

# *Inside Orbit*

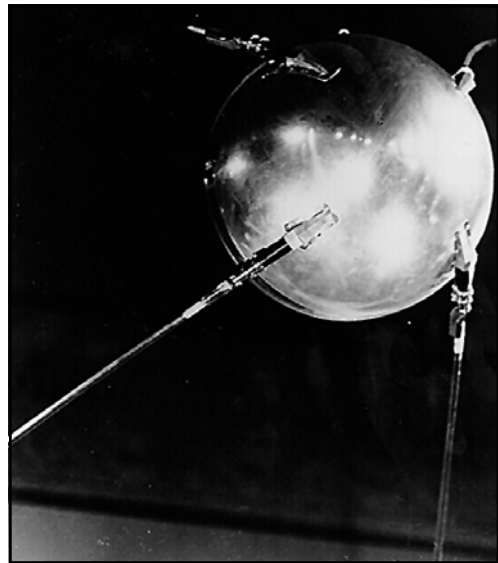
October 2007

Volume XXXXIII - Number X

A Publication of the Grand Rapids Amateur Astronomical Association

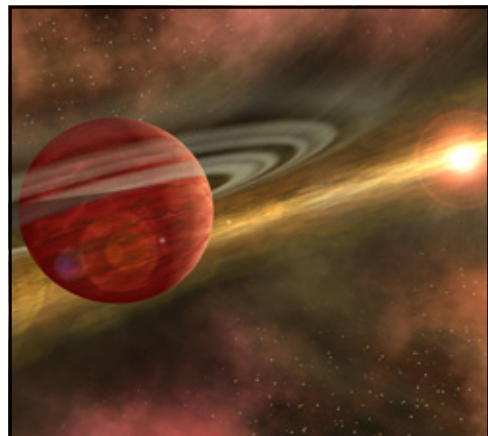
★★  
★ *Science is not formal logic—it needs* ★  
★ *the free play of the mind in as great* ★  
★ *a degree as any other creative art. It* ★  
★ *is true that this is a gift which can* ★  
★ *hardly be taught, but its growth can* ★  
★ *be encouraged in those who already* ★  
★ *posses it.* ★

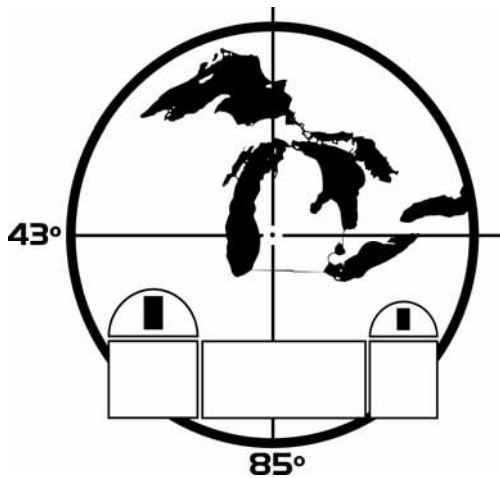
★ -- Max Born (1882-1970) ★  
★ German Physicist. ★  
★★



## **This Issue:**

- ☆ Calendar of Events & News Notes
- ☆ The Solar System - October 2007
- ☆ Moon Over Madison Heights
- ☆ NASA's Space Place
- ☆ Roger B. Chaffee Planetarium





# ***Inside Orbit***

A Publication of the  
Grand Rapids Amateur  
Astronomical Association

## **In This Issue:**

### **Calendar of Events & News Notes**

*Happenings in the GRAAA and the astronomical community*

### **The Solar System - October 2007** .....by Jeff Kozarski

*What is that red object high in the morning sky? This is the article for you*

### **Moon Over Madison Heights** .....by G.M. Ross

### **NASA's Space Place - "A Missile in Your Eye"**

*The wonders of the world of science and technology, brought to you by NASA and the Jet Propulsion Laboratory*

### **Roger B. Chaffee Planetarium**

**Note:** Any views and opinions expressed by the authors in this publication are not necessarily those of the GRAAA or its members.

#### **Inside Orbit Staff**

Editor-In-Chief	Kevin Jung
Editing, Layout & Graphics	Kevin Jung, Jeff Kozarski
Contributing Authors	Jeff Kozarski
Contributing Authors (this edition)	Gary Ross
Production Staff	Kevin Jung

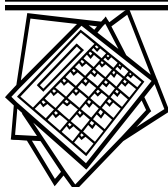
#### **GRAAA Website**

**[www.graaa.org](http://www.graaa.org)**

Images Credit:

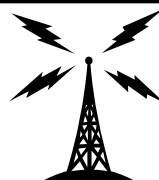
#### **Mailing Address:**

Inside Orbit  
3308 Kissing Rock Ave SE  
Lowell, MI 49331



## News and Events

(Latest News and Events always online  
at [www.graaa.org](http://www.graaa.org))



**VISITORS' NIGHTS FOR OCTOBER:** The Observatory will be open to the public - *clear skies only* - on Saturday, October 13th and Saturday, October 27th. Times are 7.30pm-10.30pm. Come out and help if you can. As usual, emails will be sent out the week of the particular night as a reminder to all.

