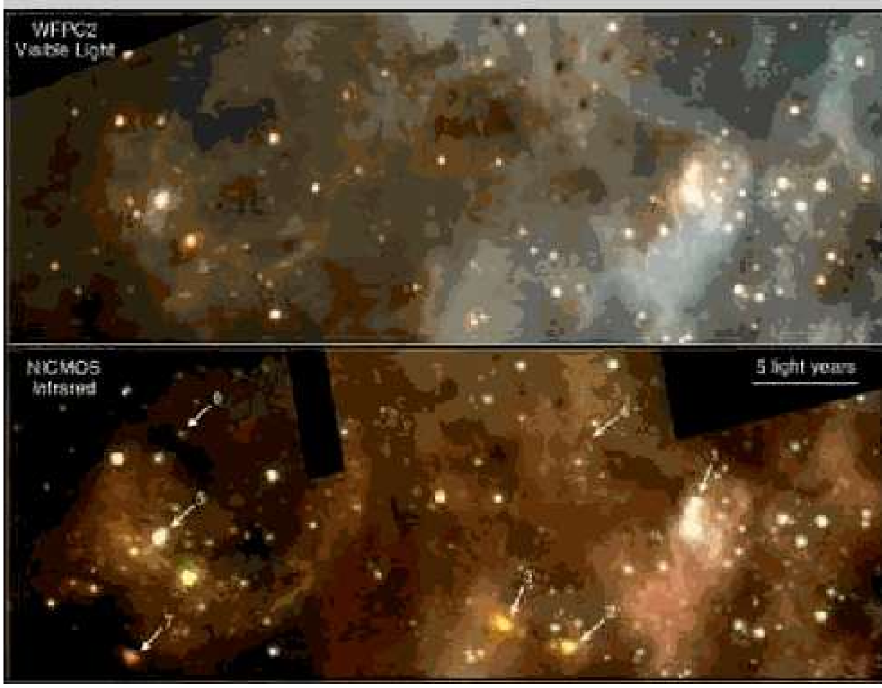
REFLECTIONS REFRACTIONS

of the University Lowbrow Astronomers

October 1999

The University Lowbrow Astronomers is a club of Astronomy enthusiasts which meets on the third Friday of each month in the University of Michigan's Physics and Astronomy building (Dennison Hall, Room 807). Meetings begin at 7:30 pm and are open to the public. Public star parties are held twice a month at the University's Peach Mountain Observatory on North Territorial Road (1.1 miles west of Dexter-Pinkney Road; further directions at the end of the newsletter) on Saturdays before and after the new Moon. The party is canceled if it's cloudy or very cold at sunset. For further information call (313)480-4514.



New Stars In 30 Doradus
Credit: John Trauger (JPL), James Westphal (Caltech), Nolan Walborn (STScI), Rodolfo Barba' (La Plata Observatory), NASA

Explanation: Compare these matched Hubble Space Telescope views (visible-light on top; infrared on bottom) of a region in the star-forming 30 Doradus Nebula. Find the numbered arrows in the infrared image which identify newborn massive stars. For example, arrows 1 and 5 both point to compact clusters of bright young stars. Formed within collapsing gas and dust clouds, the winds and radiation from these hot stars have cleared away the remaining obscuring material making the clusters easily apparent in both visible and infrared images. But still shrouded in dust and readily seen only in the penetrating infrared view are newborn stars and star systems indicated by arrows 2, 3, and 4. Perhaps even more remarkable are the infrared bright spots indicated by arrows 6 and 7. Exactly in a line on opposite sides of the bright cluster at arrow 5, they may actually be caused by symmetric jets of material produced by one of the young cluster stars. These luminous spots are each about 5 light-years from the cluster and would correspond to points at which the energetic jet material impacts the surrounding dust clouds. Astronomy Picture of the Day – http://antwrp.gsfc.nasa.gov/apod/ap991001.html

This Month:

October 9 - Public Star Party at Peach Mountain Observatory – New Moon today at 7:34 am EDT.

October 15 - Meeting at 807 Dennison – Mark Deprest presents "Deep-Sky Delights of the King of Constellations" - A Star Hop thru Cepheus

October 16 – A Night on Peach Mtn/Moonwalk is tonight. Come out and enjoy the Moon – something we don't do enough. See article in last month's REFLECTIONS or our web site for further details.

Next Month:

November 6 - Public Star Party at Peach Mountain Observatory – Jupiter and Saturn are at prime viewing.

Nov 13 - Public Star Party at Peach Mountain Observatory – The Moon is six days old.

Nov 17 – Leonids Meteor Storm– Yea, that's right. It will storm! A special open house is scheduled at Hudson-Mills Metropark to allow the public to view the Leonid Meteor Shower. Open house begins at sunset on Wednesday evening.

