Vendelinus Astronomy Newsletter

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Contents

1 Solar System

1.1 International Spacecraft Reveals Detailed Processes on the Sun

Source: NASA News Release, March 21st, 2007 [1]

NASA released on Wednesday never-before-seen images that show the sun's magnetic field is much more turbulent and dynamic than previously known. The international spacecraft Hinode, formerly known as Solar B, took the images.

Hinode, Japanese for "sunrise," was launched Sept. 23, 2006, to study the sun's magnetic field and how its explosive energy propagates through the different layers of the solar atmosphere. The spacecraft's uninterrupted high-resolution observations of the sun will have an impact on solar physics comparable to the Hubble Space Telescope's impact on astronomy.

"For the first time, we are now able to make out tiny granules of hot gas that rise and fall in the sun's magnetized atmosphere," said Dick Fisher, director of NASA's Heliophyics Division, Science Mission Directorate, Washington. "These images will open a new era of study on some of the sun's processes that effect Earth, astronauts, orbiting satellites and the solar system."

Hinode's three primary instruments, the Solar Optical Telescope, the X-ray Telescope and the Extreme Ultraviolet Imaging Spectrometer, are observing the different layers of the sun. Studies focus on the solar atmosphere from the visible surface of the sun, known as the photosphere, to the corona, the outer atmosphere of the sun that extends outward into the solar system.

"By coordinating the measurements of all three instruments, Hinode is showing how changes in the structure of the magnetic field and the release of magnetic energy in the low atmosphere spread outward through the corona and into interplanetary space to create space weather," said John Davis, project scientist from NASA's Marshall Space Flight Center, Huntsville, Ala.

Space weather involves the production of energetic particles and emissions of electromagnetic radiation. These bursts of energy can black out long-distance communications over entire continents and disrupt the global navigational system.

"Hinode images are revealing irrefutable evidence for the presence of turbulence-driven processes that are bringing magnetic fields, on all scales, to the sun's surface, resulting in an extremely dynamic chromosphere or gaseous envelope around the sun," said Alan Title, a corporate senior fellow at Lockheed Martin, Palo Alto, Calif., and consulting professor of physics at Stanford University, Stanford, Calif.

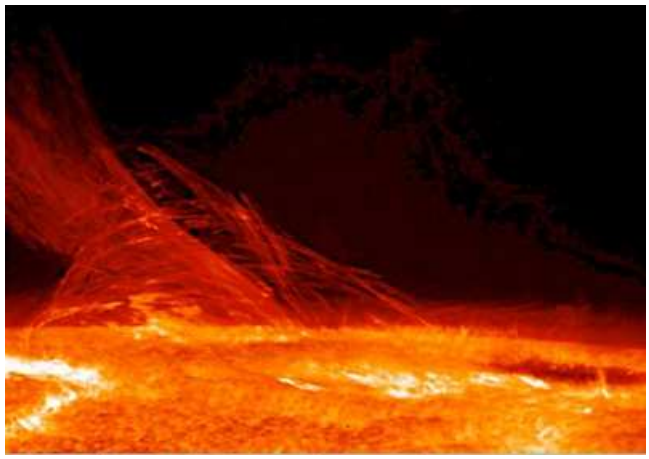

Figure 1: *Taken by Hinode's Solar Optical Telescope on Jan. 12, 2007, this image of the sun reveals the filamentary nature of the plasma connecting regions of different magnetic polarity. Hinode captures these very dynamic pictures of the chromosphere. The chromosphere is a thin "layer" of solar atmosphere "sandwiched" between the visible surface, photosphere, and corona. Image credit: Hinode JAXA/NASA*

Hinode is a collaborative mission led by the Japan Aerospace Exploration Agency and includes the European Space Agency and Britain's Particle Physics Astronomy Research Council. The National Astronomical Observatory of Japan, Tokyo, developed the Solar Optical Telescope, which provided the fine-scale structure views of the sun's lower atmosphere, and developed the X-ray Telescope in collaboration with the Smithsonian Astrophysical Observatory of Cambridge, Mass. The X-ray Telescope captured the rapid, time-sequenced images of explosive events in the sun's outer atmosphere.

"By following the evolution of the solar structures that outline the magnetic field before, during and after these explosive events, we hope to find clear evidence to establish that magnetic reconnection is the underlying cause for this explosive activity," said Leon Golub of the Smithsonian As-

trophysical Observatory.

1.2 New evidence puts 'Snowball Earth' theory out in the cold

Source: Imperial College London News Release, March 23rd, 2007 [2]

The theory that Earth once underwent a prolonged time of extreme global freezing has been dealt a blow by new evidence that periods of warmth occurred during this so-called 'Snowball Earth' era.

