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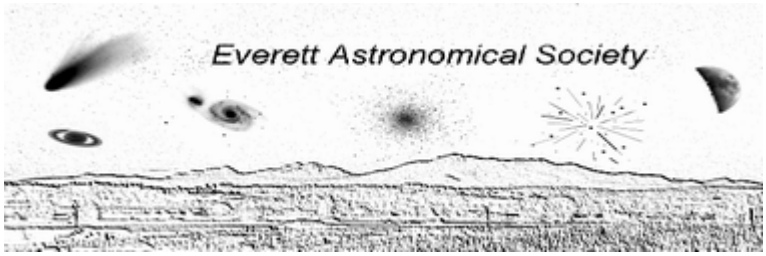

The Stargazer

November 2004

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EAS BUSINESS…

NEXT EAS MEETING - SATURDAY NOVEMBER 20TH 7:00 PM - PROVIDENCE PACIFIC CLINIC (916 PACIFIC AVENUE) IN THE MONTE CRISTO ROOMS ON THE MAIN FLOOR.

★ Film – Unfolding Universe.

Map/directions to the EAS meeting are available at: http://members.tripod.com/everett_astronomy/directions_to_club_meetings.htm

Scheduled Meeting Dates:
Nov 20th – EAS Meeting – 7:00 PM
Dec 11th – EAS Holiday Dinner

MEMBER NEWS

★ New EAS T-Shirts available ! See our updated T-shirts, available at this month's meeting. Chose from T, Long-sleeve T, or sweat shirt in a variety of sizes.

★ Officer elections at November meeting. We need candidates, particularly for Vice-President…

★ Squak Mt. Telescope Gang - There is to be a Squaking on Wednesday eve, December 8th at 7:00 pm. We are presently scheduled to gather in the Issaquah Brewhouse. (venue might possible change....still awaiting confirmation). As usual there will be an exciting agenda, but feel free to bring your latest gizmo's or gadgets and show them to the crowd. Look for more info and directions on our web site shortly (www.squakmountain.org) Don't forget you can bring your friends, wives, husbands, significant others, aliens or who ever..... all are welcome, even SAS members...

CLUB STAR PARTY INFO

Upcoming star party schedule:

We also try to hold informal close-in star parties each month during the spring and summer months on a weekend near the New moon at a member's property or a local park. (call Bob Lyons at (425) 337-1510 for info or check the EAS website.) Members contact Bob Lyons for scope borrowing.

FINANCIAL HEALTH

The club maintains a $500+ balance. We try to keep approximately a $500 balance to allow for contingencies. Emailing a digital copy of the newsletter has been suggested to reduce printing and postage costs, and speed up delivery, please email Mark if electronic copy would be OK for you.

CLUB SCOPES' STATUS

SCOPE	LOAN STATUS	WAITING
10-INCH DOBSONIAN	ON LOAN	NO WAIT LIST

EAS members: contact Bob Lyons (425) 337-1510 or 'bdlyons at verizon.net' to borrow a scope.

ASTRO CALENDAR

November 2004
Nov 03 - Taurids Meteor Shower Peak
Nov 03 - Asteroid 21 Lutetia At Opposition (9.8 Magnitude)
Nov 05 - Venus Passes 0.5 Degrees From Jupiter
Nov 07 - Asteroid 27 Euterpe At Opposition (8.8 Magnitude)
Nov 09 - Moon Occults Jupiter
Nov 10 - Moon Occults Venus
Nov 11 - Moon Occults Mars
Nov 14 - Moon Occults Mercury
Nov 17 - Leonids Meteor Shower Peak
Nov 20 - EAS Meeting – 7:00 PM
Nov 21 - Mercury At Its Greatest Eastern Elongation (22 Degrees)

December 2004
Dec 05 - Venus Passes 1.2 Degrees From Mars
Dec 07 - Moon Occults Jupiter
Dec 11 - EAS Holiday Dinner – Alfy's on Broadway
Dec 13 - Geminids Meteor Shower Peak
Dec 21 - Winter Solstice, 12:42 UT
Dec 22 - Ursids Meteor Shower Peak
Dec 24 - Cassini, Huygens Probe Release
Dec 25 - Asteroid 192 Nausikaa At Opposition (9.7 Magnitude)
Dec 30 - Mercury At Its Greatest Western Elongation (22 Degrees)

January 2005
Jan 03 - Earth At Perihelion (0.983 AU From Sun)
Jan 03 - Quadrantids Meteor Shower Peak
Jan 04 - Moon Occults Jupiter
Jan 13 - Saturn at Opposition
Jan 13 - Mercury Passes 0.3 Degrees From Venus
Jan 14 - Huygens Probe Lands on Titan

Jan 14 - Cassini, Titan Flyby
Jan 31 - Moon Occults Jupiter

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 have a good idea for an astronomy broadcast or would like to try your hand at writing a script, call Pat Lewis at (206) 524-2006 or email to joagreen@aol.com 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 8:58 A.M. and 5:58 P.M. Saturday and Sunday). 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.

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 Scott Gibson, 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 subscribe to ***Sky and Telescope*** for $7 off the normal subscription rate, contact the treasurer for more information. **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, built as a club project or the 60mm refractor. Contact Bob Lyons (425) 337-1510 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

Nov 05	Last Quarter Moon
Nov 12	New Moon
Nov 19	First Quarter Moon
Nov 26	Full Moon
Dec 05	Last Quarter Moon
Dec 12	New Moon
Dec 18	First Quarter Moon
Dec 26	Full 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/cla/menu.html
http://www.lpi.usra.edu/research/lunar_orbiter

UP IN THE SKY -- THE PLANETS

Object	Rises	Transits	Sets	Constellation
Sun	**7:22 am**	**11:55**	**16:27**	**Libra**
Mercury	Daylight	Daylight	**17:25**	**Ophiuchus**
Venus	**4:30 am**	Daylight	Daylight	**Virgo**
Mars	**5:21 am**	Daylight	Daylight	**Virgo**
Jupiter	**3:05 am**	Daylight	Daylight	**Virgo**
Saturn	**21:38**	**5:22 am**	Daylight	**Gemini**
Uranus	Daylight	**19:42**	**1:03 am**	**Aquarius**
Neptune	Daylight	**18:22**	**23:07**	**Capricornus**
Pluto	Daylight	Daylight	**19:39**	**Serpens**

(times local time for Everett PST)

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.srrb.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

