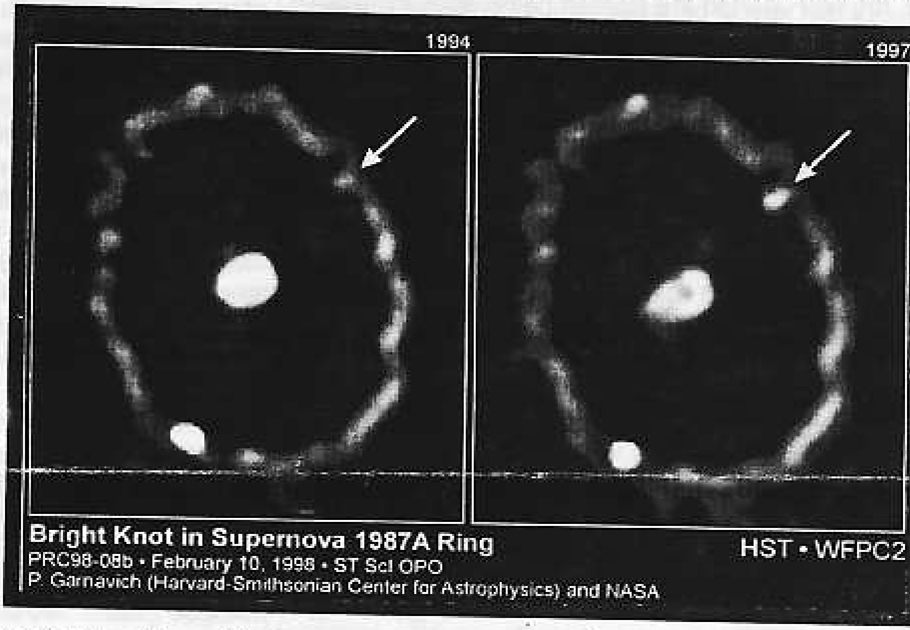
Reflections Refractions
of the University Lowbrow Astronomers

February, 1998

Bright Knot appears in Supernova 1987A Ring



Left - This NASA Hubble Space Telescope Wide Field and Planetary Camera 2 image shows the glowing gas ring around Supernova 1987A, as it appeared in 1994. The gas, excited by the light from the explosion, has been fading for a decade. Right - Recent 1997 Hubble telescope observations show a brightening knot on the upper right side of the ring. This is the site of an outward moving blast wave and the innermost parts of the circumstellar ring. The collision heats the gas and caused it to brighten in recent months. This is likely to be the first of a dramatic and violent collision that will take place over the next few years, rejuvenating SN 1987A as a powerful source of X-ray and radio emissions.

Credit: Peter Garnavich Harvard-Smithsonian Center for Astrophysics and NASA

The University Lowbrow Astronomers

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.

This Month:

February 20 - Meeting at 807 Dennison - Lowbrows speak on "Necessary Accessories". See the back page for more information on this presentation.

February 21 - Public Star Party at Peach Mountain Observatory - Orion is on the meridian - enjoy !

February 26 - New Moon - 12:26 pm EST

February 28 - Public Star Party at Peach Mountain Observatory - Better get Saturn before it sets in the west early in the night.

Next Month:

March 20 - Meeting at 807 Dennison - A visit to Russia - Art and Science in the former Soviet Union Dick Van Effen, Sunset Astronomy Society

March 21 - Public Star Party at Peach Mountain Observatory - Will Spring be sprung ? Still time to see the winter constellations.

March 27 - New Moon - 10:14 pm EST

March 28 - Public Star Party at Peach Mountain Observatory - Messier Marathon anyone ?

Computational Cosmology and the NSF Technology Grid

by Dave Snyder - dgs@umich.edu

(Note: The term 10^18 means 10 to the 18 power)

October 1, 1997 was the beginning of the NSF PACI (National Science Foundation Partnership for Advanced Computational Infrastructure). The NSF will spend not more than $340 million over the next five years to build a new information infrastructure (also known as the NSF Technology Grid). In this article I will explain what PACI is and how cosmologists intend to use PACI to improve our understanding of the early universe.