Analyses of glacial sedimentary rocks in Oman, published online today in Geology, have produced clear evidence of hot-cold cycles in the Cryogenian period, roughly 850-544 million years ago. The UK-Swiss team claims that this evidence undermines hypotheses of an ice age so severe that Earth's oceans completely froze over.

Using a technique known as the chemical index of alteration, the team examined the chemical and mineral composition of sedimentary rocks to search for evidence of any climatic changes. A high index of alteration would indicate high rates of chemical weathering of contemporary land surfaces, which causes rocks to quickly decompose and is enhanced by humid or warm conditions. Conversely, a low chemical index of alteration would indicate low rates of chemical weathering during cool, dry conditions.

The researchers found three intervals with evidence for extremely low rates of chemical weathering, indicating pulses of cold climate. However these intervals alternate with periods of high rates of chemical weathering, likely to represent interglacial periods with warmer climates.

These warmer periods mean that, despite the severe glaciation of this time in Earth history, the complete deep-freeze suggested by 'Snowball Earth' theories never took place, and that some areas of open, unfrozen ocean continued to exist. Leader of the study, Professor Philip Allen New Window of Imperial College London's Department of Earth Science and Engineering, explains:

"If the Earth had become fully frozen for a long period of time, these climatic cycles could not exist the Earth would have changed into a bleak world with almost no weather, since no evaporation from the oceans could take place, and little snowfall would be possible. In fact, once fully frozen, it is difficult to create the right conditions to cause a thaw, since much of the incoming solar radiation would be reflected back by the snow and ice. The evidence of climatic cycles is therefore hostile to the idea of 'Snowball Earth'."

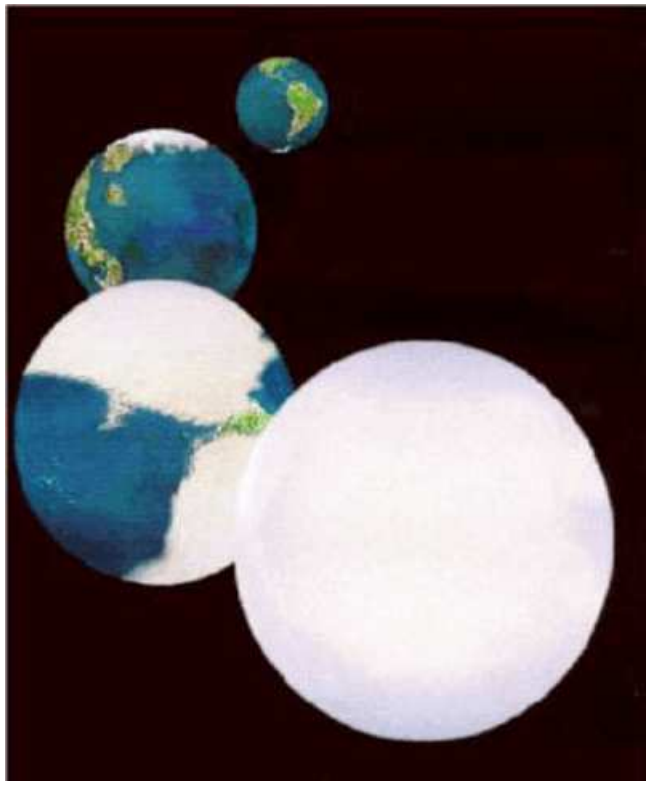

Figure 2: *Snowball Earth. Image credit: NASA*

Professor Allen adds that understanding how Earth's climate has changed in the past provides important data for current climate change models. He says:

"This isn't just curiosity about the past - we are living in a time of climate change and there is a huge debate going on over what the natural variability of the climate is. Knowledge of climate change in deep time provides clues to the way in which our climate system works under extreme conditions. But these extreme conditions were probably not a full global freeze. It is equally important to understand a picture of global climate retaining open ocean between the tropics."

This challenge to the 'Snowball Earth' opens intriguing questions about how the Earth came so close to climate disaster but managed to avoid it, according to Professor Allen.

"This was the most severe glaciation experienced by the planet over the last billion years, and the big question is - how can ice get all the way to the tropics but not finish the job?" he says. "The total icy shutdown that we came so close to would have dealt a severe blow to early life and most likely would have resulted in a completely different evolutionary pathway. The reasons for Earth?s near-miss with

global refrigeration remains an important scientific question to resolve."