CONSTELLATION(S) OF THE MONTH: TAURUS

TAURUS: The Bull, as this late fall and winter constellation is also known, borders on the constellations of Aries, Auriga, Cetus, Eridanus, Gemini, Orion, and Perseus, and ranks 12th in overall brightness among the constellations, containing 98 stars brighter than magnitude 5.5. Associated asterisms involving Taurus include The Heavenly G, The Hyades, The Pleiades, The V, The Winter Octagon, and the Winter Oval. Its central point is located at RA=4h,39m and Dec.= +15.5 degrees. It is completely visible from latitudes North of –59 degrees, and portions of it are visible worldwide; this constellation ranks 17th in overall size, and takes up 797.25 square degrees (or 1.933% of the sky). Some of Taurus's most famous bright stars are Aldebaran, Merope, Alcyone, Electra, Pleione, Sterope, and Nath and El Nath. Taurus has three associated meteor showers: the Daytime Beta Taurids (29 June); the S. Taurids (3 November) and the N. Taurids (13 November); this wonderful constellation also contains two Messier objects: M1 (the Crab Nebula) and M-45 (the Pleiades). Aldebaran is one of the four Royal Stars of the ancient Persians. The star Beta Tauri was once shared by both the constellations of Auriga and Taurus; before the 20th century, star catalogs frequently listed this star as gamma Aurigae. Ever since the Belgian astronomer Delporte's standards for constellation boundaries were adopted, this star has been officially part of Taurus. M-45 (the Pleiades or "Seven Sisters") is the brightest open cluster in the sky. It is also one of the few members of Messier's list which does not possess a corresponding NGC number (probably because it is too bright); indeed, some cataloguers down through history had listed the Pleiades as a separate and distinct constellation. About one degree north of

Zeta Tauri lies M-1 (the Crab Nebula, which received its name from Lord Rosse in the mid-19th century when he noticed that its broad filaments resembled a crab's pincers. The Crab Nebula is a gaseous remnant of a supernova which first became visible in 1054, and is the brightest supernova remnant in the sky. It is within this beautiful constellation that the Italian astronomer Piazzi discovered the first asteroid, Ceres, on New Year's Day, 1801. Taurus has a midnight culmination date of November 30th (and a solar conjunction date of June 2): try to enjoy the beauty of this wonderful constellation, and its interesting neighbors, on the next clear fall or winter night.

PLANETARY FOCUS

"Planetary Focus" is a column that will be published occasionally in the EAS "Stargazer". If you have a favorite planet that you would like similar information and/or statistics on, please contact newsletter co-editor Bill O'Neil. This month's planetary focus is on: **Neptune.** Neptune reaches eastern quadrature (i.e. 90 degrees from the Sun) this month, and is viewable in southern skies as evening twilight wanes.

Rotation around the Sun: every 164.79 years

Orbit: from 29.76 (closest or 'perihelion') to 30.36 (furthest or 'aphelion') Astronomical Units (AU)*; this is an orbit that varies between approximately 2.77 billion and 2.82 billion miles from the sun. (*Note: One AU equals approximately 93 million miles).

Inclination of Orbit to Ecliptic: 1.8 degrees.

Mean Orbital Velocity: 5.43 km/sec.

Diameter at Equator: 50,538 kilometers (or 31,586 miles).

Mass: 17.2 (approximately 17.2 times more massive than earth); (5.9742 x (10 e24 (10 to the 24th power)) kilograms = 1 Earth Mass)**.**

Density: approximately 1.80 times that of water (global density).

Surface Gravity (Earth = 1): 1.19

Period of Rotation on its own axis: approximately 18 hours, 25 minutes.

Axis tilt: 29.56 degrees.

Satellites (moons): 8, as well as planetary rings.

Special Notes About Neptune: **Neptune** is the fourth largest planet in the solar system (one of the gas giants) in terms of equatorial diameter, but is more massive than Uranus, the third largest planet in diameter. Neptune is the most distant of the giant planets, and was discovered in 1846 by J.G. Galle at the Berlin Observatory, based on French (Urbain Leverrier) predictions resulting from disturbances in the orbit of Uranus (there were similar estimates made by Englishman John C. Adams). Neptune returns to opposition two days later every year, and appears as an indistinct magnitude 7.7 bluish-green object in binoculars; in fact, no markings can be seen on its bluish-green disk from earth-bound telescopes. Neptune's color arises primarily from methane within its atmosphere, which is principally helium and hydrogen and a blend of methane, water, and ammonia. In 1989, Voyager 2 sent back remarkable images of Neptune during its fly-by. The Great Dark Spot was noted in its atmosphere. Like Jupiter's Great Red Spot, it occupies a equivalent proportion of the surface area of Neptune (as the GRS does of Jupiter's surface area), and is a high-pressure system around which near-supersonic winds flow in an anti-clockwise circuit. The Great Dark Spot measures approximately 12,000 by 8,000 kilometers. At about 50-70 kilometers above the main cloud plane, there are whitish cirrus-like clouds composed of methane ice crystals. Neptune also has belts and zones similar to Jupiter's, only much fainter. The core of Neptune is believed to be rocky, composed primarily of silicon and iron. The atmosphere of Neptune revolves more slowly than its core, and this is opposite to the atmospheres of the other gas giants; the implication is that circulation of Neptune's atmosphere may take place in a retrograde (backward or opposite) manner. Neptune also gives off more energy than it receives from the Sun, suggesting that it has its own internal source of heat; the planet also has a magnetic field, which is somewhat weaker than that of the other gas giant planets. Four dark planetary rings were discovered during the Voyager 2 fly-by in 1989.

Neptune has 8 known moons; six of them were discovered during the 1989 Voyager 2 fly-by, and the remaining two (Triton and Nereid) were discovered from Earth. Triton is the largest moon of Neptune, and was discovered the same year (1846) as the planet itself; it is about ¾ the size of our own Earth's Moon. Interestingly, Triton has an orbit in the opposite direction to that of Neptune (retrograde), and is slowly coiling its way down towards Neptune. Triton is a very cold moon, and has a thin atmosphere of mostly nitrogen, with some methane and carbon monoxide. Its South Pole cap is pinkish in color (probably nitrogen snow and ice). Triton's face has been shown to have both craters and long cracks, but no mountains; its surface resembles that of a cantaloupe. It has also been noted to have geysers of nitrogen, some reaching 8 km in height! Nereid was discovered from Earth in 1949, and has a very eccentric orbit (going from 2 to 10 million kilometers from the planet at various times during its orbit).