In 1985, the NSF started the NSF Supercomputer Centers Program. This program gave scientists and engineers across the country access to a number of high performance computers. Use of these facilities has increased by a factor often every four years and this growth is expected to continue. The Supercomputer Centers Program has officially ended: this program has been replaced by PACI. However this is more than a simple name change. In the past older computers were periodically replaced with newer more powerful computers, and PACI will ensure that this will continue. However PACI has a different focus than the Supercomputer Centers Program. From its onset PACI emphasized a collaboration between government, universities and business to make sure that new hardware meets the needs of the users. In addition there are plans to create new computer software to manage these computer resources. The intent is to develop a common set of tools and make these tools available to the research community. [Note that PACI should not be confused with the Internet-2 Project. PACI may make use of the Internet-2, but they are not the same].

The impetus for PACI was several large applications that cannot be reasonably executed with current technology. These applications include problems in the following areas:

Cosmology
Environmental Hydrology
Chemical Engineering
Molecular Biology
Nanomaterials
Scientific Instrumentation

I will only discuss the first of these, namely Cosmology. Cosmology is the study of how the universe has changed during its history. One of the first steps in understanding the evolution of the universe was the construction of a map that shows where all galaxies are located within our section of the universe. The current map shows all known galaxies within a cube of one billion billion billion cubic light years. The study of this map has created more questions than it has answered. It appears that the galaxies are not evenly distributed, rather there are vast regions of space devoid of galaxies and other regions with many galaxies. It is not clear at the moment if any of the current theories accurately explain the observed distribution.

The only way to test these theories is to run a computer simulation and see if the result of the simulation matches the observations. This will require a enormous number of calculations and doesn't appear to be feasible with present technology. To see why, lets look at what is involved.

Computer Scientists typically use rough back of the envelope calculations to estimate the running time of a program. In this way it is possible to make a good guess if the program is feasible or not. Within the cube mentioned above, there is a mass approximately 10^18 times the mass of our sun. Lets assume there are 10^18 objects each with one solar mass (this isn't true, but you have to make some simplifications when doing a simulation). In order to simulate the evolution of the universe, you need to calculate the gravitational force on each object and use that force to predict the position and velocity of all objects at the next instant in time. A naive calculation would require calculating the force between every pair of objects. This takes on the order of 10^36 operations. There is simply no way with current technology this calculation could be completed within the lifetime of any scientist.

Fortunately this is not necessary, several different mathematical tricks can be used to approximate the force acting on each object in a shorter amount of time. There are several possible approaches:

Use a Fast Fourier Transform (FFT).
Use a so-called "tree method".
Use an adaptive grid.
Reducing the number of objects (in effect we are pretending the universe is made of fewer, heavier objects).

These terms may not be familiar to everyone and there isn't space here to explain them. However, any of them allow the complicated calculation to be performed much faster and with only a slight introduced error. The most promising possibility is to use an adaptive grid along with a tree method. Tree based programs run slower than FFT based programs, but the former seem to give much more resolution (which is necessary for useful results). It also is likely that the first use of this simulation will use 10^9 objects each with 10^9 solar masses. Unfortunately using tree based methods and adaptive grids makes the programming more complicated. Furthermore adaptive grids are hard to do efficiently on parallel computers (most high performance computers are parallel). However, these problems probably can be resolved.

Doing the calculation is not the only problem facing the cosmologists. Once the calculation is finished, approximately 1 million million bytes of data (a "terabyte") will be produced. This is a large amount of data that will be difficult to store, let alone move from place to place or analyze. While moving files with a million bytes is commonly done now with the internet, I haven't heard of people transmitting terabyte files over the internet (while possible, it currently would take at best many days to transmit such a file). In addition, the analysis of such a large amount of data is almost as big a problem as the simulation itself.

It is expected that both statistical analysis and so called "visualization" will be used by cosmologists. The later is the process by which a large data set is presented in graphical form. The simplest type of visualization is to produce a two dimensional picture of the data. However this will not be adequate for the cosmological data. Here it will be necessary to show a three dimensional representation and allow a researcher to "move" through this data set in real time. This often allows a researcher to gain insights into the data which are impossible to gain through statistical analysis. It is also desirable for one researcher to show his/her results to other researchers (some of whom might be located thousands of miles away). Technology exists now to do all these tasks, but it is currently impractical with the existing internet and existing computers to perform these tasks on terabyte size data sets.