Nov 19 - Meeting at 807 Dennison

How Far Is Far?

By Lorna Simmons

Have you ever wondered how distances in the universe are calculated? Have you ever been fascinated by the methods used by astrophysicists and cosmologists to search the great unknown?

If we are going to take such an exciting journey, it always starts with that first step. Although today, there are laser measurements and radar calculations in use for distances in the Solar System. These measurements would hardly work for the farther objects in the universe, which often are the distances cosmologists really want to know more about.

With the very first rungs of the cosmological distance ladder, after radar and lasers, of course, everything heats up. Tempers flare. Friendships are lost. Personal preferences of the various cosmologists roil the waters of controversy. Skirmishes turn into battles into wars. So much in cosmology depends upon the measurements of these distances that winning becomes all in the minds of the combatants. There is ever present the incredibly difficult task to determine absolutely correct uncertainties for each of the observations. The errors are usually underestimated, seldom overestimated. Perhaps I exaggerate too much, but sometimes it seems like a battle. Cosmology is a hot topic. Reputations are at stake.

At this moment, we are on the verge of a breakthrough where precise observations will be able to reveal the secrets of distances in the universe. Because the distance scale leads to calculations of the age of the Universe, its rate of expansion, its density, and inevitably its destiny, such measurements are of immense importance in cosmology. However, that task is extremely arduous. On the ladder, every rung depends on previous lower rungs. A tiny error in the calibration of each rung will magnify the computational errors of measurements farther out on the ladder. Pretty messy.

It is best to split up the distance indicators into groups - primary and secondary. The indicators of the primary groups are calibrated from measurements in our very own Milky Way, and the secondary indicators rely on at least one of these primary indicators. Therefore, the secondary indicators become increasingly less reliable as we get farther out on the distance scale.

Primary Group

To begin our journey up the cosmological distance ladder, the parallax method of determining distance is fundamental to all of the others. It is the most certain of methods for determining distances outside of the Solar System. The parallax method uses the elliptical orbit of the Earth around the Sun to determine the baseline for its measurements of the slight changes in the placement of the nearest stars. Distances to stars within approximately 40 parsecs (pc) can easily be calculated using a simple trigonometry. An angle is measured in arcseconds at one point of Earth's orbit, and six months later, at the opposite position of Earth's orbit, another measurement of the angle in arcseconds is taken. The slight difference of the observed movement of the celestial object with relation to the seemingly fixed stars creates an angle which subsequently provides the distance to that object in parsecs, one parsec equaling 3.2616 light years (ly). Note that the recent Hipparcos satellite observations seem to be increasing the range of such parallax measurements to at least 100 parsecs.

Using parallax methods, we next move to the standard candles, of which the Cepheid variables are of first importance. Cepheid variables are large and very luminous yellow giant stars or supergiants with regular periods of pulsation from about 1 to nearly 70 days. Over 700 Cepheids have been detected in our own Milky Way and a few thousand Cepheids can be seen in our Local Group of galaxies. Changes in brightness of Cepheid variables are accompanied by changes in their stellar temperatures and in their radii. A ratio exists between their periods of pulsation and their light variation (period-luminosity). The distance to the Cepheids is calculated by measuring their brightness and their periods of brightening. In other galaxies, noting the periods of the brightening would help determine the distances to such galaxies. Moderately great distances in the universe can be calculated using Cepheids, although the uncertainties are still very large.

RR Lyrae stars, which are also pulsating variable stars similar to the Cepheid variables, are old population II stars and are common in globular clusters. Their metallicity and absolute magnitudes are compared, making RR Lyrae stars a major rung up in the cosmological distance ladder. However, because RR Lyrae have low luminosities they cannot be used much farther than M31, limiting their use.

Many other similar stellar methods exist. Statistical parallaxes measure radial velocities and the proper motions of groups of stars to calculate distances in the universe to approximately 500 pc. Other similarly luminous stars, such as W Virginis stars and Mira variables also have a period-luminosity relation. The brightest red giants in globular clusters are helpful in measuring the distance ladder as are the eclipsing binaries where both spectroscopy and photometry are useful in recording the colors. Farther out on the ladder, cosmologists obtain exceedingly accurate measurements of the nearest open clusters using the Cepheid Variables in these clusters. And the Cepheids in these clusters will open the possibility for a new and better calibration of the important period-luminosity relation for Cepheids.

Another way of measuring the universe is the converging-point method, using the proper motion of open clusters. The average velocities of open clusters is compared to that of the Sun and is large with respect to the proper motions of stars. Hence, those stars can be thought of as moving toward the same point in the universe. For example, the distance to the Hyades can be determined using this method. Next, another method called "main-sequence fitting" compares the apparent magnitude with the absolute magnitude of a star, permitting the distance to that cluster to be calculated.