YOUNG ASTRONOMER'S CORNER

The following are some questions frequently heard and asked by young astronomers, followed by an answer based on the best scientific information. Hope you learn something new!! If you have any questions about astronomy or astronomy-related space or atmospheric sciences, call or send us an e-mail, and we will do our best to answer it for you!!

★★ **Question: Do we really need the Sun? Answer**: YES!!! Not only do we need it, but we need it in every sense of the word: we would not even be here, and we could not live, without it!! The energy to grow food to eat, to grow trees for wood to build shelters to live in and paper pulp to read books, and the energy "trapped" in oil and coal to power our homes and cars, all came from or comes from the Sun. All plants need light to grow, and even those lighted artificially ultimately get their power for lighting from the Sun. Also, plants and sunlight convert carbon dioxide that we breathe out into a little something called oxygen that we need to survive!! The food chain depends on the Sun, as does the overall heating of the planet. No matter how you artificially heat your home, your office, or your car for example, without the Sun, the overall and average temperature of planet Earth would be about minus (-) 300 degrees F., a temperature at which life as we know it would be next to impossible. Also, the Earth would be a very dark place! The full moon is bright from reflected sunlight, but if there were no Sun, we would not have the light of the moon either (and again, the energy sources to power lights artificially would be virtually non-existent). Oh, and by the way, starlight as a light source would be useless because not only is it relatively dim, but there really would be no life on Earth in the first place to enjoy the starlight, study it as amateur astronomers, or to write poetry about it!!! By the way, intelligent life on Earth (who could have possibly developed alternative energy sources), would not have even developed (let alone survived) in the first place without the heat, light, and warmth of the Sun!! So next time you get up in the morning and see a beautiful sunrise or a

sunset in the evening, say a little silent "thank you" to our beautiful and powerful local star: the Sun!!!

★★ **Question:** Could we land a spacecraft on the planet Jupiter? **Answer:** No, because Jupiter has no true "surface" to land on. Additionally, any spacecraft able to make it that far would sink through thicker and thicker "clouds", until the clouds were so thick that the pressure created would crush the spacecraft. The deeper you go inside Jupiter, the greater the crushing pressures.

★★ **Question:** How long do stars live? **Answer:** When a star is born from a large cloud of gas and dust, its size determines how long it will live. In general, the smaller the star, the longer it will live. Smaller stars with very low mass make helium from hydrogen (also known as fusion) very slowly. These stars tend to be cooler and thus redder in appearance, and burn for trillions(!) of years before they use all of their hydrogen found in the core. Medium sized stars, like our Sun, burn faster however. Because they are larger, there is more pressure from gravity in their cores, which causes nuclear fusion reactions to happen more quickly: they use up their hydrogen fuel more quickly. Stars such as the size of our Sun live for a few billion years. The most massive stars are generally the hottest and most unstable; they 'die' from processes such as a collapse from their own weight to form supernovae, neutron stars, and/or pulsars for example; these largest stars die within 'only' a few million years. In general, when it comes to stars, the bigger you are, the shorter your life.

★★ **Question:** What is the "asteroid belt"? **Answer:** The 'asteroid belt' is an area located between the orbital paths of Mars and Jupiter, and in this area thousands of asteroids have been found. This area between the orbital paths of Mars and Jupiter is known as the 'main' asteroid belt. Some estimates show that there may be as many as 100,000 asteroids between the paths of both Mars and Jupiter as they travel around the Sun. Officially, only 3,000 of these heavenly bodies have been named, although nearly twice as many have been found in photographs. Where are the other estimated 95,000 asteroids (approximate number remaining in the 'main' belt from those already discovered)? Even though it is believed they are out there, they are too small to have been photographed thus far. Of all those discovered photographically, only about 230 of them are greater than 60 miles in diameter. The vast majority of the "missing" asteroids are LESS than a mile across!!

ASTRONOMY & TELESCOPE LINGO

ASTRONOMY LINGO: ***SCHWARZSCHILD BLACK HOLE:*** A black hole that possesses mass but has zero angular momentum and zero electric charge.

TELESCOPE LINGO: ***HUYGENS EYEPIECE:*** An eyepiece consisting of two planoconvex lenses arranged with their flat faces towards the eye and a field stop between them. The field lens has 2 or 3 times the focal length of the eye lens; their separation is half the sum of their focal lengths. This eyepiece has good eye relief and minimal chromatic aberration, but its large spherical aberration translates to inferior performance except with long-focus refractors.

ASTRONOMY FUN FACTS

** In November of 1980, the Voyager I spacecraft passed by Saturn's moon Titan at a distance of only 2,500 miles from the surface: this was the closest approach to any celestial body encountered by either of the two Voyager spacecraft. At that particular time, the spacecraft was travelling at a speed of about 43,000 miles per hour and was more than 946 million miles from Earth. This solar system target accuracy is comparable to shooting an arrow at an apple ***6 miles*** away and having the arrow pass by the apple at a carefully calculated distance of ***1 inch***!!!

★★ The remaining moons of Saturn are much smaller than massive Titan, but the densities of ***all*** of Saturn's moons are all very low. The best determined density is that of Titan, and it is only 1.32 times that of water. Because of these low densities, these moons of Saturn are mostly ice. Indeed, with diameters of its moons in the range of over 3,000 miles (Titan) to the smaller moons like Mimas and Hyperion (in the range of 50-325 mile diameters), these are probably the largest "snowballs" that we Earthlings will ever see!

★★ Voyager 1 and 2 together took more than 70,000 television pictures of Jupiter, Saturn, and their moons and surrounding environments. If all of these groundbreaking photographs were developed in a standard 8x10 format and mounted side by side to form a rectangular montage, the total area formed by the montage would be about 97.5 square miles, approximately equal to twice the area of Boston, Massachusetts!

★★ The longest winter (when the Sun is far south of the celestial equator) in the solar system is 21 Earth years long and is found on the south polar regions of the planet Uranus. The deep winter temperatures in this area of Uranus are estimated to be -362 degrees F. (-219 degrees C.). Any future astronauts exploring the liquid hydrogen "surface" of Uranus (if indeed that ***ever*** were to occur) would need much, much more than thermal undergarments to keep them warm!!