Cosmologists have an application that is not feasible with current technology. But it seems likely with a dedicated effort facilities could be created that will make applications like the cosmological simulation possible and even routine within the next few years. This is the goal that PACI is attempting to achieve. PACI needs to include leading edge parallel computers that can perform over a million million operations per second (a teraflop). These computers will need to store hundreds of gigabytes in main memory (a gigabyte is approximately one thousand million bytes) and be able to transfer this data quickly to storage devices. This is several orders of magnitude more powerful than a typical home computer and an order of magnitude more powerful than the fastest machines in existence.

For further reading there are a series of seven articles in the Communications of the ACM, November 1997-Volume 40, Number 11, pp. 28-94, which go into much more detail about these topics (ACM stands for "Association for Computing Machinery"). One of the articles is devoted to Cosmology.

In Remembrance - We are sadden to hear about the loss of two parents of our fellow Lowbrows. The mother of Dave Snyder died on February 2nd after a brief illness. Paul Walkowski's mother was killed in a car accident in early February near Buffalo, New York. Our thoughts and prayers go out to Dave and Paul during their difficult time.

Symposium on Comets

by Philip B. James
Department of Physics, University of Toledo

A Symposium on Comets will be held at Driscoll Center, University of Toledo, on Saturday, February 28, at 1:30 pm. This Symposium has been organized to celebrate the distinguished career of Professor Armand Delsemme on his Eightieth birthday. Guest speakers will be Dr. Michael A'Hearn, University of Maryland; Dr. Michael Combi, University of Michigan; and Dr. Michel Festou, Observatoire Midi-Pyrenees. We hope that many of our friends from Ann Arbor will be able to join us to celebrate the many contributions that Dr. Delsemme made to cometary science during his career, which has spanned almost half a century.

Kensington Spring Festival Star Party - May 1st & 2nd

by Mark Deprest

Activity - Presentation / Location / Time / Presenter(s)

Sun Spot Observing / Lawn (Telescopes with Helium Balloons) / Ongoing 5:00 -7:00 / All Clubs

Comet Video Mobile Unit Trailer / South Parking Lot /Ongoing 6:00 - 11:00 / Kensington Nature Center (Prepared by Barry Craig)

Meteorites / Pavilion Theater / 7:00 / Oakland Astronomy Club (Mike Bennett)

Moonsites / Pavilion Theater / 7:30 / University Lowbrows (Mark Deprest)

Porthole to the Moon / North Pavilion / Ongoing 8:00 - 12:00 / Detroit Astronomical Society (Barry Craig)

Comet making / Pavilion Theater / 8:00 / Kensington Metropark Nature Center
(Bob Hotaling and/or Mike Broughton)

Astronomy 101 / Pavilion Theater / 8:20 / Ford Amateur Astronomy Club/Eastern Michigan Astronomy Club
(Greg Burnett & Norb Vance)

Basic Equipment / Pavilion Theater / 9:00 / Warren Astronomical Society (TBD)

Sky Observing / North Lawn / (All Telescopes) 9:00 - 12:00 / All Clubs

Guided Tour of the Constellations / On Beach Every 1/2 Hour 9:00 - 11:00 / Seven Ponds Astronomy Club (Kevin)

Sky Tour / Lawn (Telescopes with Blinking Red Lights) / Ongoing 9:00 - 12:00 / All Clubs

There is another meeting of this planning committee on Feb. 15 1998, I will be attending and I will report back at our next Lowbrow meeting.

A Problem to Solve

by B. Friberg

Historical Tidbit - The first scientific estimates of the size of the earth is attributed to Eratosthenes, about 200 B.C. He measured the length of a shadow at one point on the earth, and knowing that at the same time there is no shadow at another point, the radius and diameter of the earth can be calculated if the distance is known. Determining an accurate distance between two distant points was no small chore back in 200 B.C. The resulting calculation from one reference is 20 percent too large for the diameter of the earth. Another source is within 1 percent.