**THE OCTOBER STAR PARTY** will be on Saturday, October 20th (if clear).

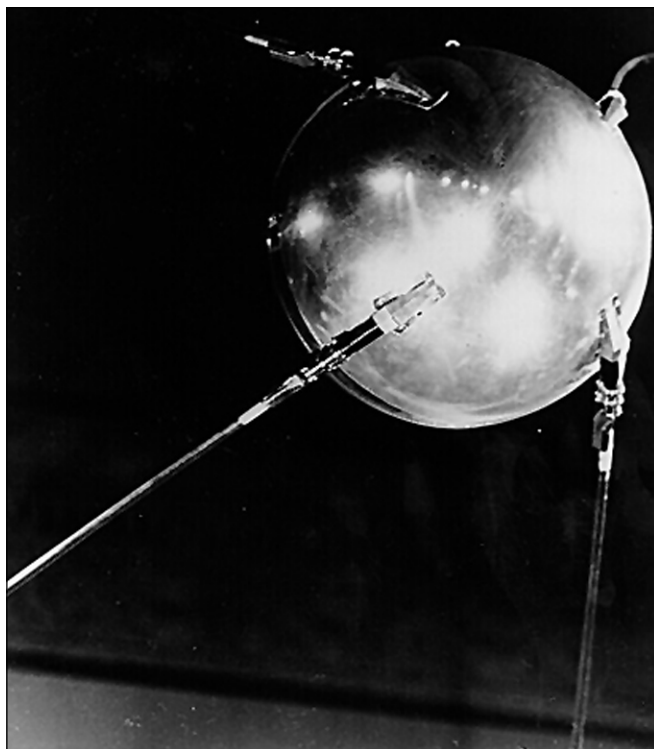
**OBSERVATORY COMMITTEE:** There are several openings on the Observatory Committee, and at the last meeting it was decided to ask the members at large to see if there is anyone interested in serving. The Observatory Committee is primarily in charge of the continual maintaining, upgrading, and running of the Veen Observatory. Members of that committee take charge and are on the forefront of projects and decisions regarding the facilities. If you are interested, or want more information, contact Ron Vander Werff at [observatory.committee@gmail.com](mailto:observatory.committee@gmail.com)

**BOARD OF DIRECTOR ELECTIONS:** It will shortly be time for elections to be held for the board of directors. Members should be sure to check their email within the next week for more information.

**GRAAA ONLINE FORUM:** Just a reminder of the forum for club members. It's a great place to get the latest scoop on club (and general astronomy) news, observing tips & tricks, and a whole bunch of other fun and informative things for all members to share in. You can find a link to the Forum in the Members' Section of the website. It hasn't been used much - c'mon people!!

**NOVEMBER INSIDE ORBIT:** The deadline for submissions to the November *Inside Orbit* is October 20th. If you'd like to write anything, please feel free to do so. The editorial staff is very relaxed concerning submissions, and take anything that's remotely interesting. In fact, they will almost guarantee that it will be published.

**DAWN OF THE SPACE AGE:** The Space Age (and Race) began fifty years ago this month, when the *Sputnik 1* satellite was launched into Earth orbit by the Soviet Union.



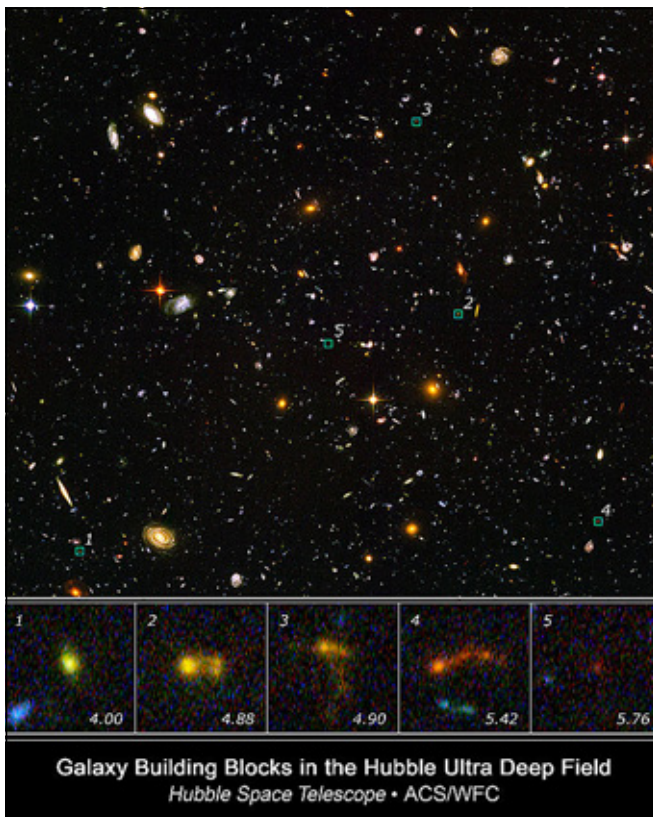
Just think of it... it took less than fifty years to go from the Wright Brothers to flying faster than the speed of sound, and just over ten years after Sputnik we were orbiting the moon. Who knows what will happen now...

**CALTECH ASTRONOMERS OBTAIN SHARPEST-EVER PICTURES OF THE HEAVENS:** Astronomers from the California Institute of Technology and the University of Cambridge have developed a new camera that produces much more detailed pictures of stars and nebulae than even the *Hubble Space Telescope*, and it does all this from here on Earth.