"MIRROR IMAGES"

"MIRROR" IMAGES" : Because we live in the Northern Hemisphere, we often tend to focus (in both observing and reading) on celestial objects in this hemisphere. The point of this column is to inform club members about similar objects in the Southern Hemisphere (to the ones we are already familiar with in the Northern Hemisphere). The general class of object will first be defined, and then a representative object from each hemisphere will be described. ***Note: "MIRROR" IMAGES" is strictly the name of the new column, and is not intended to imply that there is optical mirror symmetry between the two objects.***

CLASS OF OBJECT: PULSARS: A celestial body which emits short duration (periods range from about 1.56 milliseconds to 4 seconds) radiation pulses at very regular intervals (from a fraction of a second to about 10 seconds). Pulsars with very short duration periods (less than 0.01 seconds) are among the class noted as millisecond pulsars. Most pulsars are single, but binary pulsars are also known. They are thought to be rotating neutron stars, extremely dense stars which are generated from high mass stellar explosions such as supernovae; however, some pulsars may also be generated by other processes, such as the accretion of gas onto a white dwarf. Pulsars were originally discovered at radio wavelengths; a few others have been discovered at optical, gamma-ray, and X-ray wavelengths. These gamma-ray and X-ray pulsars will not be discussed in detail here. The first radio pulsar, PSR 1919+21, was detected by Antony Hewish and Jocelyn Bell during a study of atmospheric scintillation. More than 500 radio pulsars are now known; the Milky Way galaxy is thought to have about 100,000 of them. The received pulses occur when a beam of radio waves, emitted by a rotating neutron star, sweeps past Earth; this beam of radiation arises from electrons moving within the neutron star's strong magnetic field (the direction of which differs from that of the pulsar's rotational axis). The actual emission site of the beam (e.g., the magnetic poles; near the star, or further out) is still in some dispute. The period of all radio

pulsars is gradually lengthening as the parent neutron star loses rotational energy. The central star of the Crab Nebula, the youngest known pulsar, is slowing at a rate of one part in a million per day. A steady slow down rate can also be interrupted or changed by rearrangements of the crust or core of the parent neutron star. The Crab and Vela pulsars' slow down rate are thought to be interrupted in this way; these two pulsars are optical radio pulsars.

REPRESENTATIVE NORTHERN HEMISPHERE OBJECT: *CRAB NEBULA (M-1; NGC 1952)* The star whose explosion produced the Crab nebula is an optical pulsar (Crab pulsar NP-0532; discovered in 1967). Its pulsations are also observed at radio, infrared, X-ray, and gamma-ray wavelengths; these pulsations have a period of only 0.0331 seconds. The energy loss by the highly energetic electrons mentioned above equals the total energy lost by the Crab nebula; ultraviolet aspects of this radiation ionizes the gas in the filaments, causing the atoms to fluoresce. It is associated with a supernova remnant; in fact, the Crab nebula is the prototype member of the class of filled supernova remnants, known as plerions.

REPRESENTATIVE SOUTHERN HEMISPHERE OBJECT: *VELA PULSAR:* The second optical pulsar discovered (1977). With a brightness of only 26 magnitudes, it is much fainter than the Crab pulsar, although it is 4 times nearer (about 500 parsecs). It is known to emit pulses of radio emission in a period of every 0.089 seconds, and gamma ray pulses twice every revolution (at gamma-ray wavelengths, it is the brightest object in the sky). The Vela pulsar is a young pulsar (about 10,000 years old). The associated supernova remnant (Vela-X) has been observed at X-ray, XUV, optical, and radio wavelengths.

ASTRONOMICAL NOTES -- ON & OFF THE NET...

AN UNUSUAL AURORAL LIGHT SHOW

Millions of people around the world were treated to a brilliant display of aurora lights this week. The Sun produced at least five major "halo" coronal mass ejections (CMEs) over the period of Nov. 4-8, an unusually fast pace for solar activity. A "halo" CME occurs when a CME produces an expanding circle of particles all around the Sun. When observers see this they know the CME is heading directly towards or away from Earth. In this case, all were headed in our direction, bringing the auroral light show with them. The source of storms was a group of sunspots called Active Region 696. The area also produced powerful solar explosions called flares. The most significant solar storm occurred late on Nov. 5th (UT). The aurora, also known as the Northern and Southern Lights, form when solar particles and magnetic fields pump energy into the Earth's magnetic field, accelerating electrically charged particles trapped within. The high-speed particles crash into Earth's upper atmosphere (ionosphere) over the polar regions, causing the atmosphere to emit a ghostly, multicolored glow. This kind of solar activity is getting increasingly rare as we enter into the quiet period of the Sun's eleven-year cycle of activity. The years 2000-2001 marked the highest point of activity, but that doesn't preclude the occasional surprise like this week's CMEs. Even more significant were the intense solar storms that raged about a year ago.

TITAN STILL OFFERS ALL POSSIBILITIES FOR HUYGENS PROBE LANDING

The prospect of the Huygens probe landing on a hard, soft or liquid surface when it lands on Titan next January still remain following further analysis of data taken during the Cassini mother ship's closest encounter with Saturn's largest moon during its fly-by on 26th October. Commenting on the latest data results and implications for the Huygens probe Mark Leese, Program Manager for Science Surface Package [SSP] instruments that will unravel the mysteries of Titan said: "*It's interesting that all of the possible landing scenarios that we envisaged -- a hard crunch onto ice, a softer squelch into solid organics or a splash-down on a liquid hydrocarbon lake -- still seem to exist on Titan*." Leese added, "*A first look at the measurements of Titan's atmosphere during the fly-by suggest that the "Atmosphere Model" developed and used to design the Huygens probe is valid and all looks good for the probe release on Christmas day and descent to the surface on 14th January 2005*." Further analysis of Titan's upper atmosphere, the thermosphere, has revealed a strange brew as Dr Ingo Mueller-Wodarg explained, "*The Ion Neutral Mass Spectrometer (INMS), made in-situ measurements of atmospheric gases in Titan's upper atmosphere and found a potent cocktail of nitrogen and methane, stirred up with signatures of hydrogen and other hydrocarbons. We are now working on a 'Weather Report' for the Huygens landing in January*". Commenting on the surface characteristics of Titan, Dr. John Zarnecki, lead scientist for the Huygens SSP said: "*The recent results from the fly-by have started to show us a very diverse and complicated surface. Titan is geologically active but hasn't yet given up all of its secrets. Combining the visible images with infrared and RADAR data from this and future fly-bys should help to clarify the picture -- but the arrival of the Huygens probe in January will perhaps be the key to unlock these mysteries*." Dr. Carl Murray, of the Imaging Science System [ISS] team also commented on the surface features: "*The images of the Huygens' landing site returned by the cameras show a diverse range of features. We see bright and dark areas roughly aligned in an east-west direction. These are similar to wind streaks seen on Mars and may indicate that material on Titan has been deposited by the effects of wind blowing across the landscape. All indications suggest that we are in for a real treat in January when the Huygens probe reaches Titan's surface and returns the first in situ data from this alien world*." The data has provided a wealth of information about Saturn's largest moon, which will not only assist the Huygens team in advance of the probe landing on Titan in January 2005 but will also increase our understanding of the relationship between Titan and its parent planet Saturn.