Suppose that a 10 ft. pole casts a shadow of 6 1/16", and the distance is 200 miles. Calculate the diameter of the earth. Rhys, are you there?

Shock Wave Sheds New Light on Fading Supernova

Press Release No.: STScI-PR98-08, February 10, 1998

NASA's Hubble Space Telescope is giving astronomers a ringside seat to a never before seen titanic collision of an onrushing stellar shock wave with an eerie glowing gas ring encircling a nearby stellar explosion, called supernova 1987A.

Though the star's self-destruction was first seen nearly 11 years ago on Feb. 23, 1987, astronomers are just now beginning to witness its tidal wave of energy reaching the "shoreline" of the immense light-year wide ring.

Shocked by the 40-million mile per hour sledgehammer blow, a 100-billion mile diameter knot of gas in a piece of the ring has already begun to "light up", as its temperature surges from a few thousand degrees to a million degrees Fahrenheit.

"We are beginning to see the signature of the collision, the hammer hitting the bell. This event will allow us to validate ideas we have built up over the past ten years of observation," says Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, MA. "By lighting up the ring, the supernova is exposing its own past."

Astronomers predict it's only a matter of years before the complete ring becomes ablaze with light as it absorbs the full force of the crash.

Illuminating the surrounding space like a flashlight in a smoky room, the glowing ring is expected to literally shed a brilliant new light on many unanswered mysteries of the supernova: What was the progenitor star? Was it a single star or binary system? Are a pair of bizarre outer rings attached to an invisible envelope of gas connecting the entire system?

"We have a unique opportunity to probe structure around the supernova and uncover new clues to the final years of the progenitor star before it exploded," adds Richard McCray of the University of Colorado in Boulder, CO. "The initial supernova flash only lit up a small part of the gas that surrounds the supernova. Most of it is still invisible. But the light from the crash will give us a chance to see this invisible matter for the first time, and then perhaps we can unravel the mystery of the outer rings."

Though scientists will never solve the paradox of what happens when an irresistible force meets an immovable object, the supernova collision is the closest real-world example yet. "This supernova gives us an unprecedented opportunity to directly witness new physics of shock interactions," says McCray. "Though astronomers have measured shock effects from the expanding debris of many supernovae which are centuries-old, their impact velocities are at least ten times slower than the ones we see today in supernova 1987A."

The ring was formed 20,000 years before the star exploded. One theory is that it resulted from stellar material flung off into space as the progenitor star devoured a stellar companion. The ring's presence was given away when it was heated by the intense burst of light from the 1987 explosion. The ring has been slowly fading ever since then as the gas cools.

Several years ago radio waves and X-rays were detected as the fastest moving explosion debris slammed into cooler invisible gas inside the ring. In spring of 1997 the newly installed Space Telescope Imaging Spectrograph (STIS) first measured the speed of the supernova debris pushing along the shock wave. "The STIS lets you see the invisible stuff," says George Sonneborn of Goddard Space Flight Center in Greenbelt, MD. "We see the shock happening everywhere around the ring." In July, Hubble Wide Field and Planetary Camera-2 images taken by Robert Kirshner and co-investigators showed that a compact region on the ring lit up like a sparkling diamond set in an engagement ring.

Supernova 1987A is the brightest stellar explosion seen since Johannes Kepler observed a supernova in the year

1604. It is located about 167,000 light-years from Earth in the Large Magellanic Cloud.

The Space Telescope Science Institute is operated by the Association of Universities for Research in Astronomy, Inc., for NASA, under contract with the Goddard Space Flight Center, Greenbelt, MD. The Hubble Space Telescope is a project of international cooperation between NASA and the European Space Agency.

Hubble Finds Most Of Visible Light In The Universe

Press Release No.: STScI-PR98-06, January 7, 1998

A closer look at the Hubble Space Telescope's most detailed image, the Hubble Deep Field, reveals that the faint galaxies seen by Hubble could account for most of the visible light in the cosmos. ``We appear close to completing a 'light census' of the universe," reports Michael S Vogeley of the Princeton University Observatory. ``The extraordinary smoothness of the background sky suggests that most of the visible light in the universe hails from galaxies that Hubble can detect."