Secondary Group

There are a number of secondary distance indicators for measuring even farther out into the universe. First, there is the Tully-Fisher relation which uses spiral galaxies to calculate distances easily; well, almost easily for professional cosmologists. There are several versions of the Tully-Fisher relation. The first type measures the absolute magnitude of the galaxy, while the second type uses the infrared spectrum. The third type determines the rotational velocity of the galaxy. Another method, called the Fundamental Plane, finds similar relations for elliptical galaxies.

Supernovae, particularly Type Ia, are frequently used and are exceedingly promising standard candles. Supernovae are some of the brightest objects in the Universe and are visible to exceedingly high redshifts. The distances can be estimated because Type Ia supernovae have extraordinarily precise variations in light and color variations. The distribution of absolute magnitudes at maximum light seems to be very narrow. A few cases where Type Ia supernovae have been unusually red or spectroscopically peculiar lack this relation. Most recently, Type Ia supernovae have shown that the universe is accelerating in its expansion. So far, the Type Ia supernovae have given promising results in this study. Time will tell.

Next, the Sunyaev-Zel'dovic effect appears when the Cosmic Microwave Background Radiation (CMBR) passes through galactic clusters which contain extremely hot intracluster gas. The accompanying dimming of the CMBR is measured as resulting from the scattering of the CMBR photons in the intracluster gas and results in a measure of the physical depth of the cluster. This, combined with the angular extension of the cluster, gives its distance. This method reaches far into the universe.

Finally, there are Quasi-stellar Objects (QSOs) or Quasars which have undergone gravitational lensing. The time delay is measured between the fluctuations in the multiple images of these distant objects. This probes into the very distant universe and perhaps will become useful in future cosmological tests. Using QSOs is a problem because this method is dependent on the measuring of the lensing mass in front of the QSO which leads to quite large uncertainties in the resulting calculations.

In addition to all of the above, there are many other secondary methods for determining cosmic distances. However, there is much greater scatter in their measurements making the accuracy much less certain.

In closing, it is important to mention the doppler effect shown by blueshift and redshift calculations which are part of the cosmologists' tools to determine velocities of objects, both toward and away from the observer, within the Milky Way. Outside of the Milky Way, redshifts and blueshifts are calculated within our Local Group of galaxies to determine relative radial velocities toward and away from our galaxy. Extragalactic sources, including quasars, also show a doppler effect which results from the expansion of the universe. Recessional velocities of distant galaxies can be exceedingly large and the expression for redshift of "z" is used in these cases. Redshifts, themselves, exhibit a photon energy loss in radiation for overcoming the effects of recession or expansion. Using Hubble's law for distance determination, the measurements of galactic redshifts are also used to calculate the distances of galaxies. Redshifts can also be produced by the presence of strong gravitational fields, as predicted by Einstein's General Theory of Relativity. It should be understood that, although galactic redshifts can

be interpreted as caused by the relativistic doppler effect alone, both the expansion and the gravitation fields of the universe are involved. Therefore, we should be aware that redshifts may, alternatively or in combination, be considered as doppler redshifts, gravitational redshifts, and/or cosmological redshifts.
So next time you wonder about the accuracy of the methods for determining cosmic distances, rest assured that the cosmologists are handling it just fine - if we can ever get them away from the battlefield.

Y2K Calendars

by Doug "the REAL treasurer" Scobel

It's that time of year again - time to think about calendars for 2000. I'm trying to get an idea of how many of each I should order, so please let me know how many of each kind (described below) you would like to purchase. I'm not asking for firm orders or money; I just want to get an idea of how many we'll need. Based on the responses I get, I'll order an appropriate number of each. Don't worry about Observer's Handbook 2000's, becabattlefield.use I do not pre-order those - I'll post another request for those in the next month or two.

I will be ordering a number of "Wonders of the Universe" wall calendars from Hansen Planetarium. These are the beautiful wall calendars containing excellent images [astronomical and terrestrial (Earth as planet)] and daily notes on sky happenings. The club makes a few dollars on each one we sell, so you are encouraged to buy some extras for Christmas/holiday gifts, and/or to sell them at work. YOU WILL NOT HAVE TO PRE-ORDER THEM FROM ME. I will simply make them available to you on a first come, first served basis, but once they're gone they're gone. Price will be around $9.00 or $10.00 each. Last year I ordered 40 and I ran out - I may order more this year.

I also will be ordering a number of the popular "Year in Space" desk calendars. These 164 page desk calendars have 54 space images, planning calendars, and much more. You can check it out at http://www.YearInSpace.com. AGAIN, YOU DO NOT HAVE TO ORDER OR RESERVE ONE - they will be available to you on a first come, first served basis. Price will be $8.95 each ($1.00 less than last year!). We do not make a profit on these, but feel free to ask for as many as you like, for gifts or whatever. Last year I ordered ten and we also ran out - I will probably order more this year.