Dr. Michele Dougherty is lead scientist on the Cassini Magnetometer, which is studying the interaction between the plasma in Saturn's magnetosphere and the atmosphere and ionosphere of Titan. "*We have been able to model the Magnetometer data very well from the Titan flyby. There does not seem to be an internal magnetic field at Titan from the observations we obtained during this flyby, but we will have a much better idea about this when we have a further flyby in December which is on a very similar trajectory. All we can say at this point is that if there is a magnetic field generated in the interior of Titan, then it is very small*." Dr Andrew Coates, a Co-Investigator on the Cassini Electron Spectrometer team, said: "W*e received some remarkable new information about Titan's plasma environment within the context of Saturn's fascinating magnetosphere. Unexpectedly, it looks like we can directly use features of the electron results to understand what Titan's upper atmosphere is made of, supplementing the ion measurements from companion sensors on other instruments. Our electron results contain tell-tale fingerprints of photoelectrons and Auger electrons which we will use for this. Also, the total picture shows how important electrons, raining down on Titan's upper*

atmosphere, are in helping the feeble sunlight drive the complex chemistry in Titan's upper atmosphere."

http://www.pparc.ac.uk/Nw/landing-dry.jpg
http://www.pparc.ac.uk/Nw/landing-goo.jpg
http://www.pparc.ac.uk/Nw/landing-wet.jpg

POSSIBLE ORIGIN OF COSMIC RAYS REVEALED WITH GAMMA RAYS

A team of astronomers has produced the first ever image of an astronomical object using high energy gamma rays, helping to solve a 100 year old mystery -- the origin of cosmic rays. Their research was carried out using the High Energy Stereoscopic System (H.E.S.S.), an array of four telescopes, in Namibia, South-West Africa. The astronomers studied the remnant of a supernova that exploded some 1,000 years ago, leaving behind an expanding shell of debris which, seen from the Earth, is twice the diameter of the Moon. The resulting image helps to solve a mystery that has been puzzling scientists for almost 100 years -- the origin of cosmic rays. Cosmic rays are extremely energetic particles that continually bombard the Earth, thousands of them passing through our bodies every day. The production of gamma rays in this supernova shock wave tells us that it is acting like a giant particle accelerator in space, and thus a likely source of the cosmic rays in our galaxy.

Dr Paula Chadwick said, "*This picture really is a big step forward for gamma-ray astronomy and the supernova remnant is a fascinating object. If you had gamma-ray eyes and were in the Southern Hemisphere, you could see a large, brightly glowing ring in the sky every night*." Dr. Ian Halliday said, "*These results provide the first unequivocal proof that supernovae are capable of producing large quantities of galactic cosmic rays -- something we have long suspected, but never been able to confirm*." Gamma rays are the most penetrating form of radiation we know, around a billion times more energetic than the X-rays produced by a hospital X-ray machine. This makes it very difficult to use them to create an image -- they just pass straight through any surface which we might use to reflect them, for instance. However, luckily for life on Earth, gamma rays from objects in outer space are stopped by the atmosphere; when this happens, a faint flash of blue light is produced, lasting for a few billionths of a second. The astronomers used images of these flashes of light, called Cherenkov radiation, to make a gamma ray 'image' for the first time.

CASSINI RADAR SEES BRIGHT FLOW-LIKE FEATURE ACROSS TITAN SURFACE

A strikingly bright, 'lobate' feature has turned up in one of Cassini's first radar images of Saturn's moon Titan. "*It may be something that flowed*," Cassini radar team member Ralph Lorenz said. "*Or it could be something carved by erosion. It's too early to say." "But it looks very much like it's something that oozed across the surface. It may be some sort of 'cryo-volcanic' flow, an analog to volcanism on Earth that is not molten rock but, at Titan's very cold temperatures, molten ice*." http://saturn.jpl.nasa.gov and http://www.nasa.gov/cassini .

Cassini radar mapped about one percent of Titan's surface during the Cassini spacecraft's first close Titan flyby Oct. 26. The radar survey covered a strip 75 miles wide (120 kilometers) and 1,200 miles (1,960 kilometers) long in Titan's northern hemisphere. Cassini was flying about 1,550 miles (2,494 kilometers) above Titan's surface, with its radar centered at about 45 degrees north, 30 degrees west, when it mapped the 90-square-mile (230-square-kilometer) area shown in the new radar image.

The radar instrument works by bouncing radio signals off Titan's surface and timing their return. The more signal reflected back to the spacecraft, the brighter the imaged area. Turning radio signals into radar images is time consuming because so many numerical calculations must be made. "*There's no such thing as a 'raw' radar image,"* Lorenz said. But two days after the Oct. 26 flyby, Cassini scientists knew that Titan is no impact-crater-pocked dead world, but a much more interesting place. Titan's surface is young -- it's been shaped by dynamic geologic processing, Lorenz, Cassini interdisciplinary scientist Jonathan Lunine, and other Cassini scientists agree. Given this newest image, Lunine said, "*Radar has provided the first evidence for possible young cryovolcanism on Titan's surface. Now our challenge is to find out what is flowing, how it works, and the implications for Titan's evolution*."

SPITZER SEES ICE AND WARM GLOWS IN DARK AND DUSTY PLACES

Two new results from the Spitzer Space Telescope are helping astronomers better understand how stars form out of thick clouds of gas and dust, and how the molecules in those clouds ultimately become planets. Two discoveries -- the detection of an oddly dim object inside what was thought to be an empty cloud, and the discovery of icy planetary building blocks in a system believed to resemble our own solar system in its infancy -- were presented today at the first Spitzer science conference in Pasadena, Calif. Since Spitzer science observations began less than one year ago, the infrared capabilities of the space observatory have unveiled hundreds of space objects too dim, cool or distant to be seen with other telescopes. In one discovery, astronomers have detected a faint, star-like object in the least expected of places -- a "starless core." Named for their apparent lack of stars, starless cores are dense knots of gas and dust that should eventually form individual newborn stars. Using Spitzer's infrared eyes, a team of astronomers led by Dr. Neal Evans probed dozens of these dusty cores to gain insight into conditions that are needed for stars to form.