These results are being announced today by Dr. Vogeley to the 191st meeting of the American Astronomical Society in Washington, DC.

The Hubble Deep Field, an image obtained in 1995 when Hubble observed one location on the sky for two weeks, found galaxies that are billions of times fainter than could be seen with the naked eye. Vogeley probed apparently blank patches that lie between the faint galaxies. He searched for tiny ripples in the sky brightness that would indicate the presence of even more galaxies.

``Just as large waves require a deep ocean, large variations in the sky brightness would indicate a large amount of extra light from undetected galaxies," says Vogeley. ``We find only very tiny variations. In between the faint galaxies, the sky brightness varies by less than one-tenth of one percent over regions that are about one-millionth of the area of the Moon."

This measurement of fluctuations in the sky brightness is extremely complicated because small variations in the sensitivity of the camera on Hubble could masquerade as variations caused by faint galaxies. A new instrument on Hubble, the Advanced Camera for Surveys (to be installed using the Space Shuttle in 1999), will more accurately measure this sky brightness.

Identification of all the sources of visible light is a crucial step toward understanding the history of star formation and galaxy evolution. If, as astronomers suspect, the universe underwent a period of copious star formation when it was about half its current age, then the radiation from this burst of star formation would now be detected as visible light.

``An important task for cosmologists is to understand the origins of cosmic background radiations at all wavelengths," says David T. Wilkinson of the Princeton University Physics Department. ``Now that the visible component seems to have been measured, it is important to account for it. Vogeley's work indicates that most of the visible light filling the universe comes from galaxies like those in the Hubble Deep Field and not from still fainter galaxies."

``This is an important advance in surveying the contents of our universe," says James E. Peebles of the Princeton University Physics Department.

``Astronomers have always been plagued with the question of whether some, or even most of the universe lurks below the detection limits of our telescopes," commented Neil deGrasse Tyson of the American Museum of Natural History's Department of Astrophysics. ``We can now construct theories about the evolution of the universe with the added confidence that few galaxies are missing when we look to the sky with our most powerful optical telescopes."

Recently, Rebecca A. Bernstein of the Carnegie Observatories used ground-based telescopes in conjunction with Hubble to measure the average brightness of all the light that comes to Earth from beyond our own Galaxy. Uncertainty in this difficult measurement allowed the possibility that this average brightness could be much larger than the light from detected faint galaxies. Today's announcement indicates that there is not a large excess of background light.

Questions remain about exactly how many fainter galaxies continue to evade detection by Hubble. More galaxies could exist, but are either too faint or too distant for them to contribute significantly to the visible light seen from Earth. This analysis of the Hubble Deep Field also does not address the possibility of many galaxies that are hidden from view by dust or are so far away that the expansion of the universe has redshifted their visible light into infrared wavelengths. NASA's proposed Next Generation Space Telescope would allow us to observe the universe as it appeared when it was a small fraction of its current age, by capturing this infrared radiation.

SEDS addresses

submitted by Mark Deprest

Here are some SEDS addresses you might like to check out:

1. http://seds.lpl.arizona.edu/
SEDS main page
2. http://www.seds.org/messier
SEDS Messier Catalog
3. http://www.seds.org/~spider/ngc/ngc.html
SEDS NGC Interactive Catalog

Qaqortoq Meteorite Fall, Greenland

by Holger Pedersen, Copenhagen University Observatory, Denmark
e-mail holger@astro.ku.dk
http://www.astro.ku.dk/~holger/

It appears that an enormous meteorite has fallen over the southern part of the Greenland Ice cap. The event was witnessed by people on the west coast of Greenland, and by fishermen off shore. Further records come from seismic data, weather satellites, and a video camera at Nuuk.

The event occurred on December 9, at 08:21 UTC. At this moment, local solar time was 05:21 A.M. According to reports, the sky was clear.