Until now, images from ground-based telescopes have been invariably blurred by Earth's atmosphere. Astronomers have developed a technique, known as adaptive optics (AO), to correct

the blurring, but so far it has only worked successfully in the infrared, where the smearing is greatly reduced. However, a new noise-free, high-speed camera has been developed at the Institute of Astronomy in Cambridge that, when used behind the infrared Palomar Adaptive Optics System, at last makes very high resolution imaging possible in ordinary visible light.

**NASA SPACE TELESCOPES FIND 'LEGO-BLOCK' GALAXIES IN EARLY UNIVERSE:** NASA's *Hubble* and *Spitzer Space Telescopes* have joined forces to discover nine of the smallest, faintest, most compact galaxies ever observed in the distant Universe. Blazing with the brilliance of millions of stars, each of the newly discovered galaxies is a hundred to a thousand times smaller than our Milky Way Galaxy.



"These are among the lowest mass galaxies ever directly observed in the early universe," says Nor Pirzkal of the Space Telescope Science Institute and the European Space Agency in Baltimore, Md.

**NEW RESEARCH REVEALS A LARGE ASTEROID BREAKUP TO BE THE LIKELY SOURCE OF THE IMPAC-**

**TOR THAT CAUSED A MASS EXTINCTION EVENT ON EARTH 65 MILLION YEARS AGO:** The impactor believed to have wiped out the dinosaurs and other life forms on Earth some 65 million years ago has been traced back to a breakup event in the main asteroid belt. A joint U.S.-Czech team from Southwest Research Institute (SwRI) and Charles University in Prague suggests that the parent object of asteroid (298) Baptistina disrupted when it was hit by another large asteroid, creating numerous large fragments that would later create the Chicxulub crater on the Yucatan Peninsula as well as the prominent Tycho crater found on the Moon.

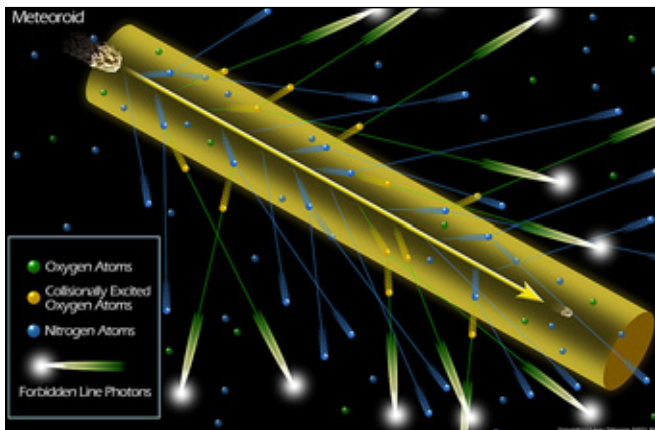


The team of researchers, including Dr. William Bottke (SwRI), Dr. David Vokrouhlicky (Charles University, Prague) and Dr. David Nesvorny (SwRI), combined observations with several different numerical simulations to investigate the Baptistina disruption event and its aftermath. A particular focus of their work was how Baptistina fragments affected the Earth and Moon.

**SUBARU ASTRONOMERS MEASURE METEOROID TUNNELS IN EARTH'S ATMOSPHERE:** When meteoroids flash through the Earth's atmosphere, they bore tunnels through the air, leaving behind narrow meteor tracks that are heated by the collision of the fast-moving incoming object with atoms of highly diluted atmospheric gases. Most meteoroids are bits of space debris the size of a



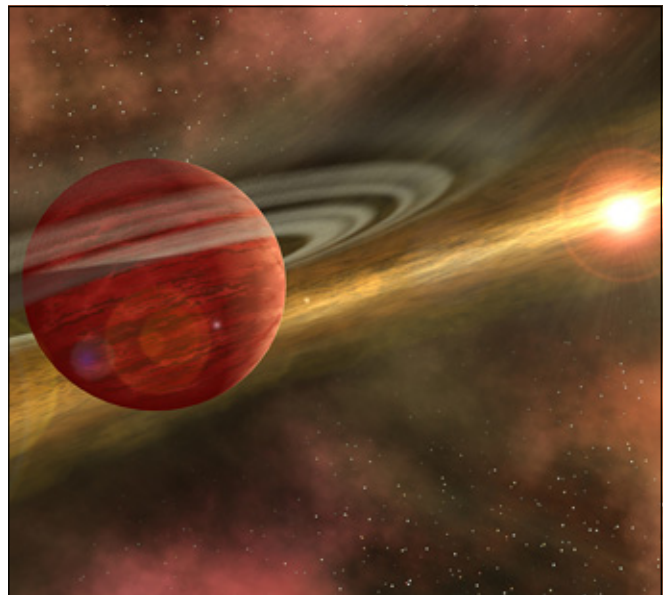
grain of sand. The width of the tracks they make has long been known to be narrower than a meter, but until recently, more precise measurements have been impossible to make.