Detroit Observatory 1999 Fall Schedule

Excerpted from an e-mail by Patricia S. Whitesell, Director and Curator

You are cordially invited to visit the newly restored, historic 1854 University of Michigan Detroit Observatory. The restoration project and museum received several awards, including "Preservation Project of the Year" from the City of Ann Arbor's Historic District Commission and the prestigious "Award of Merit" from the American Association for State and Local History. And, the Observatory was featured in Architecture Magazine, on Michigan Public Radio, etc.

Initially, the Observatory will be open to the public once a month for self-guided tours. The schedule and public program offerings will gradually expand as resources and staffing permit. The Open House schedule for fall is:

October 21st, 1-4 pm
November 18th, 1-4 pm
December 16th, 1-4 pm

The Observatory also has a monthly lecture series. The schedule for fall is:

October 12, 3 pm - Inaugural Lecture, Dr. Russell Bidlack, Professor and Dean Emeritus, Library Science, "Asa Gray's Role as the First University Professor"

November 9, 7:30 pm - Paul H. Gross, Meteorologist, WDIV-TV, Detroit
"Michigan's Storm of the Century: The Great Storm of 1913"

December 7, 7 pm, Matthew Linke, Planetarium Director, UM Exhibit Museum, "Winter Sky Preview: Planets, bright stars and constellations projected on the Observatory library's ceiling"

The winter term schedule will be announced later this fall. We look forward to participation in these and future events by the members of the University Lowbrow Astronomers.

LOWBROWS - Your help please…
If you would be willing to accept your copy of REFLECTIONS <u>on line</u> instead of receiving a hardcopy in the mail <u>please</u> e-mail Bernard Friberg or myself and let us know. It will greatly reduce the work load of your Publisher. Thanks - Ed

What's Happening... Astronomically That Is

By Ed (your faithful scribe)

Great News

Bernard Friberg, the Lowbrow's Observatory Director, tells us that "an amazing thing happen" at the September 28th Dexter Planning Commission meeting. The commission met to vote on the proposed gas station/mini mart/car wash at the corner of the Dexter-Pinckney Road and North Territorial Road. A unanimous six votes <u>against</u> this development (with one absent commission member) occurred. Bernard writes,

"Thanks everyone for your help, your cards, your letters to the Commission. The Friends of Stinchfield Woods have spent a lot of time on this project going door to door to all of the residents collecting No votes and writing letters. The Ann Arbor News wrote a nearly full-page article about mostly the negative aspects of this project. Thank you Ann Arbor News. What is going to happen at this point is unknown, the issue is not going away, but we have won another round. "

Next time you see Bernard please offer him your thanks for his effort in following this effort. It just goes to show you that one person can make a difference! Thanks again Bernard.

Saturday Morning Physics

Its Multimedia, Its science made entertaining, Its free coffee and donuts, but mostly its back - Saturday Morning Physics at Dennison Hall Auditorium starting this October 9th at 10:30 am. Come on out and join about 400 or so individuals, and a few fellow Lowbrows, as we listen to the latest on these interesting topics hosted by The University of Michigan's Physics Department. This fall's schedule is:

- October 9, 16, and 23 - Robert Kehoe, " Explosions in the Heavens: Gamma Ray Bursts"
- October 30, November 6 and 13 - Ken Bloom, "Essential Physics: What is everything made of?"
- November 20, December 4 and 11 - Robbie Dohm-Palmer, "The Milky Way"

Observing Naked (<u>or</u> I got 5.5 arcmins resolution)

Everyone knows how to split the famous double star *Mizar* (mag 2.4) and *Alcor* (mag 4.0) in the handle of the Big Dipper. With a separation of 11.8 arcmins this is "easy". Most everyone I have ever pointed the pair out at a star party can "split" this famous pair with naked eye observing (except the most visually challenged). Years ago I happened to look up at Alpha Capricornus, *Algedi* and notice this star could be split with only your keen eyesight and a night of generally clear skies. This pair consists of 3.6 and 4.2 mag stars with a separation of 6 arcmins (376"). Another pair that will test your observing skills is up at zenith this time of year. Omicron 1 Cygni (mag 3.8) and 30 Cygni (mag 5) are separated by 5.5 arcmins (338"). You will need to look with determination to split this pair, but it can be done on a night of steady seeing. The faint 5th mag star will pop in and out of view as you look at this pair. All three pairs a well placed for fall viewing. Do try these naked eye doubles at your next observing session and let me know how you did. I would like to know.