The team's findings come from analyses of sedimentary rock from the Huqf Supergroup, Oman's oldest sedimentary sequence that spans around 200 million years of the Neoproterozoic era.

1.3 New research tool indicates those countries most at risk of 'small' asteroid impact

Source: University of Southampton News Release, March 9th, 2007 [3]

Researchers at the University of Southampton have developed a software package for modelling asteroid impacts that enables them to assess the potential human and economic consequences across the globe.

The software, called NEOimpactor, has been specifically developed for measuring the impact of 'small' asteroids under one kilometre in diameter, and early results indicate that the ten countries most at risk are China, Indonesia, India, Japan, the United States, the Philippines, Italy, the United Kingdom, Brazil and Nigeria.

'The threat of the Earth being hit by an asteroid is increasingly being accepted as the single greatest natural disaster hazard faced by humanity,' comments Nick Bailey of the University of Southampton's School of Engineering Sciences, who developed the software with University colleague Dr Graham Swinerd, and Dr Richard Crowther of the Rutherford Appleton Laboratory.

'Since 1998 the international Spaceguard survey has been cataloguing all near earth asteroids (NEA) larger than one kilometre in diameter. However, small asteroids, under one kilometre in diameter, remain predominantly undetected. While the direct consequences might not be quite as extreme, these small objects exist in far greater numbers and therefore will impact more frequently. It is on these sub-kilometre asteroid impacts that we have been focusing to assess the consequences for both humans and for infrastructure across the globe.'

Initial investigations have examined how the consequences of an impact change with increasing impact energy. Taking a spherical stony asteroid travelling at 12,000 miles per second and varying the diameter to increase kinetic energy, the results indicate that a 100 metre diameter asteroid will predominantly cause localised casualties and damage across a few countries when impacting on either land or ocean. However, the consequences of a 200 metre diameter asteroid hitting the ocean increase significantly, with the generated tsunamis reaching a global scale. At 500 metres in diameter, almost any ocean impact will generate significant casualties and economic cost across the world.

The team used the raw data from the multiple impact simulations to rank each country based on the number of times and how severely they would be affected by each impact. Early results show that in terms of population lost, China, Indonesia, India, Japan and the United States face the greatest overall threat; while the United States, China, Sweden, Canada and Japan face the most severe economic effects due to the infrastructure destroyed.

In both rankings, the United Kingdom appears eighth in the list of countries most affected. Of the top twenty for each ranking, over half the countries appear in both lists.

'The consequences for human populations and infrastructure as a result of an impact are enormous,' continues Nick Bailey. 'Nearly one hundred years ago a remote region near the Tunguska River witnessed the largest asteroid impact event in living memory when a relatively small object (approximately 50 metres in diameter) exploded in mid-air. While it only flattened unpopulated forest, had it exploded over London it could have devastated everything within the M25.

'Our results highlight those countries that face the greatest risk from this most global of natural hazards and thus indicate which nations need to be involved in mitigating the threat.'

1.4 Binary asteroid revealed as twin rubble piles

Source: UCBerkeley Press Release, March 29th, 2007 [4]

Roping together observations from the world's largest telescopes as well as the small instrument of a local backyard amateur, astronomers have assembled the most complete picture yet of a pair of asteroids whirling around one another in a perpetual pas de deux.

In a paper to be published in the April 2007 issue of the journal Icarus, a team of University of California, Berkeley, and Paris Observatory astronomers depict the asteroid 90 Antiope as two slightly egg-shaped rubble piles locked in orbit, like two twirling dancers facing one another with linked arms.

This new view of Antiope is the culmination of research that started in 2003 and that eventually included data supplied by both professional and amateur astronomers from around the globe.

Before the year 2000, Antiope was just another main-belt asteroid, one of millions between the orbits of Mars and Jupiter. But that year, it was resolved into a doublet, thanks to sharper pictures obtained with adaptive optics (AO) on the largest ground-based telescope, the 10-meter Keck II telescope in Hawaii. Yet, even with AO, these two asteroids were too small for astronomers to discern their shape or to see more than two bright blobs revolving around their center of mass.

Two years ago, with improved images from the European Southern Observatory's 8-meter Very Large Telescope (VLT) in Chile and Keck II, University of California, Berkeley astronomer Franck Marchis and colleagues in France were able to determine the orbits of the two asteroids, each of them about 86 kilometers in diameter and separated by about 171 kilometers.

But uncertainties remained, and in 2005 the team invited observers around the world to turn their telescopes on the asteroid pair during a time when they predicted a mutual eclipse or occultation would cause a drop in brightness. In an eclipse, one of the pair casts a shadow over the other; in an occultation, one passes in front of, and completely blocks light from, the other.