SEISMIC DATA - Seismic records show a very special event. It lasts more than 10 seconds, indicating a time extended source. It is a high-frequency event, reminiscent of the Lunar meteorite seismic records made by the Apollo missions. This makes phase correlation, hence localization, difficult, but initial indication is that the event occurred in Greenland.

VIDEO - A parking lot video surveillance camera in Nuuk, capital of Greenland (64 North, 51 West), recorded an extremely bright flash of light from a moving source. One the footage shown on Danish TV, the event lasted about 2 seconds. However, the time compression factor was not reported.

WEATHER SATELLITE IMAGING - At least two weather satellites show the dramatic development of a cloud system near 63 degrees North 45 degrees West. The clearest images can be obtained from a polar orbiting satellite monitored at the Dundee Satellite Receiving station. One set of multicolor images show a dark cloud 120 km across, on December 9 14:24 UTC Channel 3 The cloud is still visible 26 hours later, at which moment one can see a 100 km long dark line on the
Ice Cap, marking the western edge of the cloud. The line points some 10
degrees West of North, which we interpret as the arrival direction of the
meteoroid.

The cloud height has been estimated by the Tycho Brahe Planetarium to be 6 - 8 km (based on the shadow cast).

The enclosed volume of air is thus at least 50,000 cubic km. If the moist air contains 0.1 gram of water per litre derived either from the meteoroid or from evaporating ice, this amounts to 5 billion tons. The minimum meteorite mass required to melt and evaporate this amount of water is 4 million tons, if the velocity of the impactor was 70 km per second.

SEARCH PARTY - According to Danish TV (DR1 and TV2 text-tv), a search mission is being
planned by the ice service at Narssaq.

THE NAME - Old tradition dictates that a fall is named from the closest postal office. This is Qaqortoq, at the south tip of Greenland. The city was formerly called Julianehaab.

The above report was compiled using data supplied by Morten Bo Madsen, Anja Andersen, Torben Risbo, and Lars Lindberg Christensen.

Moon Gets Out of Comets'Way

from Sky & Telescope's News Bulletin of February 13, 1998

A waning Moon leaves the evening sky behind this week (and heads toward the total solar eclipse on the 26th) improving the odds of seeing a pair of comets in the west after sunset. Comet 55P/Tempel-Tuttle, the parent of the Leonid meteor stream, continues to move south through Pisces at 8th magnitude. Observers in mid-northern latitudes should look soon after sunset, as the earlier you look in the west (to the upper right of Saturn) the higher up in the sky the comet will be. More information about the comet can be found in the February issue of Sky & Telescope, page 91, and on SKY Online Comet Page (http://www.skypub.com/comets/comets.html). Here are positions for Tempel-Tuttle at 0 hours Universal Time in 2000.0 coordinates:

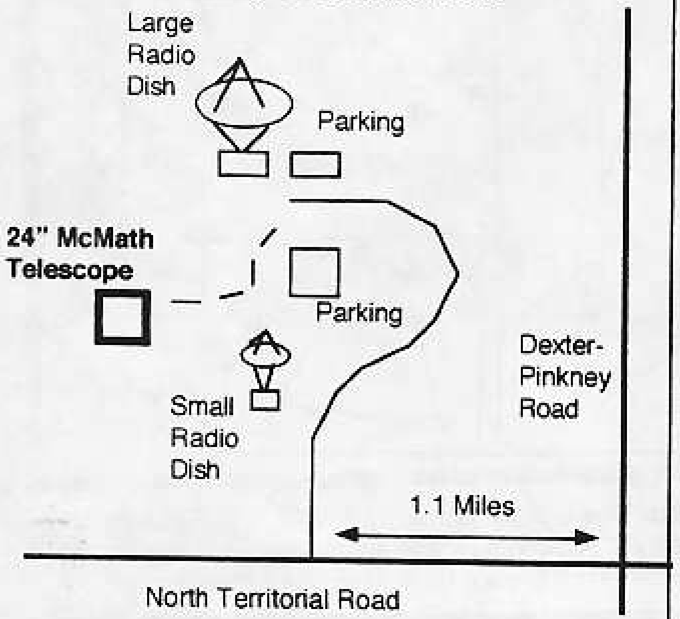
	R.A.	Dec.
February 15	01h 15m	+15.4 deg.
February 17	01 15	+14.2
February 19	01 15	+13.2

Slightly higher above the horizon is Comet 103P/Hartley 2, which is about 9th magnitude. It is moving east through Aries. Its positions for the week are:

	R.A.	Dec.
February 15	03h 10m	+02.0 deg.
February 17	03 19	+02.5
February 19	03 38	+02.9

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.



