressure and density of such an object. "*We want observational data that shows which models fit the reality of nature,*" Hessels said. If the scientists can't use PSR J1748-2446ad to do that, they are hopeful some of its near neighbors will yield the data they seek. Using the GBT, the astronomers so far have found 30 new fast "millisecond pulsars" in the cluster Terzan 5, making 33 pulsars known in the cluster in total. This is the largest number of such pulsars ever found in a single globular cluster.

Dense globular clusters of stars are excellent places to find fast-rotating millisecond pulsars. Giant stars explode as supernovae and leave rotating pulsars which gradually slow down. However, if a pulsar has a companion star from which it can draw material, that incoming material imparts its spin, or angular momentum, to the pulsar. As a result, the pulsar spins faster. "*In a dense cluster, interactions between the stars will create more binary pairs that can yield more fast-rotating pulsars,*" Ransom said.

The great sensitivity of the giant, 100-meter diameter GBT, along with a special signal processor, called the Pulsar Spigot, made possible the discovery of so many millisecond pulsars in Terzan 5. "*We think there are many more pulsars to be found in Terzan 5 and other clusters, and given that the fast ones are often hidden by eclipses, some of them may be spinning even faster than this new one,*" Ransom said. "*We're excited about using this outstanding new telescope to answer some important questions about fundamental physics,*" he said. Graphic: 'How Are Millisecond Pulsars Formed?' - [http://www.nrao.edu/pr/2006/mspulsar/mspulsar\\_graphics.shtml](http://www.nrao.edu/pr/2006/mspulsar/mspulsar_graphics.shtml)

### WANTED: AMATEUR STARGAZERS TO HELP SOLVE SUPERNOVA MYSTERY

Ohio State scientists have thought of a new way to solve an astronomical mystery, and their plan relies on a well-connected network of amateur stargazers and one very elusive subatomic particle. To understand what happens inside exploding stars, or supernovae, scientists need to study particles called neutrinos, explained John Beacom. Neutrinos are formed in the nuclear reactions that make stars like our sun shine. Exploding stars overflow with the particles, and flood the universe with them. Neutrinos should be everywhere, but they are very hard to detect -- so hard to detect, in fact, that even though countless neutrinos burrow through our planet every second, scientists only capture a few of them each day. Scientists know that most neutrinos they do detect probably come from our own Sun, from nuclear reactors in terrestrial power plants, or from cosmic radiation interacting with our atmosphere. There has been no way to distinguish whether a particular neutrino came from elsewhere, until now.

That's why Beacom and his team's discovery -- that each year, one or two of the neutrinos detected on Earth can probably be matched to the exploding star that made them -- represents a major step forward for supernova astrophysics. The discovery also comes at a special time, Beacom said. The method will fully exploit the capabilities of the next generation of neutrino detectors, which are now being planned, and take advantage of a growing number of amateur astronomers who are capable of discovering supernovae. For a study appearing in a recent issue

of the journal *Physical Review Letters*, Beacom and his coauthors developed a kind of litmus test for finding supernova neutrinos: If a detector on Earth registers two of the particles within ten seconds, odds are high that they came from a supernova in a nearby galaxy. Alternatively, if an astronomer -- amateur or otherwise -- spots a supernova, scientists at neutrino detectors can look back through their records to see if they captured a neutrino around that time.

Given that a few supernovae occur in nearby galaxies every year, and given the sensitivity of neutrino detectors on Earth, they've determined that at least one of those scenarios -- the two-in-ten-seconds event or the identification of a supernova neutrino after the fact -- should be able to happen about once a year. The professionals need amateur astronomers to help spot new supernovae fast, so scientists can quickly match captured neutrinos with the exploding stars that made them. *"Even with all our modern telescopes, the professionals can't look at the whole sky at once,"* Beacom said. *"But the amateurs are everywhere. With relatively small telescopes, they can see these nearby supernovae, which are very bright -- often brighter than their host galaxies."* Here, "relatively small" means smaller than a telescope in an astronomical observatory, but larger than the average backyard telescope.

Coauthor Hasan Yüksel explained that many of today's so-called amateur astronomers aren't really so amateur. *"You can think of them more as 'professional amateurs,'"* he said. These are the semi-pro players of the hobby set -- skilled folks who build custom telescopes. They have day jobs, but they scan the skies at night, and share their findings with other amateurs over the Internet. Often, they have ties to professional astronomers. When a major discovery is made, they know as soon as the professionals do.

Yüksel also pointed out that since 2002, there were at least nine supernovae identified in galaxies within about 30 million light years (180 trillion miles) of our Milky Way, and more than half of those were discovered by amateurs.

Surprisingly, the physicists got their idea in a "eureka" moment -- after a discussion with colleagues at their morning coffee event. This daily review of new journal papers posted to an online archive (<http://arXiv.org>) has been going on since the 1990s, and often inspires faculty and students to pursue new lines of research. Walking back to their offices after coffee, Yüksel asked Beacom and visiting scholar Shin'ichiro Ando about a special class of galaxies called starburst galaxies, in which unusually high numbers of stars are being born. Wouldn't those galaxies also have large numbers of supernovae? Wouldn't nearby starburst galaxies be good places to look and find out? Beacom said that something clicked. *"We realized that maybe it's not totally crazy to look for neutrinos from supernovae in nearby galaxies,"* he said.