Sure enough, at the appointed time on May 31, 2005, one of the asteroids eclipsed the other, and team member Tadeusz Michalowski e-mailed Marchis and their colleagues from South Africa to confirm the eclipse. Michalowski, an astronomer at Adam Michiewicz University's Astronomical Observatory in Poznan, Poland, recorded the dip in Antiope's brightness from the South African Astronomical Observatory.

Over the next six months, at Marchis' invitation, amateurs and professionals from as far afield as Brazil, France, Runion Island in the Indian Ocean and Grass Valley, Calif., observed repeated occultations, as well as shadows passing over one of the pair.

"This is the first publication I've had in a professional journal, and I'm really happy about it," said amateur astronomer Peter Dunckel, 75, a retired paper company executive who observes from the backyard of his vacation home in Grass Valley. "What is really a thrill is to have my little 7-inch telescope along with an 8-meter telescope on the same paper; it is unbelievable."

Dunckel observed the binary pair for 35 hours over a period of six weeks, recording Antiope's brightness every minute with a CCD camera attached to his Maksutov Newtonian reflector telescope.

"Amateurs can be used for professional studies, compensating for the small size of their telescopes by the large numbers of observations and the frequency of observations they can do," Marchis said. "You can time the orbits more precisely when a mutual event happens, which allows you to extract also the size, shape and surface detail of each component, and also what it's made of."

The asteroid pair is itself the remnant of an ancient asteroid, dubbed Themis, which astronomers estimate was destroyed around 2.5 million years ago, probably hit by another asteroid. The rubble spread out from the point of impact but continued to follow approximately the same orbit around the sun in the outer part of the main asteroid belt. Themis was a carbonaceous chondrite left over from the formation of the solar system 2.5 billion years ago.

Evidently, either another asteroid hit Antiope again to split it in two, or two of the Themis pieces remained bound to one another after the initial break up, possibly even remaining attached. However the doublet arose, computer simulations by another group suggest that the spinning, elongated rubble pile would have separated into two egg-shaped rubble piles, each the shape of a Roche ellipsoid, the theoretical shape predicted for a system if their composition was liquid or loosely aggregated, rather than solid, and if the components are deformed due to mutual gravitation.

The eclipse and occultation observations, combined with previous observations of Antiope during a grazing occultation, confirmed the ellipsoid shape of each component of the asteroid, Marchis said. Each component differs from a sphere by less than 7 percent, or 6 kilometers out of 86. They orbit around their center of mass every 16.5 days

Figure 3: *Artist's rendering of the binary asteroid 90 An-*

tiope, located in the outer part of the main asteroid belt between Mars and Jupiter. UC Berkeley and Paris Observatory astronomers found these two asteroids to be rubble piles, each 86 kilometers in diameter and about 30 percent empty space, orbiting one another in a perpetual pas de deux. (Copyright European Southern Observatory)

"Due to mutual gravitation, both components took a shape very close to the pure hydrostatic shape, the Roche ellipsoid, as if the asteroid was a fluid," Marchis said. "This result indicates that the internal strength in the components must be low, so possibly a rubble pile structure."

They were able to calculate the density as 1.25 grams per cubic centimeter (water is one gram per cubic centimeter), which, if one assumes that the rock component is carbonaceous chondrite, means the asteroid pair is 30 percent empty space.

"Despite this intensive study, the origin of this unique doublet still remains a mystery," said team member Pascal Descamps, an astronomer at the Institut de Mecanique Celeste et de Calculs des Ephemerides (IMCCE) of the Observatoire de Paris. "The formation of such a large double system is an improbable event and represents a formidable challenge to theory. It is possible that a parent body was spun up so much that it broke apart, but this seems very hard to do for asteroids in the main belt, unlike, for example, near-Earth asteroids."

Marchis and his team are employing both amateur and professional astronomers to observe more of these mutual events between components of binary asteroid systems. These partnerships are a powerful way to get direct and accurate insights about these systems, he said.

As for Dunckel, who commutes from San Francisco to the Grass Valley vacation home he refers to as "Rattlesnake Creek Observatory," he says he's hooked on scientific amateur observing, "now that I've broken the dam, so to speak." He has upgraded to a 10-inch reflecting telescope and is excited about applying a new computer program that will allow him to create 3D models of asteroids from light curves he obtains in collaboration with others.