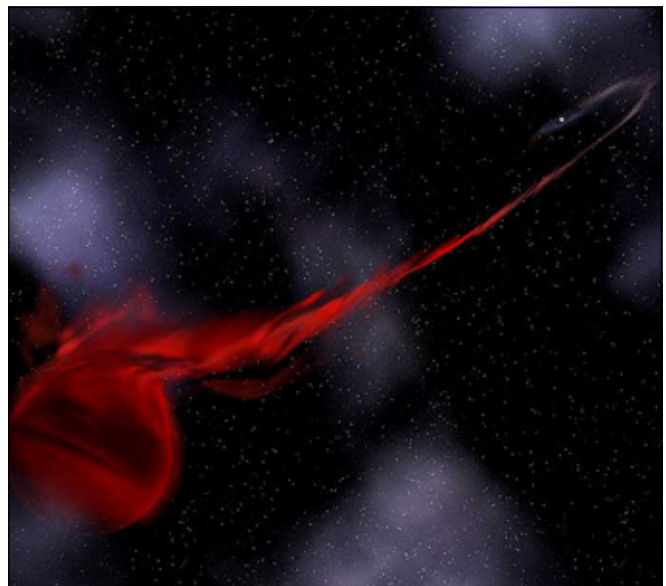
Researchers from the National Astronomical Observatory of Japan, the University of Tokyo, the Japan Aerospace Exploration Agency, the University of Electro-Communication, the RIKEN research institute, and Nagano National College of Technology have evaluated the diameters of the heated tunnels left behind as typical sporadic meteors as penetrated the upper atmosphere, scattering atmospheric atoms and releasing photons of light. The team compared the number of special photons produced as a meteoroid collided with the atmospheric atoms and found a typical column width as narrow as a few millimeters across. This is the first time the width of a meteor track column has been precisely measured using a physical analysis of the light emitted during the event.

**COSMIC NEON LIGHTS THE WAY:** On Earth, neon signs point to motel vacancies and nearby eateries. Now for the first time, astronomers have spotted neon gas in disks around stars -- and they're hoping the glowing gas will point the way to new discoveries about how planets rise from the materials that swirl around young stars.

*"Gas is a very important ingredient in the evolution of a circumstellar disk. It plays an important role in the temperature balance and density structure of the disk, the chemistry, the dynamics, and eventually the formation of gas-rich and gas-poor planets,"* says Dr. Fred Lahuis of Leiden Observatory and SRON -- the Netherlands Institute for Space Research.



**NASA ASTRONOMERS FIND BIZARRE PLANET-MASS OBJECT ORBITING NEUTRON STAR:** Using NASA's *Swift* and *Rossby X-ray Timing Explorer* (RXTE) satellites, astronomers have discovered one of the most bizarre planet-mass objects ever found.

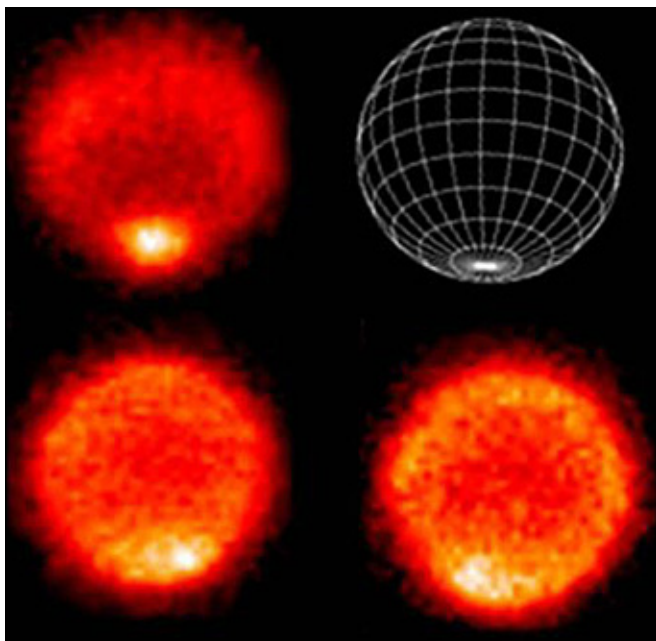


The object's minimum mass is only about 7 times the mass of Jupiter. But instead of orbiting a normal star, this low-mass body orbits a rapidly spinning pulsar. It orbits the pulsar every 54.7 minutes at an average distance of only about 230,000 miles (slightly less than the Earth-Moon distance).

*"This object is merely the skeleton of a star,"*

says co-discoverer Craig Markwardt of NASA's Goddard Space Flight Center in Greenbelt, Md. *"The pulsar has eaten away the star's outer envelope, and all that remains is its helium-rich core."*

**A WARM SOUTH POLE? YES, ON NEPTUNE!** An international team of astronomers has discovered that Neptune's south pole is much hotter than the rest of the planet. They have published the first temperature maps of the lowest portion of Neptune's atmosphere, which show that this warm south pole is providing an avenue for methane to escape out of the deep atmosphere.



*"The temperatures are so high that methane gas, which should be frozen out in the upper part of Neptune's atmosphere, the stratosphere, can leak out through this region,"* said Glenn Orton of NASA's Jet Propulsion Laboratory, Pasadena, Calif. Orton is lead author of a paper appearing in the Sept. 18 issue of the journal *Astronomy and Astrophysics*. These findings were made using the *Very Large Telescope*, located in Chile, operated by the European Organization for Astronomical Research in the Southern Hemisphere (known as ESO).

**NASA ORBITER PROVIDES INSIGHTS ABOUT MARS WATER AND CLIMATE:** NASA's *Mars Reconnaissance Orbiter* is examining several features on Mars that address the role of water at different

times in Martian history.

Features examined with the orbiter's advanced instruments include material deposited in two gullies within the past eight years, polar ice layers formed in the recent geologic past, and signs of water released by large impacts when Mars was younger.

**DAWN SPACECRAFT SUCCESSFULLY LAUNCHED:** NASA's Dawn spacecraft began its 3 billion kilometer (1.7 billion mile) journey through the inner solar system to study a pair of asteroids Thursday at 7:34 a.m. Eastern Time (4:34 a.m. Pacific Time).