The Bad Astronomer - Phil Plait

The Bad Astronomy Web Page:
`http://www.badastronomy.com`

Kurt Hillig, Lowbrow Newsletter Emeritus, likes to say one his favorite goals in publishing the newsletter was to "scoop" *Sky & Telescope* magazine with some breaking astro news by getting it published in the *REFLECTIONS* before the magazine did. Imagine my surprise when *Sky & Telescope* scooped yours truly with an article about Phil Plait's <u>Bad Astronomy</u> web page in Stuart J. Goldman's <u>Astronomy Online</u>. I have been enjoying this web site for some time and thought I would write the author for permission to feature it in our humble publication. Well I did and he is Phil's response:

Sure, go ahead! I am flattered, and ironically amused. When I read your letter, I thought, "Where have I heard about the Lowbrows before?" Then realized you are at the U of M. I got my BS there in 1987. I think Dan Durda was a president of the club for a while around then; he and I are still good friends. I used Peach Mountain once or twice, once freezing my butt off getting streaked images of M31. One of these days I plan on going back and seeing A^2. I miss it. Anyway, help yourself to the site. ;-)

Small world isn't it? Anywho, do check out this web site. The main idea is to combat bad astro information in TV, movies, and news. Another feature worth looking up is Phil's Bitesize Astronomy, which features short articles on popular astronomy subjects.

BAD ASTRONOMY

Twinkle Twinkle Little Star

Week of August 23, 1999

It's semi-common knowledge that stars twinkle and planets don't. By semi-common, I mean that a lot of folks know that, but I also mean it isn't strictly true.

Stars twinkle because we see them from the bottom of a sea of air. Little cells of air, about ten centimeters across and many kilometers high, move across our vision as we watch the sky. These small bundles of air act like little lenses, bending light as it passes through them. This bending, called *refraction*, is familiar to anyone who drives on a hot day: hot air just above the road surface bends light more than the cooler air slightly above it. That's why you can sometimes see that shimmery veil of what looks like water on the road; it's really the air bending the light above it. Sometimes you can even see cars reflected in the road!

Anyway, these parcels of air up high in the atmosphere travel to and fro, bending the light from a star in more or less random directions. Stars are big, but they are so far away that they appear to be very small, much smaller to our eyes than each of these air bundles. So when the light gets bent, the apparent movement of the star is larger than the size of the star in the sky, and we see the star shifting around. Our eye can't really detect that motion, because it's too small. What we see is the light from the star flickering. That's why stars twinkle!

So why don't planets twinkle? It's because planets are bigger. Well, really, they're smaller than stars, but they are so much closer they *appear* bigger to us. They are much bigger in apparent size than the air bundles, so the smearing out of their light is much less relative to the size of the planet itself. Since the image doesn't jump around, they don't appear to twinkle.

There's always an exception though. In very turbulent air, even planets can appear to twinkle. The air is moving so rapidly and so randomly that even something as large as a planet can twinkle.

This effect also plays with a star's color. Blue and green light get bent more than orange and red, so sometimes in very turbulent seeing a star's colors will rapidly change. This usually happens when the star is low on the horizon (so there's more air for it to pass through). The brighter the star, the easier it is to see; Sirius, the brightest nighttime star, is often seen changing from green to red to orange and back, very rapidly. I've seen it myself and it's quite lovely. If you're not prepared for it it's quite surprising; many people report a UFO when they see it! If they're driving, the star appears to follow them too, just like any distant object appears to follow you while you're driving (it's due to parallax). So if a friend says they saw a bright UFO, low to the ground, rapidly changing color and following the them gently point out that most likely it wasn't a spaceship, but it was almost certainly extraterrestrial!

Twinkling is actually a serious problem for astronomers. Next week's Snack will deal with how it affects astronomers and what they do about it.

Reprinted with permission of Phil Plait
The Bad Astronomy Web Page:
http://www.badastronomy.com

Peering at the Heart of a Crab

NASA's Marshall Space Flight Center
Space Sciences Laboratory

September 28, 1999: "Modern astrophysics," an astrophysical wag once said, "has two areas of study: The Crab Nebula and everything else."

It's a bit of hyperbole that illustrates a point: The Crab Nebula seems to have most of what's in the celestial bestiary. It is one of the most spectacular nebulas in the sky. It's a supernova remnant. It has a pulsar that emits in radio, visible, ultraviolet, and X-ray wavelengths. It even has a well-established pedigree since it was sighted by royal Chinese astronomers when light from the supernova arrived here in 1054.

"The Crab Nebula and the star at the center of it are the Rosetta Stone of modern astrophysics," said Dr. Martin Weisskopf, Project Scientist for the Chandra X-ray Observatory. The Rosetta Stone is a block of black granite (discovered in 1799) inscribed in Greek, Demotic, and Egyptian hieroglyphs. From this, archaeologists were able to start decoding the texts of ancient Egypt.

Provenance for a supernova

Like an antiques dealer, astrophysicists often are faced with the challenge of estimating the age of an artifact such as a supernova remnant. Calculations can yield reasonably good estimates, but because most art happened long before modern instruments, the estimates have margins of error.