Starless cores are fascinating to study because they tell us what conditions exist in the instants before a star forms. Understanding this environment is key to improving our theories of star formation, said Evans. But when they looked into one core, called L1014, they found a surprise -- a warm glow coming from a star-like object. The object defies all models of star formation; it is fainter than would be expected for a young star. Astronomers theorize that the mystery object is one of three possibilities: the youngest "failed star," or brown dwarf ever detected; a newborn star caught in a very early stage of development; or something else entirely. This object might represent a different way of forming stars or brown dwarfs. Objects like this are so dim that previous studies would have missed them. It might be like a stealth version of star formation, Evans said. The new object is located 600 light-years away in the constellation Cygnus.

In another discovery, Spitzer's infrared eyes have peered into the place where planets are born -- the center of a dusty disc surrounding an infant star -- and spied the icy ingredients of planets and comets. This is the first definitive detection of ices in planet-forming discs. This disc resembles closely how we imagine our own solar system looked when it was only a few hundred thousand years old. It has the right size, and the central star is small and probably stable enough to support a water-rich planetary system for billions of years into the future, said Dr. Klaus Pontoppidan, who led the team that made this discovery.

Previously, astronomers had seen ices, or ice-coated dust particles, in the large cocoons of gas and dust that envelop young

stars. But they were not able to distinguish these ices from those in the inner planet-forming portion of a star's disc. Using Spitzer's ultra- sensitive infrared vision and a clever trick, Pontoppidan and his colleagues were able to overcome this challenge. Their trick was to view a young star and its dusty disc at "dawn." Discs can be viewed from a variety of angles, ranging from the side or edge-on, where the discs appear as dark bars, to face-on, where the discs become washed out by the light of the central star. They found that if they observed a disc at a 20-degree angle, at a position where the star peeks out like our Sun at dawn, they could see the ices. "*We hit the sweet spot*," said Pontoppidan. "*Our models predicted that the search for ices in discs is a problem of finding an object with just the right viewing angle, and Spitzer confirmed that model*." In this system, astronomers found ammonium ions as well as components of water and carbon dioxide ice.

GOOD NEWS FOR PLUTO – KBOS MAY BE SMALLER THAN THOUGHT

Pluto's status as our solar system's ninth planet may be safe if a recently discovered Kuiper Belt Object is a typical "KBO" and not just an oddball. Astronomers have new evidence that KBOs are smaller than previously thought. KBOs - icy cousins to asteroids and the source of some comets - are the leftover building blocks of the outer planets. Astronomers using the world's most powerful telescopes have discovered about 1,000 of these objects orbiting beyond Neptune since discovering the first one in 1992. These discoveries fueled debate on whether Pluto is a planet or a large (1,400-mile diameter) closer-in KBO.

Researchers estimate that the total mass of the Kuiper Belt is about a tenth of Earth's mass. Most theorize that there are more than 10,000 KBOs with diameters greater than 100 kilometers (62 miles), compared to 200 asteroids known to be that large in the main asteroid belt between Mars and Jupiter. "*People were finding all these KBOs that were huge - literally half the size of Pluto or larger*," astronomer John Stansberry said. "*But those supposed sizes were based on assumptions that KBOs have very low albedos, similar to comets*."

CASSINI SPACECRAFT IMAGES OBJECTS, DENSITY WAVES IN SATURN'S RINGS USING ULTRA-VIOLET INSTRUMENT

An instrument riding on the Cassini-Huygens spacecraft is being used to distinguish objects in Saturn's rings smaller than a football field, making them twice as sharp as any previous ring observations. Joshua Colwell said the observations were made with the Ultraviolet Imaging Spectrograph, or UVIS, when Cassini was about 4.2 million miles, or 6.75 million kilometers, from Saturn in July. Saturn orbits the Sun roughly 1 billion miles from Earth.

Colwell and his colleagues used a technique known as stellar occultation to image the ring particles, pointing the instrument through the rings toward a star, Xi Ceti. The fluctuations of starlight passing through the rings provide information on the structure and dynamics of the particles within them, said Colwell, a UVIS science team member.

He likened the Saturn system to a mammoth phonograph record, with the planet in the middle and the rings stretching outward more than 40,000 miles, or 64,000 kilometers. The size of the ring particles varies from dust specks to mountains, with most ranging between marbles and boulders, he said.

The Cassini observations show dramatic variations in the number of ring particles over very short distances, Colwell said. The particles in individual ringlets are bunched closely together, with the amount of material dropping abruptly at the ringlet edge. "*What we see with the new observations is that some of the ring edges are very sharp*," said Colwell. The sharp edges of small ringlets are especially evident in the C ring and in the so-called Cassini Division on either side of the bright B ring, Saturn's largest ring. The Cassini observations with UVIS show that the distance between the presence and absence of orbiting material at some ring edges can be as little as 160 feet, or 50 meters, about the length of a typical commercial jetliner, he said. The sharp edges illustrate the dynamics that constrain the ring processes against their natural tendency to spread into nearby, empty space, said Colwell. "*Nature abhors a vacuum, so it is likely gravity from a nearby small moon and ongoing meteoroid collisions confine the particles in the ring*."

The team also detected a density wave -- a ripple-like feature in the rings -- in the so-called Cassini Division. The Cassini Division is the gap between the bright A and B rings of Saturn that are visible from Earth using backyard telescopes, he said. "*Analysis of such waves determines the size, mass and velocity of the ring particles*," said Esposito. The stellar occultation process using UVIS also shows very high-resolution views of several density waves visible in the rings, including a previously unstudied one, he said. Density waves are caused by the influence of Saturn's moons -- in this case, the small moon, Janus. "*Small moons near Saturn's rings stir the ring particles with their gravitational pull*," Colwell said. At certain locations in the rings, known as resonances, the orbit of a particular moon matches up with the orbit of certain ring particles in a way that enhances the stirring process, he said. The density waves, which resemble a tightly wound spiral much like the groove in a phonograph record, slowly propagate away from the resonance toward the perturbing moon, he said. "*This can create a wave in the ring that looks like a ripple in a pond*," said Colwell. "*The shapes of these wave peaks and troughs help scientists understand whether the ring particles are hard and bouncy, like a golf ball, or soft and less bouncy, like a snowball*," Colwell said. He noted that a density wave analysis by scientists involved in NASA's Voyager 2 mission that visited Saturn in 1981 were used to determine the mass and thickness of the planet's rings.