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.

Monthly meetings of the Lowbrows are held on the 3rd Friday of each month at 7:30 PM in 807 Dennison Hall. During the summer months, and when weather permits, a club observing session at Peach Mountain will follow the meeting.

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 mosquitos - 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.

Dues:

Membership dues in the University Lowbrow Astronomers are $20 per year for individuals or families, and $12 per year for students. 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: $27 / year
Astronomy: $20 / year
Odyssey: $16.95 / 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.

Newsletter Contributions:

Members and (non-members) are encouraged to write about any astronomy related topic of interest. Call Newsletter Editor Kurt Hillig at (313)663-8699(h) or (313)647-2867(o) or e-mail to khillig@umich.edu to discuss length and format. Announcements and articles are due by the first Friday of each month. Articles should be mailed to Kurt at:

7654 W. Ellsworth Road
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Lowbrow's WWW Home Page:

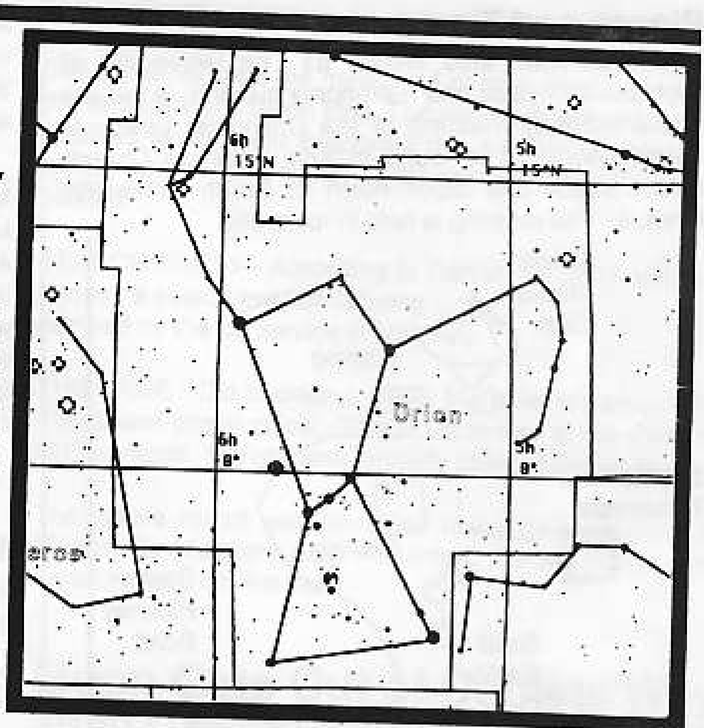
http://www.astro.lsa.umich.edu/lowbrows.html

Monthly Meeting :
February 20, 1998, 7:30 pm

Room 807 Dennison Hall (Physics & Astronomy Building) at The University of Michigan

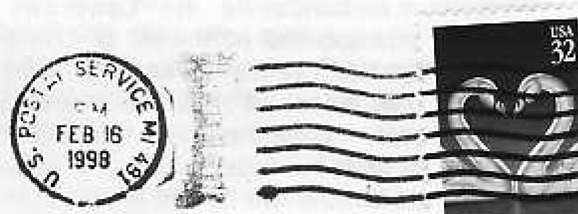
Necessary Accessories: Five Lowbrows present Five Multimedia Planetarium Programs for the home computer.

If you are trying to decide which Astronomy Planetarium Program to buy for use on you home PC you will want to attend this month's meeting.



Orion flies high in February's Winter sky. See how different Astronomy Planetarium Programs compare this constellation to each other at our next meeting.

University Lowbrow Astronomers
3684 Middleton drive
Ann Arbor, Michigan 48105



Check your membership expiration date on the mailing label !