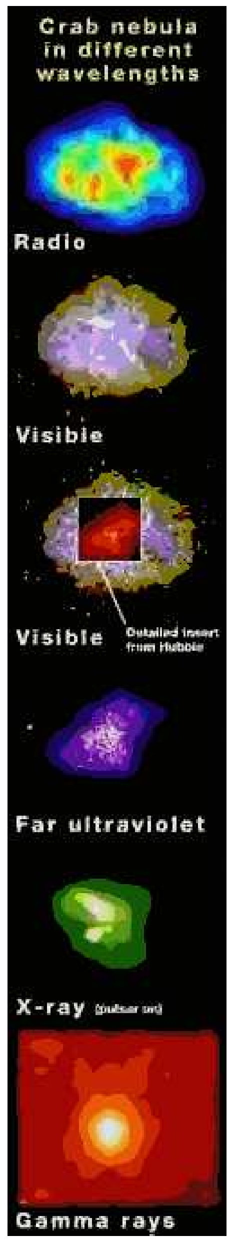
Like the antiques business, the most valuable artifacts are the ones with a provenance, a record that removes all doubt about its origins and history. The Crab Nebula has a provenance, starting with records kept by royal court astronomers in China and Native Americans.

Right: The many colors of the Crab Nebula as recorded over the years by various observatories on Earth and in orbit.

The Crab appeared in July or August A.D. 1054, according to Chinese records, probably on July 5, according to Native American cave drawings White Mesa and Navajo Canyon. Appearing in the sky above the southern horn of the constellation Taurus was a star the Chinese described as six times brighter than Venus, about as brilliant as the full Moon - and visible during the day for almost a month, and at night for a year.

Small wonder. At its peak it blazed with the light of about 400 million suns. That was enough energy to have destroyed all living things on any planet within 50 light years. Fortunately for us, the Crab is more than 7,000 light years away, so the pulse Earth received was about 1/20,000th what it would have been for a closer world.

Then it faded from view and memory until 1731 when English physicist and amateur astronomer John Bevis observed the strings of gas and dust that form the nebula. While hunting for comets in 1758, Charles Messier spotted the nebula, spotted it as he started his list of objects that are not comets, his real quarry. The nebula became M1 in his famous "Catalogue of Nebulae and Star Clusters," published in 1774. Lord Rosse named the nebula the "Crab" in 1844 because its tentacle-like structure resembled the legs of the crustacean.



In the decades following Lord Rosse's work, astronomers continued to study the Crab because of their fascination for the strange object. In 1939, astronomer John Duncan concluded that the nebula was expanding and probably originated from a point source about 766 years earlier (he was only off by a century, a remarkably accurate estimate). Historians later linked the Crab with the "guest star" of 1054.

Walter Baade probed deeper into the nebula, observing in 1942 that a prominent star near the nebula's center might be related to its origin. Six years later, scientists discovered that the Crab was emitting among the strongest radio waves of any celestial object. Baade noticed in 1954 that the Crab possessed powerful magnetic fields, and in 1963, a high-altitude rocket detected X-ray energy from the nebula.

Radio waves. X-rays. Strong magnetic fields. Scientists knew that the Crab Nebula was a powerful source of radiation, but what was its power source? They discovered it in 1968: an object in the nebula's center - Baade's prominent star - that emitted bursts of radio waves 30 times per second.

Scientists soon concluded that the pulsar was a neutron star because theory suggested that these stars existed at the centers of supernova remnants.

The Crab Pulsar acts as a celestial power station, generating enough energy to keep the entire nebula radiating over almost the whole electromagnetic spectrum. Because of the pulsar's power, the nebula shines brighter than 75,000 suns. That's bright enough to draw the constant attention of astrophysicists from across the planet and the spectrum.

In like manner, the Crab Nebula has features serve as clues to the inner workings of a range of astrophysical phenomena. In the last couple of weeks, Chandra and its remarkable X-ray telescope targeted the Crab Nebula to collect more clues with the High Resolution Camera. Those images are to be released today in a Space Science Update at NASA headquarters.

"Right now [before Chandra] we're looking at the glow of activity near the center of the nebula as you might see the glow of city lights from a distance," Weisskopf said in a 1998 interview. "Examining the pulsar in the center using Chandra will be like using a telescope to focus on a single street light in the middle of the city."