1.5 Solar Power at Play

Source: ESO Press Release, March 7th, 2007 [5]

For the very first time, astronomers have witnessed the speeding up of an asteroid's rotation, and have shown that it is due to a theoretical effect predicted but never seen before. The international team of scientists used an armada of telescopes to discover that the asteroid's rotation period currently decreases by 1 millisecond every year, as a consequence of the heating of the asteroid's surface by the Sun. Eventually it may spin faster than any known asteroid in the solar system and even break apart.

"The Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect is believed to alter the way small bodies in the Solar System rotate," said Stephen Lowry (Queens University Belfast, UK), lead-author of one of the two companion papers in which this work is reported.

"The warming caused by sunlight hitting the surfaces of asteroids and meteoroids leads to a gentle recoil effect as the heat is released," he added. "By analogy, if one were to shine light on a propeller over a long enough period, it would start spinning."

Although this is an almost immeasurably weak force, its effect over millions of years is far from negligible. Astronomers believe the YORP effect may be responsible for spinning some asteroids up so fast that they break apart, perhaps leading to the formation of double asteroids. Others may be slowed down so that they take many days to complete a full turn. The YORP effect also plays an important role in changing the orbits of asteroids between Mars and Jupiter, including their delivery to planet-crossing orbits, such as those of near-Earth asteroids. Despite its importance, the effect has never been seen acting on a solar system body, until now.

Using extensive optical and radar imaging from powerful Earth-based observatories, astronomers have directly observed the YORP effect in action on a small near-Earth asteroid, known as (54509) 2000 PH5.

Shortly after its discovery in 2000, it was realised that asteroid 2000 PH5 would be the ideal candidate for such a YORP detection. With a diameter of just 114 metres, it is relatively small and so more susceptible to the effect. Also, it rotates very fast, with one 'day' on the asteroid lasting just over 12 Earth minutes, implying that the YORP effect may have been acting on it for some time. With this in mind, the team of astronomers undertook a long term monitoring campaign of the asteroid with the aim of detecting any tiny changes in its rotation speed.

Over a 4-year time span, Stephen Lowry, Alan Fitzsimmons and colleagues took images of the asteroid at a range of telescope sites including ESO's 8.2-m Very Large Telescope array and 3.5-m New Technology Telescope in Chile, the 3.5-m telescope at Calar Alto, Spain, along with a suite of other telescopes from the Czech Republic, the Canary Islands, Hawaii, Spain and Chile. With these facilities the

astronomers measured the slight brightness variations as the asteroid rotated.

Over the same time period, the radar team led by Patrick Taylor and Jean-Luc Margot of Cornell University employed the unique capabilities of the Arecibo Observatory in Puerto Rico and the Goldstone radar facility in California to observe the asteroid by 'bouncing' a radar pulse off the asteroid and analysing its echo.

"With this technique we can reconstruct a 3-D model of the asteroid's shape, with the necessary detail to allow a comparison between the observations and theory," said Taylor.

After careful analysis of the optical data, the asteroid's spin rate was seen to steadily increase with time, at a rate that can be explained by the YORP theory. Critically, the effect was observed year after year, for more than 4 years. Furthermore, this number was elegantly supported via analysis of the combined radar and optical data, as it was required that the asteroid is increasing its spin rate at exactly this rate in order for a satisfactory 3-D shape model to be determined.

To predict what will happen to the asteroid in the future, Lowry and his colleagues performed detailed computer simulations using the measured strength of the YORP effect and the detailed shape model. They found that the orbit of the asteroid about the Sun could remain stable for up to the next 35 million years, allowing the rotation period to be reduced by a factor of 36, to just 20 seconds, faster than any asteroid whose rotation has been measured until now.

"This exceptionally fast spin-rate could force the asteroid to reshape itself or even split apart, leading to the birth of a new double system," said Lowry.

1.6 New Horizons' LORRI Takes an Even Closer Look at the Little Red Spot

Source: New Horizons Press Release, March 23rd, 2007 [6]

The New Horizons Long Range Reconnaissance Imager (LORRI) has returned stunning new images of Jupiter's Little Red Spot, obtained as a 2-by-2 mosaic at 0312 UTC on February 27, 2007, from a distance of 3 million kilometers (1.8 million miles). The image scale is 15 kilometers (about 9 miles) per pixel.

By comparison, team members say, ground-based and Earth-orbiting imagers rarely do better than 200-kilometer (130-mile) resolution on Jupiter.

"These LORRI images of the Little Red Spot are amazing in their detail," says New Horizons Project Scientist Dr. Hal Weaver, of the Johns Hopkins University Applied Physics Laboratory, where the spacecraft and LORRI camera were designed and built. "They show the early stages of this newly reddened storm system with a resolution that far surpasses anything available until now."