The Delta 2 rocket, fitted with nine strap-on solid-fuel boosters, safely climbed away from the Florida coastline and launch complex 17B at the Cape Canaveral Air Force Station. "We have our time machine up and flying," said Dawn Principal Investigator Christopher Russell of the University of California, Los Angeles.

Dawn is scheduled to begin its exploration of Vesta in 2011 and Ceres in 2015. The two icons of the asteroid belt are located in orbit between Mars and Jupiter and have been witness to so much of our solar system's history.

**ORPHAN STARS FOUND IN LONG GALAXY TAIL:** Astronomers have found evidence that stars have been forming in a long tail of gas that ex-



tends well outside its parent galaxy. This discovery suggests that such "orphan" stars may be much more prevalent than previously thought.

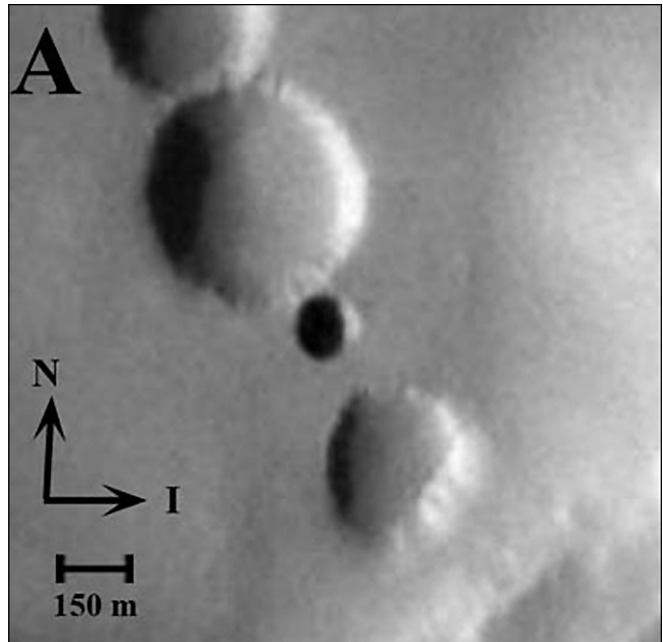


The comet-like tail was observed in X-ray light with NASA's Chandra X-ray Observatory and in optical light with the Southern Astrophysical Research (SOAR) telescope in Chile. The feature extends for more than 200,000 light years and was created as gas was stripped from a galaxy called ESO 137-001 that is plunging toward the center of Abell 3627, a giant cluster of galaxies.

**NASA RESEARCH INDICATES OXYGEN ON EARTH 2.5 BILLION YEARS AGO:** NASA-funded astrobiologists have found evidence of oxygen present in Earth's atmosphere earlier than previously known, pushing back the timeline for the rise of oxygen in the atmosphere. Two teams of researchers report that traces of oxygen appeared in Earth's atmosphere from 50 to 100 million years before what is known as the Great Oxidation Event. This event happened between 2.3 and 2.4 billion years ago, when many scientists think atmospheric oxygen increased significantly from the existing very low levels. Scientists analyzed a kilometer-long drill core from Western Australia, representing the time just before the major rise of atmospheric oxygen. They found evidence that a small but significant amount of oxygen was present in Earth's oceans

and atmosphere 2.5 billion years ago. The findings appear in a pair of research papers in the Sept. 28 issue of the journal Science.

**NASA ORBITER FINDS POSSIBLE CAVE SKYLIGHTS ON MARS:** NASA's Mars Odyssey spacecraft has discovered entrances to seven possible caves on the slopes of a Martian volcano. The find is fueling interest in potential underground habitats and sparking searches for caverns elsewhere on the Red Planet.



Very dark, nearly circular features ranging in diameter from about 100 to 250 meters (328 to 820 feet) puzzled researchers who found them in images taken by NASA's Mars Odyssey and Mars Global Surveyor orbiters. Using Mars Odyssey's infrared camera to check the daytime and nighttime temperatures of the circles, scientists concluded that they could be windows into underground spaces.

**INFORMATION SPOT:** The Schwarzschild Radius is the distance between the central singularity and event horizon of a black hole. The length of the Schwarzschild Radius depends on the mass of the black hole. Anything inside this radius can not escape the black hole.

Ω Ω Ω Ω Ω Ω Ω Ω  
...news to be continued next month



# The Solar System: October 2007

by Jeff Kozarski

October skies highlight Venus & Saturn huddled in the morning sky. Mars is rising before midnight EDT by early in the month. Jupiter hangs low in the SW at dusk. Neptune & Uranus are prominently placed during mid-evening hours all month.

**Mercury** is low in the WSW after sunset most of the month. This is a poor apparition for Mercury and it will be difficult to view it in the bright evening twilight. Inferior conjunction is on the 23rd.

**Venus** will reach greatest elongation from the Sun ( $46^\circ$ ) on the 28th. Now a month past greatest brilliancy, Venus is still an impressive  $-4.4$  magnitude sight high in the east rising nearly 4 hours before sunrise at mid-month. Venus peaks out in elevation at nearly  $40^\circ$  up at sunrise; the highest it will be for this apparition. Tele-scopically, Venus is displaying a half-lit phase near the days of greatest elongation and a  $24''$  of arc wide disc.