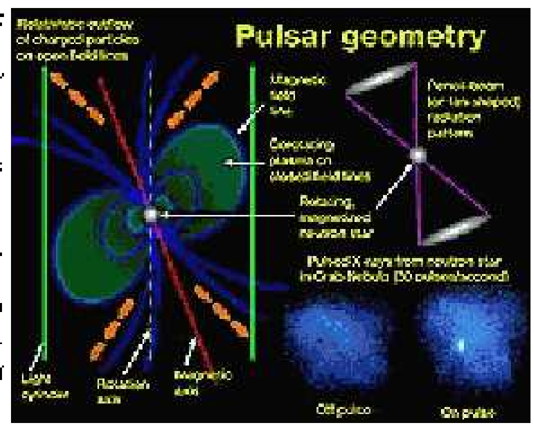
Right: I'll take Manhattan, plus the rest of Earth if a neutron star was near our planet. This artist's concept shows the relative scale of a neutron star to New York City. While no one knows if a neutron star is dark gray, the sunlight glaring off it probably is real since the star's intense gravity would make it the smoothest object in the universe. Credit: NASA/ Marshall Space Flight Center.

As it happens, that single light has " a brilliant ring around a cosmic powerhouse at the heart of the Crab Nebula," the NASA press announcement promises. Aside from being the most observed of all pulsars, the Crab Pulsar is also believed to be the youngest of more than 700 known to astronomers.

"Since it is the youngest, it's also the hottest," explained Weisskopf, "and X-rays offer the best way to observe it at these temperatures." Neutron stars cool as they age and the temperature offers evidence of the physical activity occurring inside the star.

"Neutron stars are a unique laboratory for probing various physical phenomena," Weisskopf continued. "Of interest here is the thermal evolution of the stars." The physical activity in the star's superfluid interior, under a 2-kilometer-thick crystalline neutron crust, is impossible to recreate in any laboratory on Earth, so scientists have been working up theories based on observations of the Crab and other neutron stars. Different theories predict different temperature ranges for such stars.

The ACIS image is not the only view of the Crab that will be taken by Chandra. As a guest investigator, Weisskopf has time allocated to observe the Crab Nebula in more detail using Chandra's High Resolution Camera (HRC) which provides X-ray images that approach the rich detail of the Hubble Space Telescope's Wide-Field Camera. The HRC actually is two cameras in one, an imager to make pictures of X-ray sources and a spectrometer to take pictures of their "colors."



Right: The geometry of the Crab extends far beyond the oversize billiard ball sitting atop Manhattan at the lead of this story. It includes an intense magnetic field whose rotation (with the star) controls and drives the activities of plasma for billions of miles around the Crab.

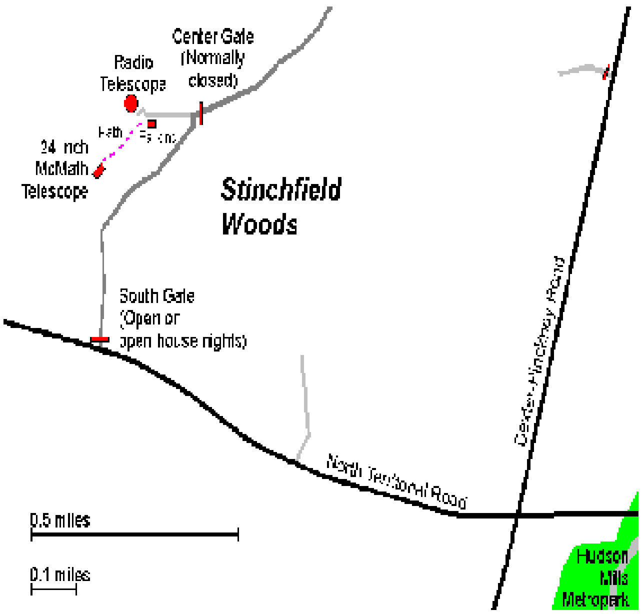
One of the important features of the HRC is its speed. Its time resolution is 0.000016 second, the equivalent of taking 62,500 pictures a second, letting Weisskopf capture images of the Crab when it is "on" or "off."

Complicating the task is the fact that the star is a pulsar, meaning that the X-ray readings must be synchronized with Crab. Some HRC readings will have to be made when the pulse is off - actually, when the source is not pointed at Earth - and others when it is on - source pointed at Earth.

In addition to providing information on the Crab Pulsar and its neutron star, the HRC will provide pictures of other discrete structures within the nebula. High-resolution spectroscopy of interstellar material and high-resolution spectroscopy of the nebula itself are also part of the mission plan.

Places and Times:

Dennison Hall, also known as The University of Michigan's Physics and Astronomy building, is the site of the monthly meeting of the University Lowbrow Astronomers. It is found in Ann Arbor on Church Street about one block north of South University Avenue. The meeting is held in room 807. Monthly meetings of the Lowbrows are held on the 3rd Friday of each month at 7:30 PM. During the summer months, and when weather permits, a club observing session at Peach Mountain will follow the meeting.