LORRI took this mosaic 9.5 hours - or not quite one Jupiter rotation period - after snapping its previous images of the Little Red Spot on Feb 26, 2007, at a longer range of 3.5 million kilometers (2.2 million miles) and at a lower resolution of 17 kilometers (10.5 miles) per pixel. The new mosaic was obtained with the Little Red Spot closer to the center of the visible disk of Jupiter, so there is less foreshortening and better illumination.

The Little Red Spot is an Earth-sized storm on Jupiter that changed its color from white to red in 2005. Swimming to the east, its clouds rotate counterclockwise (or in the anticyclonic direction), meaning that it is a high-pressure region. In that sense, the Little Red Spot is the opposite of a hurricane on Earth, which is a low-pressure region - and it is of course much larger than any hurricane on Earth.

Scientists don't know exactly how or why the storm turned red - though they speculate that the change could stem from a surge of exotic compounds from deep within Jupiter, caused by an intensification of the storm system. In particular, sulfur-bearing cloud droplets might have been propelled about 50 kilometers into the upper level of ammonia clouds, where brighter sunlight bathing the cloud tops released the red-hued sulfur embedded in the droplets - causing the storm to turn red. A similar mechanism has been proposed for the Little Red Spot's "big brother," the Great Red Spot, a massive energetic storm system that has existed for centuries.

The smaller, brighter oval to the south of the Little Red Spot is another storm moving more rapidly to the east, as can be seen by comparing the previous mosaic to the newer one. Any feature that moved by as much as 100 pixels between the earlier mosaic and the new one - as many features have done - has shifted at an average relative speed faster than 95 miles per hour, indicating hurricane force winds. The awesome violence of the storms in Jupiter's atmosphere contrasts with the serene isolation of New Horizons' LORRI, snapping pictures from millions of miles away.

"The new images are further proof that LORRI is one of the best imagers ever flown on a planetary mission," says Dr. Andy Cheng, the LORRI principal investigator from the Applied Physics Laboratory, "and more delights are yet to come."

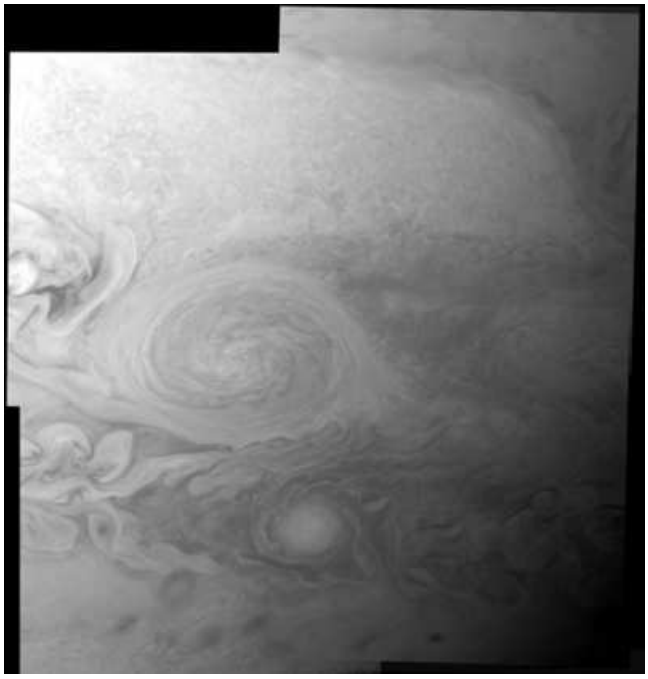

Figure 4:

1.7 Cassini Images Bizarre Hexagon on Saturn

Source: JPL/NASA Press Release, March 27th, 2007 [7]

An odd, six-sided, honeycomb-shaped feature circling the entire north pole of Saturn has captured the interest of scientists with NASA's Cassini mission.

NASA's Voyager 1 and 2 spacecraft imaged the feature over two decades ago. The fact that it has appeared in Cassini images indicates that it is a long-lived feature. A second hexagon, significantly darker than the brighter historical feature, is also visible in the Cassini pictures. The spacecraft's visual and infrared mapping spectrometer is the first instrument to capture the entire hexagon feature in one image.

"This is a very strange feature, lying in a precise geometric fashion with six nearly equally straight sides," said Kevin Baines, atmospheric expert and member of Cassini's visual and infrared mapping spectrometer team at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "We've never seen anything like this on any other planet. Indeed, Saturn's thick atmosphere where circularly-shaped waves and convective cells dominate is perhaps the last place you'd expect to see such a six-sided geometric figure, yet there it is."