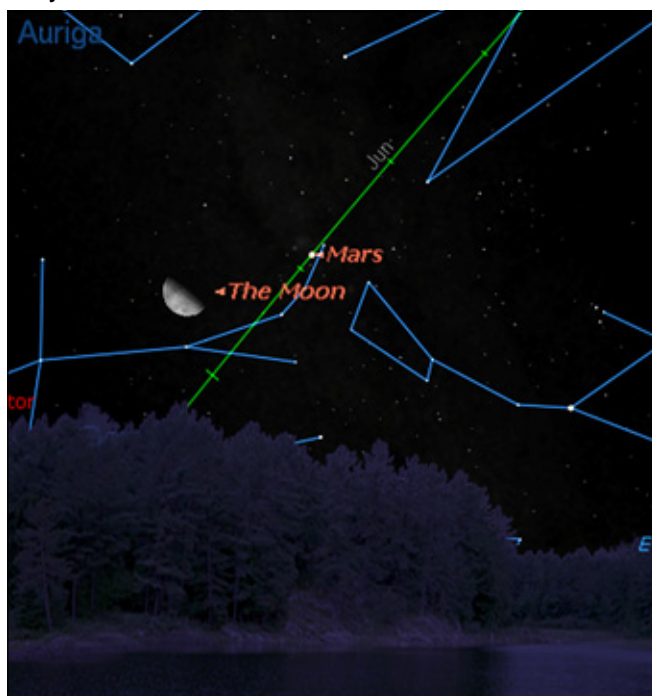


Venus at sunrise on the morning of the 23rd when it is about  $40^\circ$  above the horizon.

## October 2007 Lunar Data:

- ☆Last Quarter on the 3rd at 6.06am EDT
- ☆New Moon on the 11th at 1.01am EDT
- ☆First Quarter on the 19th at 4.33am EDT
- ☆Full Moon on the 26th at 12.51am EDT

**Mars** is now rising before the midnight hour in the ENE sky early in the month. The Red Planet is now in Gemini and brightens noticeably from  $-0.0$  to  $-0.6$  magnitude this month. Tele-scopically Mars increases to  $12''$  of arc across by the 25th and is now marginally favorable enough to begin serious observations. It will also be about two months away from opposition on that day

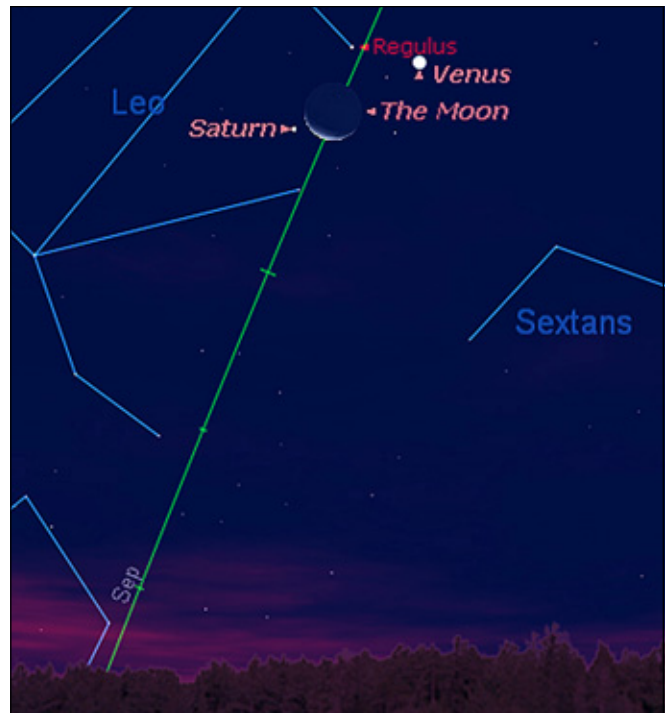


Mars & the last quarter moon rising above the trees on October 3rd at 1:00 am EDT.

**Jupiter** is bright & low in the SW at dusk setting nearly 3 hours after the Sun early in the month. By Halloween, Jupiter sets about 2 hours after sunset. Next month will be the last opportu-



**Saturn** is near Venus around the 12th-14th. It is now at +0.7 magnitude in Leo and continues to rise earlier each morning. By month's end, Saturn is rising around 5 hours before the Sun .



**Uranus** is transiting before midnight at mid-month. It is a +5.7 magnitude object in Aquarius, an easy target for telescopes appearing 3.7" or arc wide.

**Neptune** is also an easy target for telescopes this month transiting around 9:30 p.m. EDT at mid-month. It is a +7.8 magnitude object in Capricornus and 2.3" of arc wide

-- Boris Chertok, Deputy Director of USSR ICBM projects, upon hearing about how the news of the launch and orbit of Sputnik I effected the world



# Moon Over Madison Heights

by GM Ross

It might as well have been in south Georgia, the evening of 22 August 2007. The air was thick to sight and smell as the last light left the west at 22.00 E.S.T. I was crossing that purgatorial feature of the North American metropolitan landscape -- the parking lot of a big box store (where once two industrial establishments once stood) -- when I actually paused for an unnatural sight.

The gibbous Moon was dull and mauve. Extinction was brutal. More to the point, the Moon was very near meridian, but how very, very close to the southern horizon she stood! One could almost believe I was looking east at the rising, but no, this was at culmination. The Moon's position in the sky and orientation bordered on the unreal. Jupiter, the only other object visible in the south, was to the west and above her.