The three performed detailed calculations about supernova rates in nearby galaxies, and found that the explosions probably happen more often than people once thought -- about three times a year. Then they looked at the rates at which neutrinos are caught in giant underground detectors on Earth.

Their discovery came down to calculating the odds: it's highly unlikely that a neutrino detector on Earth would capture two particles within any 10 second interval unless both of those

neutrinos came from a supernova -- in fact, the same supernova. *"We were kicking ourselves for not thinking of this before,"* Beacom said. He cited Supernova 1987A, which occurred in a galaxy that is a very close companion to the Milky Way. Because detectors on Earth captured 20 neutrinos in only a few seconds during that event, astronomers knew for sure that they came from 1987A. But since then? *"A big fat zero,"* he said. *"What if using this technique, we could have been identifying one additional supernova neutrino per year? By now, we would have collected a sample as big as that burst in 1987."* With the much larger neutrino detectors that are now being devised, and with the large number of supernovae that are being spotted these days, it could be done.

Galaxies up to 200 times farther away than the one that spawned Supernova 1987A are still considered near by astronomical standards, and amateurs would be able to spot supernovae in them. Those galaxies may give us only one or two neutrinos per year, but that's still more than scientists would be able to study otherwise. *"These are somewhat desperate measures,"* Ando admitted. *"Why are we so desperate? Since a supernova expends 99 percent of its energy in neutrinos, those neutrinos tell the story of how the explosion works, and therefore we have to find them."* Supernova neutrinos are everywhere, but the vastness of space keeps them hidden.

So, at least a thousand years after people first noticed supernovae in the skies, what's happening inside these exploding stars is still a mystery. When scientists simulate supernovae on computer, something always goes wrong. The explosion starts, and then it fizzles. *"If we can't make a supernova blow up on the computer, that means we're missing something. We need clues. We need to find those neutrinos,"* Ando continued. Beacom envisions that scientists at neutrino detectors could sound an alarm whenever they detect two particles in ten seconds. Since supernovae emit neutrinos at the very start of the explosion, the particles would reach Earth hours before the supernovae would be visible in telescopes, and the announcement would amount to a supernova forecast.

Alternatively, when astronomers spot a nearby supernova, they could ask the scientists at the detectors to look back through their data from previous hours to find any particle events. At Beacom's suggestion, scientists working at the Japanese neutrino detector Super-Kamiokande are going to search their records for events that could be linked to nearby supernovae in past years.

*"While this detector is smaller than those envisioned for the future, it's been in operation for a decade or two, so it actually stands a good chance of having detected the first neutrino from an identified supernova beyond the Milky Way and its closest companions,"* Beacom said.

#### FROM THE EDITOR'S TERMINAL

*The Stargazer* is your newsletter and therefore it should be a cooperative project. Ads, announcements, suggestions, and literary works should be received by the editor before the 1st of the month of publication, for example, material for May's newsletter should be received May 1st. If you wish to contribute an article or suggestions to *The Stargazer* please contact Mark Folkerts by email or by telephone (425) 486-9733 or co-editor Bill O'Neil, at (774) 253-0747.

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### **In January's Stargazer:**

- \*\*\*\* **OBSERVER'S INFORMATION**
- \*\*\*\* **ASTRO CALENDAR**
- \*\*\*\* **CONSTELLATIONS OF THE MONTH:**
- \*\*\*\* **STARDUST CAPSULE PARACHUTES TO SOFT LANDING IN UTAH WITH DUST SAMPLES**
- \*\*\*\* **PUBLIC TO LOOK FOR DUST GRAINS IN STARDUST DETECTORS**
- \*\*\*\* **OBSERVATORY MEASURES SUPERNOVA FORMATION RATE FOR THE MILKY WAY**
- \*\*\*\* **KUIPER BELT MOONS ARE STARTING TO SEEM TYPICAL**
- \*\*\*\* **LARGE SURVEY OF GALAXIES YIELDS NEW FINDINGS ON STAR FORMATION PROCESS**
- \*\*\*\* **ASTEROID BREAKUP EVENT COVERED THE EARTH IN EXTRATERRESTRIAL DUST**
- \*\*\*\* **GALAXY'S NEIGHBORING SPIRAL ARM IS CLOSER THAN THOUGHT**
- \*\*\*\* **ASTRONOMERS SEIZE RARE OPPORTUNITY TO MEASURE DISTANT CHARON**
- \*\*\*\* **ASTRONOMERS SPOT RARE LUNAR METEOR STRIKE**
- \*\*\*\* **ASTRONOMERS DISCOVER FASTEST-SPINNING PULSAR**
- \*\*\*\* **WANTED: AMATEUR STARGAZERS TO HELP SOLVE SUPERNOVA MYSTERY**

**The next EAS Meeting is 3:00 P.M. SATURDAY, January 28<sup>th</sup> 2006  
at the Everett Public Library Auditorium.**