The hexagon is similar to Earth's polar vortex, which has winds blowing in a circular pattern around the polar region. On Saturn, the vortex has a hexagonal rather than circular shape. The hexagon is nearly 25,000 kilometers (15,000 miles) across. Nearly four Earths could fit inside it.

The new images taken in thermal-infrared light show the hexagon extends much deeper down into the atmosphere than previously expected, some 100 kilometers (60 miles) below the cloud tops. A system of clouds lies within the hexagon. The clouds appear to be whipping around the hexagon like cars on a racetrack.

"It's amazing to see such striking differences on opposite ends of Saturn's poles," said Bob Brown, team leader of the Cassini visual and infrared mapping spectrometer, University of Arizona, Tucson. "At the south pole we have what appears to be a hurricane with a giant eye, and at the north pole of Saturn we have this geometric feature, which is completely different."

The Saturn north pole hexagon has not been visible to Cassini's visual cameras, because it's winter in that area, so the hexagon is under the cover of the long polar night, which lasts about 15 years. The infrared mapping spectrometer can image Saturn in both daytime and nighttime conditions and see deep inside. It imaged the feature with thermal wavelengths near 5 microns (seven times the wavelength visible to the human eye) during a 12-day period beginning on Oct. 30, 2006. As winter wanes over the next two years, the feature may become visible to the visual cameras.

Based on the new images and more information on the depth of the feature, scientists think it is not linked to Saturn's radio emissions or to auroral activity, as once contemplated, even though Saturn's northern aurora lies nearly overhead.

The hexagon appears to have remained fixed with Saturn's rotation rate and axis since first glimpsed by Voyager 26 years ago. The actual rotation rate of Saturn is still uncertain.

"Once we understand its dynamical nature, this long-lived, deep-seated polar hexagon may give us a clue to the true rotation rate of the deep atmosphere and perhaps the interior," added Baines.

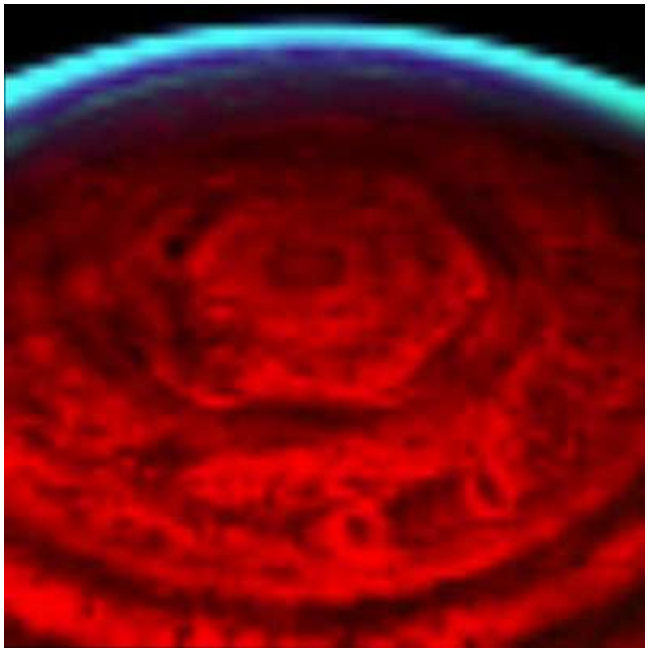

Figure 5: *This nighttime view of Saturn's north pole by the visual and infrared mapping spectrometer onboard NASA's Cassini orbiter clearly shows a bizarre six-sided hexagon feature encircling the entire north pole. This is one of the first clear images taken of the north polar region ever acquired from a unique polar perspective.*

The hexagon images and movie, including the north polar auroras are available at: [8] and [9] and [10] .

1.8 Tiny Enceladus masks mighty Saturn?s clock

Source: Imperial College London News Release, March 23rd, 2007 [11]

New data from NASA's Cassini spacecraft, reported in the online version of Science today (22 March 2007), shows how the small moon, Enceladus, is weighing down Saturn's magnetic field so much that the field is rotating slower than the planet. This phenomenon makes it nearly impossible to measure the length of the Saturn day using techniques that work at the other giant planets.

"No one could have predicted that the little moon Enceladus would have such an influence on the radio technique that has been used for years to determine the length of the Saturn day," said Dr. Don Gurnett of the University of Iowa, Iowa City. Gurnett is the principal investigator on the radio and plasma wave science experiment onboard NASA's Cassini spacecraft. The radio technique measures the rotation of the planet by taking its radio pulse rate - the rhythm of natural radio signals from the planet.