Once again the Metonic Cycle was at work. The nodes of the lunar orbit with the Plane of the Ecliptic regress completely around the Celestial Sphere every 18.6 years. Moreover, the Moon's orbit is inclined to the Ecliptic, some over five degrees, so every eighteen to twenty years the Moon can be found well to the south of that great circle in Sagittarius or well above it in Gemini. The latter is tough to notice since high up there are no points of reference except the constellations, but when the Moon stands outside the southern Ecliptic the observer has a familiar metric -- the horizon. The first time I noticed this effect, and knew what I was looking at, was in the summer of 1966 when the July or August full Moon seemed too close to the horizon from southern Michigan. To repeat: the Metonic Cycle, after Meton, the first at least in the west to describe the motion.

Now for the numbers. The next evening was the Discussion Group of the Warren Astronomical Society, to which I brought cheap pizza but even then could not get agenda time. One of the Society's more notorious members got out his little hand thingy with more computing power than ENIAC and UNIVAC combined, and told us the declination was bang-on -29°. That number struck me as about right, as low as the Moon can go on the Celestial Sphere. Now, my latitude was 42° 30". The arithmetic plays out (not "do the math"), the Moon at 20h E.S.T. was 18° 30' high on the more-or-less meridian, since I do not know the exact transit time.

If this was an arresting sight from south-eastern Lower Michigan, from the typically over-specified

parking lot of a cookie cutter store, let the magic carpet of the mind take hold: go sailing off with Peter Pan or Mary Poppins...

In the early summer of 1961 my family went on a 'round Superior trip using the spanking new Trans-Canada Highway. What a departure from the old, temporary route via Kapuskasing, but that is another story. We spent the night at some campground west of Marathon very close to the water, Neys or Rossport (!) Provincial Park. What a fine moonlit night, and with my brother's 4.25" reflector to boot. I recall how *low* everything was in the south. Jupiter and Saturn in those days were summer planets, and Sagittarius and Scorpius were scraping the horizon for this boy used to the torrid south. What would the Moon have looked like " 'way up" there last August 22? 'Zounds! But even though Ontario sorts think they are at the end of the world at Marathon, and Michigan lads think Houghton is Ultima Thule, try someplace really "up north," like... Warsaw or Swinging London, as we said for some bizarre reason in the late 1960s. Warsaw is at fifty two, nine and one-half degrees more latitude than Swinging Madison Heights.

Nine degrees at transit, repeat NINE DEGREES up at Warsaw -- although to be a spoiler that fabled city is six time zones to the east, so the Moon had not arrived at nadir at close of twilight. She moves a diameter every half-hour. Alright, say ten degrees elevation. We should hope they had a clear summer night in middle Poland with long, long shadows from a Moon just peaking over the southern horizon before sinking too quickly again. Old Polish song: "Oh, how lovely is the evening, is the evening. [ Key change] Oh, how lovely..."

Not to look up is to look at the ground.

Addendum: It was clear in Mother Poland after a hot day, 32C at Warsaw, warmer than even tropical Oakland County. There should have been numerous people in Park Lazienkowski at twilight, and a few of them would have noticed the Moon, what she is for on hot summer nights.

Note: These articles are courtesy **NASA Space Place Program** at the Jet Propulsion Laboratory.

## A Missile in Your Eye

by Patrick L. Barry

Satellite technology designed to catch ballistic missile launches may soon help doctors monitor the health of people's eyes.

For the last 15 years, Greg Bearman and his colleagues at JPL have been working on a novel design for a spectrometer, a special kind of camera often used on satellites and spacecraft. Rather than snapping a simple picture, spectrometers measure the spectrum of wavelengths in the light coming from a scene. From that information, scientists can learn things about the physical properties of objects in the photo, be they stars or distant planets or vegetation on Earth's surface.

In this case, however, the challenge was to capture snapshots of short-lived events—like missile launches! The team of JPL scientists designed the new spectrometer, called a computed tomographic imaging spectrometer (CTIS), in collaboration with the Ballistic Missile Defense Organization as a way to detect missiles by the spectral signatures of their exhaust.

But now the scientists are pointing CTIS at another fast-moving scene: the retina of an eye.

Blood flowing through the retina has a different spectral signature when it is rich in oxygen than when it is oxygen deprived. So eye doctors can use a spectrometer to look for low oxygen in the retina—an indicator of disease. However, because the eye is constantly moving, images produced by conventional spectrometers would have motion blurring that is difficult to correct.

The spectrometer that Bearman helped to develop is different: It can capture the whole retina and its spectral information in a single snapshot as quick as 3 milliseconds. "We needed some-

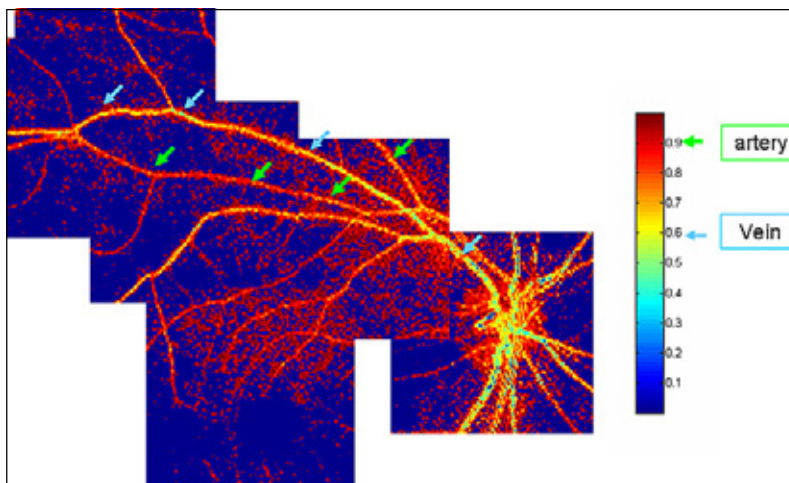
thing fast," says Bearman, and this spectrometer is "missile-quick."