Larry Esposito the principal investigator for the UVIS instrument said UVIS is revealing a dynamic dance in the Saturn system. "*Instead of a quiet panorama, UVIS sees rapidly changing phenomena, including interactions between the rings, moons, radiation belt, solar wind and the planet Saturn*," he said. "At the time Cassini went into orbit around Saturn, UVIS produced the highest detail images of Saturn's rings ever made in UV light," he said. "*These images show the amount of water-ice varies in the ring particles' surfaces*." The variation is caused by the contamination of the rings with meteoric dust, and by the subsequent transfer of material between the ring particles from collisions and meteoroid bombardment, Esposito said. "*The fluctuations we see can be explained by the recent destruction of small moons within the rings and by wave action in the rings that dredges fresh material onto the surfaces of the ring particles*," Esposito said. "*This indicates that the material in the rings is continually recycled from rings to moons and back*."

The instrument has detected oxygen atoms in an immense cloud surrounding Saturn, the result of moonlets in the ring system colliding, shattering and releasing ice particles. The ice grains are bathed by Saturn's radiation belt, liberating the oxygen atoms that reflect sunlight and which makes them visible to the ultraviolet spectrometer, said Esposito.

A UVIS analysis of Phoebe - a tiny, dark moon about 1-15th the diameter of Earth's moon -- confirms the suspicions of many space scientists that it was born elsewhere, most likely in the Kuiper Belt. The Kuiper Belt is a region beyond Neptune believed to be populated by thousands of small, icy moons created during the formation of the solar system more than four billion years ago. "*UVIS sees the absorption signature of water ice on its surface, showing Phoebe was born in the outer solar system*," Esposito said. Exhibiting an unusual retrograde, or backward, orbit, Phoebe likely was lassoed by Saturn's powerful gravitational field during the planet's formative years, he said.

The UVIS research team also has noted significant brightening of the auroras at Saturn's poles as the solar wind periodically ramps up to speeds of 250 miles, or 400 kilometers, per second, Esposito said. "*Dense puffs of the charged particles from the sun excite the hydrogen molecules in Saturn's upper atmosphere to glow more brightly*."

The UVIS instrument also is showing a bright glow in the upper atmosphere of Titan, the most intriguing of Saturn's 33 known moons, which will be targeted by the Cassini-Huygens probe slated for release by the spacecraft on Christmas Eve. "*Observations of Titan show the glow of nitrogen atoms, molecules and ions energized by electrons striking the upper atmosphere*," he said. During the spacecraft's four-year tour of the Saturn system, the UVIS team will continue to track the dynamic interactions of the planet's rings, moons and radiation belts, Esposito said.

KECK PICTURES OF URANUS SHOW BEST VIEW FROM THE GROUND

Observations of Uranus conducted at the W. M. Keck Observatory in Hawaii are surprising astronomers with the level of detail they can see from the ground. Two separate teams of astronomers, one from Berkeley and one from Wisconsin, used advances in Keck adaptive optics (AO) to help make major scientific discoveries regarding the planet's atmosphere and ring system. The results are a powerful example of how ground-based telescopes are helping astronomers study planets in the outer solar system that once could only be studied from space.

"*We are stunned by the quality and detail of these images*," said Dr. Frederic Chaffee, director of the Keck Observatory. "*These are the best pictures of Uranus that have ever been produced by a telescope, and they are opening new windows of understanding for this unique and special world*." The most recent observations of Uranus show the planet as it approaches its southern autumnal equinox, which takes place in 2007 (the length of the year on Uranus is 84 Earth years). The two teams used narrow filters at infrared wavelengths to study features in the atmosphere and ring sets, both of which are enormously enhanced by the Keck adaptive optics system. Ground-based telescopes are helping astronomers track climatic changes in the planet's atmosphere.

"*People may think that Uranus is relatively inactive, but these images show that Uranus is definitely changing, and perhaps quite dramatically*," said Imke de Pater, lead investigator for the team responsible for the observations. "*What is causing it, no one knows for sure. Only time will tell*."

The new images are the result of many general improvements to the Keck adaptive optics system. A new calibration technique removes artifacts previously present in the images when measuring the atmospheric distortion with a planet instead of a point source of light. Another major improvement is a new wavefront reconstructor to improve the data processing within the AO system. This dramatically reduces the effect that "noise" or errors in measuring the atmospheric distortion have on the image quality.

A dramatic visualization of the power of adaptive optics (Figure 1) was made by Dr. Heidi Hammel of the Space Science Institute in and Dr. Imke de Pater. They took images of Uranus and its rings with the second-generation Near Infrared Camera (NIRC2) behind the AO system on the Keck II telescope, first with the AO system off, and then with the AO system on. In this figure, the ring system is more readily visible through the 2.2-micron filter because methane absorption at this wavelength renders the planet extremely dark except for a few high altitude clouds. In contrast, the 1.6-micron image shows deeper atmospheric cloud structure, including many discrete features peppering the planet's northern hemisphere. At 1.6 microns, the rings are just barely visible as a faint streak across the planet's northern hemisphere. "*The differences are stunning*," said Hammel. "*The detail provided by Keck's AO system for the atmosphere and the rings of Uranus fundamentally changes the science we can achieve*."

Later observations, also with the Keck II AO system, were formed into a composite image in which the highest clouds appear white, the middle level clouds appear bright green, and the lower clouds appear darker blue. The color balance used to reveal the cloud structure in these infrared exposures, which are not normally visible to human eyes, makes the ring system appear red in these images and is an artifact of the process. The higher clouds are most abundant in the planet's northern hemisphere.

Dr. Lawrence Sromovsky, principal investigator for the Wisconsin observations said, "*Twenty years ago we simply couldn't see the types of details in the outer solar system the way we can today with large, ground-based telescopes like Keck. These images actually reveal many more cloud features than the Voyager spacecraft found after traveling all the way to Uranus*." Until recently, little was known about the oddball planet, which gets its name from the Greek word "Ouranos," a mythological god who personifies the heavens. Uranus lies tipped on its side, probably the result of an ancient cosmic collision, and its magnetic field lays strangely off-set from and tilted with respect to the planet's rotational pole. In 1986, the Voyager 2 spacecraft sent pictures to earth of what appeared to be a non-descript ball suspended in space. At that time, Uranus' South Pole was pointed almost directly at the sun, and the North Pole pointed away. Now, more than 18 years later, the planet is drawing near the point in its orbit where the planet's equator will be pointing toward the Sun, and both poles will get about 17 hours of sunlight a day. On Earth, the massive storms captured in the new pictures of Uranus would engulf nations as large as the continental United States, about 3 million square miles. But at a distance of more than 1.6 billion miles, even such large storms are barely detectable and require the use of the world's most powerful telescopes.