Peach Mountain Observatory is the home of The University of Michigan's 25 meter radio telescope as well as the University's McMath 24 inch telescope which is maintained by the Lowbrows. The observatory is located northwest of Dexter. The entrance is on North Territorial Road, 1.1 miles west of Dexter-Pickney Road. A small maize-and-blue sign marks the gate. Follow the gravel road one mile to a parking area near the radio telescopes. Walk along the path between the two fenced in areas (about 300 feet) to reach the McMath telescope building.

Public Star Parties:

Public Open House/Star Parties are held on the Saturday before and after each new Moon at the Peach Mountain Observatory. Star Parties are canceled if the sky is cloudy at sunset or the temperature is below 10 degrees F. Call 480-4514 for a recorded message on the afternoon of a scheduled Star Party to check on the status. Many members bring their telescopes and visitors are welcome to do likewise. Peach Mountain is home to millions of hungry mosquitoes - bring insect repellent, and it does get cold at night so dress warmly !

Amateur Telescope Making Group meets monthly, with the location rotating among member's houses. See the calendar on the front cover page for the time and location of next meeting.

Membership:

Membership dues in the University Lowbrow Astronomers are $20 per year for individuals or families, and $12 per year for students and seniors (age 55/+). This entitles you to the monthly REFLECTIONS newsletter and the use of the 24" McMath telescope (after some training). Dues can be paid to the club treasurer Doug Scobel at the monthly meeting or by mail at this address:
1426 Wedgewood Drive
Saline, MI 48176

Magazines:

Members of the University Lowbrow Astronomers can get a discount on these magazine subscriptions:
Sky and Telescope: $29.95 / year
Astronomy: $29.00 / year

For more information contact the club Treasurer. Members renewing subscriptions are reminded to send your renewal notice along with your check when applying through the club Treasurer. Make the check payable to "University Lowbrow Astronomers".

Newsletter Contributions:

Members and (non-members) are encouraged to write about any astronomy related topic of interest. Call or E-mail to Newsletter Editors at:

Bernard Friberg (743)761-1875 Bfriberg@aol.com
Chris Sarnecki (734)426-5772 chrisandi@aol.com

to discuss length and format. Announcements and articles are due by the first Friday of each month.

Telephone Numbers:

President: Mark Deprest (734)662-5719
Vice Presidents: Lorna Simmons (734)525-5731
Dave Snyder (734)747-6537
Paul Walkowski (734)662-0145
Treasurer: Doug Scobel (734)429-4954
Observatory Director: Bernard Friberg (734)761-1875
Newsletter Editors: Chris Sarnecki (734)426-5772
Bernard Friberg (734)761-1875
Keyholders: Fred Schebor (734)426-2363
Mark Deprest (734)662-5719

Lowbrow's Home Page:

http://www.astro.lsa.umich.edu/lowbrows.html

Dave Snyder, webmaster
http://www-personal.umich.edu/~dgs/lowbrows/

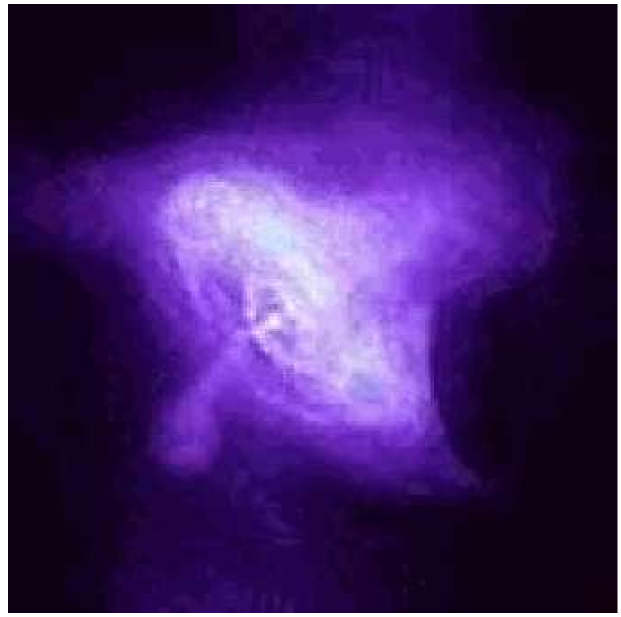
Monthly Meeting
Oct 15, 1999, 7:30 pm

Room 130 Dennison Hall
Physics & Astronomy Building
The University of Michigan

Mark Deprest

Presents

"Deep-Sky Delights of the King of Constellations" - A Star Hop thru Cepheus



The Crab Nebula as seen by the Chandra X-ray Observatory. Credit: NASA and Chandra Science Center. See story inside this issue of REFLECTIONS

UNIVERSITY LOWBROW
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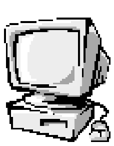
3684 Middleton Drive
Ann Arbor, Michigan 48105



Lowbrow's WWW Home Page:
www.astro.lsa.umich.edu/lowbrows.html

Check your membership expiration date on the mailing label !