CTIS is even relatively cheap to build, consisting of standard camera lenses and a custom, etched, transparent sheet called a grating. "With the exception of the grating, we bought everything on Amazon," he says.

The grating was custom-designed at JPL. It has a pattern of microscopic steps on its surface that split incoming light into 25 separate images arranged in a 5 by 5 grid. The center image in the grid shows the scene undistorted, but colors in the surrounding images are slightly "smeared" apart, as if the light had passed through a prism. This separation of colors reveals the light's spectrum for each pixel in the image.

"We're conducting clinical trials now," says Bearman. If all goes well, anti-missile technology may soon be catching eye problems before they have a chance to get off the ground.

Information about other NASA-developed technologies with spin-off applications can be found at <http://www.sti.nasa.gov/tto>.



*This three-color composite image from the computed tomographic imaging spectrometer shows the oxygenation of the blood in the arteries and veins of a human retina. (Arteries appear red, veins appear yellow.)*

# ROGER B. CHAFFEE PLANETARIUM

# Public Museum, Grand Rapids

## October 2007 Show Schedule

**For general audiences**

**STAR TREK: ORION RENDEZVOUS** – Audience members become Starfleet cadets, joining actors from *Star Trek: The Next Generation* on an adventure through a mysterious series of wormholes. At each stop, they encounter an exciting celestial wonder. **40 minutes**

SHOWTIMES: Daily at 2:00 pm

**UNDER STARLIT SKIES** – The planetarium operator hosts a live tour of the night sky, pointing out prominent stars, constellations, and planets currently visible. **30-40 minutes**

SHOWTIMES: Saturday and Sunday at 3:00 pm

**Added Value:** This show is free with paid Museum admission; or arrive after 2:30 p.m. for the planetarium show only and pay only \$3.00/ person.

## **For Families and Children**

**THE GREAT SPACE CHASE** – A police detective investigating a robbery pursues a criminal mastermind across the universe. Brilliant laser light, along with the planetarium's wide array of effects take you on the adventure. The show includes five exciting musical interludes, featuring artists such as U2, Madonna and Monty Python. **40 minutes**

SHOWTIMES: Saturday and Sunday at 1:00 pm

*But are we sure of our observational facts? Scientific men are rather fond of saying pontifically that one ought to be quite sure of one's observational facts before embarking on theory. Fortunately those who give this advice do not practice what they preach. Observation and theory get on best when they are mixed together, both helping one another in the pursuit of truth. It is a good rule not to put overmuch confidence in a theory until it has been confirmed by observation. I hope I shall not shock the experimental physicists too much if I add that it is also a good rule not to put overmuch confidence in the observational results that are put forward **until they have been confirmed by theory.***

-- Sir Arthur Stanley Eddington (1882-1944) English astronomer and physicist.



**Grand Rapids Amateur Astronomical Association  
Membership Application or Renewal Form**

DATE: \_\_\_\_\_

☐ **New Membership**      ☐ **Renewal**

Please fill out the information below as completely as possible.  
For Family memberships, please include all persons for whom membership is desired.

**Please Print**

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Name: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_

Home Phone: \_\_\_\_\_ Cell Phone: \_\_\_\_\_

E-Mail: \_\_\_\_\_

(Note: For Family members, if more than one e-mail address, please list others on back of application)

☐ **Adult** (18 or older, a Minimum of \$40.00) . . . . . \$ \_\_\_\_\_

☐ **Student** (through 17 yrs old, a Minimum of \$25.00) . . . . . \$ \_\_\_\_\_

☐ **Family** (all members of one family, a Minimum of \$50.00) . . . . . \$ \_\_\_\_\_

*(Note: Contributions greater than the minimum dues are considered a donation and are tax-deductible)*

☐ **Observatory Endowment Fund** . . . . . \$ \_\_\_\_\_

☐ **Miscellaneous Donations** . . . . . \$ \_\_\_\_\_

*(Note: Contributions to these funds are tax-deductible. Indicate amount of donation)*

☐ **OBSERVATORY USER FEE:** (a Minimum of \$25.00 per user) . . . . . \$ \_\_\_\_\_

*(Contributions of more than \$25 will help meet repairs and upgrade of equipment costs.)*

If you are a qualified user of the Veen Observatory, and wish to remain so,  
check the box for **"User Fee."**

**TOTAL ENCLOSED** (From all categories above) . . . . . \$ \_\_\_\_\_

Make Check or Money Order to:

**GRAND RAPIDS AMATEUR ASTRONOMICAL ASSOCIATION (or GRAAA)**

Mail to: Jerry Persha, GRAAA Treasurer  
199 Smith St.  
Lowell, MI 49331

Grand Rapids Amateur Astronomical Association  
3308 Kissing Rock Ave. SE  
Lowell, MI 49331-8918