MEASURING COSMIC DISTANCES WITH STELLAR HEART BEATS - VLTI WATCHES THE CHANGING SIZE OF BRIGHT CEPHEIDS

Taking advantage of the very high spatial resolution provided by the VLT infra-red interferometer, a team of astronomers has measured directly the change in angular diameter of four southern Cepheid variable stars over their pulsation cycle. When combined with spectroscopic radial velocity measurements, this allowed the astronomers to measure very accurately the distances of these stars in a geometrical way, and to calibrate the zero-point of the Cepheid Period-Luminosity empirical law. This is a fundamental step towards independent verification of the extragalactic distance scale by interferometry. Cepheids and the cosmic distance ladder. It is very difficult to measure the distance to an astronomical object. In fact, this is one of the greatest

challenges facing astronomers. There is indeed no accurate, direct way to determine the distance to galaxies beyond the Milky Way: astronomers first determine the distance to nearby stars in our galaxy as accurately as possible and then use a series of other techniques that reach progressively further into space to estimate distances to more distant systems. This process is often referred as the "cosmic distance ladder". Over the years, a number of different distance estimators have been found. One of these is a particular class of stars known as Cepheid variables. They are used as one of the first "steps" on this cosmic distance ladder.

Cepheids are rare and very luminous stars whose luminosity varies in a very regular way. They are named after the star Delta Cephei in the constellation of Cepheus, the first known variable star of this particular type and bright enough to be easily seen with the unaided eye. In 1912, American astronomer Henrietta Leavitt observed 20 variable stars of the Cepheid-type in the Small Magellanic Cloud (SMC), one of the closest galaxies to the Milky Way. For all purposes, these stars are all at the same distance (the size of the SMC is negligible compared to its much larger distance from us). Apparently brighter stars in this group are thus also intrinsically brighter (more luminous). Henrietta Leavitt discovered a basic relation between the intrinsic brightness and the pulsation period of Cepheid variable stars in the SMC and showed that intrinsically brighter Cepheids have longer periods. This relation is now known as the "Period-Luminosity relation" and is an important way to derive the distance to stars of this type. By measuring the period of a Cepheid star, its intrinsic brightness can be deduced and from the observed apparent brightness, the distance may then be calculated. In this way, Cepheid stars are used by astronomers as one of the "standard candles" in the Universe. They act either as distance indicators themselves or are used to calibrate other distance indicators. The Cepheid stars have taken on an even more important role since the Hubble Space Telescope Key Project on the extragalactic distance scale relies completely on them for the calibration of distance indicators to reach cosmologically large distances. In other words, if the calibration of the Cepheid Period-Luminosity relation were wrong, the entire extragalactic distance scale and with it, the rate of cosmic expansion and the related acceleration, as well as the estimated age of the Universe, would also be off. A main problem is thus to calibrate as accurately as possible the Period-Luminosity relation for nearby Cepheids. This requires measuring their distances with the utmost precision, a truly daunting task. And this is where interferometry now enters the picture. Independent determinations of the distance of variable stars make use of the so-called Baade-Wesselink method, named after astronomers Walter Baade (1893 - 1960) and Adriaan Wesselink (1909 - 1995). With this classical method, the variation of the angular diameter of a Cepheid variable star is inferred from the measured changes in brightness (by means of model atmosphere calculations) as it pulsates. Spectroscopy is then used to measure the corresponding radial velocity variations, hence providing the linear distance over which the star's outer layers have moved. By dividing the angular and linear measures, the distance to the star is obtained.

This sounds straightforward. However, it would obviously be much better to measure the variation of the radius directly, and not to rely on model atmosphere calculations. But here the main problem is that, despite their apparent brightness, all Cepheids are situated at large distances. Indeed, the closest Cepheid star (excluding the peculiar star Polaris), Delta Cephei, is more than 800 light-years away. Even the largest Cepheids in the sky subtend an angle of only 0.003 arcsec. To observe this is similar to view a two-storey house on the Moon. And what astronomers want to do is to measure the change of the stars' sizes, amounting to only a fraction of this! Such an observing feat is only possible with long-baseline interferometry. Also on this front, the VLT Interferometer is now opening a new field of observational astrophysics.

Some time ago, a team of astronomers started a major research program aimed at measuring the distance to several Cepheids by means of the above outlined Baade-Wesselink interferometric method. For these observations they combined sets of two near-infra-red ‘beams’ -- one set from the two VLTI Test Siderostats with 0.3m aperture and the other set from two Unit Telescopes (Antu and Melipal; 8.2m mirrors) -- with the VINCI (VLT Interferometer Commissioning Instrument) facility. Three VLTI baselines were used for this program with, respectively, 66, 140 and 102.5m ground length. A total of 69 individual angular diameter measurements were obtained with the VLTI, over more than 100 hours of total telescope time, distributed over 68 nights; the largest angular diameter measured was 0.0032 arcsec (L Car at maximum).

Seven Cepheids observable from Paranal were selected for this program: X and W Sagittarii, Eta Aquilae, Beta Doradus, Zeta Gemini, Y Ophiocus and L Carinae. Their periods range from 7 to 35.5 days, a fairly wide interval and an important advantage to properly calibrate the Period- Luminosity relation. The distances to four of the stars (Eta Aql, W Sgr, Beta Dor and L Car) were derived using the interferometric Baade- Wesselink method, as their pulsation is detected by the VLTI. The data shows the angular diameter measurements and the fitted radius curve of L Car (P = 35.5 days); this measures its distance with a relative precision better than 5%. For the remaining three objects of the sample (X Sgr, Zeta Gem and Y Oph), a hybrid method was applied to derive their distances, based on their average angular diameter and pre-existing estimations of their linear diameters.

Combining the distances measured with the apparent magnitudes of the stars, the astronomers determined the absolute magnitude (intrinsic brightness) of these stars and arrived at a very precise calibration of the zero-point of the Period-Luminosity relation (assuming the slope from previous work). It turned out that this new and independently derived value of the zero-point is exactly the same as the one obtained during previous work based on a large number of relatively low-precision Cepheid distance measurements by the ESA Hipparcos astrometric satellite. The agreement between these two independent, geometrical calibrations is remarkable and greatly increases the confidence in the cosmic distance scale now in use.

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 November's Stargazer:

The next EAS Meeting is 7:00 P.M. Saturday, November 20th at the Providence Pacific Clinic – 916 Pacific Avenue in Everett.