A new study of Cassini data determined that Saturn's magnetic field lines are being forced to slip relative to the rotation of the planet by the weight of electrically charged particles originating from geysers spewing water vapor and ice from Enceladus. These results are based on joint observations by two Cassini instruments - the radio and plasma wave instrument and the magnetometer.

"The direct link between radio, magnetic field and deep planetary rotation has been taken for granted up to now. Saturn is showing we need to think further," said Professor Michele Dougherty New Window, principal investigator on Cassini's magnetometer instrument from Imperial College London.

The neutral gas particles ejected from the geysers on Enceladus form a doughnut-like ring around Saturn. As these particles become electrically charged, they are captured by Saturn's magnetic field, forming a disk of ionized gas, or plasma, which surrounds the planet near the equator. The particles weigh down the magnetic field so much that the plasma disk slows down slightly. This slippage causes the radio period, controlled by the plasma disk rotation, to be longer than the planet's actual rotation period.

Scientists conclude the period Cassini has been measuring from radio emission is not the length of the Saturn day, but rather the rotation of the plasma disk. At present, because of Saturn's cloud motion, no technique is known that can accurately measure the planet's actual internal rotation.

Finding out the length of Saturn's day has been a challenge because the gaseous planet has no surface or fixed point to clock its rotation rate. Initially, the approach was to use periodic regular radio signals, as has been done for Jupiter, Uranus and Neptune. However, Saturn's radio period has turned out to be troubling in two ways. It seems to be a pulsed signal rather than a rotating, lighthouse-like beam. Secondly, the period seems to be slowly changing over months to years. The day measured by Cassini is some six minutes longer than the day recorded by NASA's Voyager spacecraft in the early 1980s, a change of nearly 1 percent.

"We have linked the pulsing radio signal to a rotating magnetic signal. Once each rotation of Saturn's magnetic field, an asymmetry in the field triggers a burst of radio waves," said Professor David Southwood New Window, co-author, Imperial College London, and director of science at the Eu-

ropean Space Agency. ”We have then linked both signals to material that has come from Enceladus.”

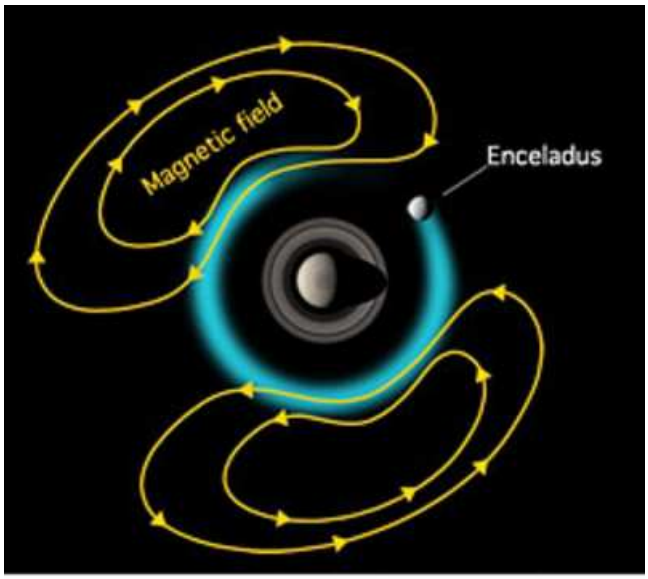

Figure 6:

Based on the new observations, scientists now think there are two possible reasons for the change in radio period. The first theory is that the geysers on Enceladus could be more active now than in Voyagers? time. The second is that there may be seasonal variations as Saturn orbits the sun once every 29 years.

”One would predict that when the geysers are very active, the particles load down the magnetic field and increase the slippage of the plasma disk, thereby increasing the radio emission period even more. If the geysers are less active, there would be less of a load on the magnetic field, and therefore less slippage of the plasma disk, and a shorter period,” said Gurnett.

Dr Hugo Alleyne from the University of Sheffield is a UK co-investigator on the radio and plasma wave instrument. He comments, ”This is a very significant result which would not have been possible without the suite of instruments on the Cassini spacecraft making simultaneous measurements of fields, waves and plasma. It is likely to have implications in the interpretation of other astronomical and planetary measurements.”

1.9 A Hot Start Might Explain Geysers on Enceladus

Source: JPL/NASA Press Release, March 12th, 2007 [12]

A hot start billions of years ago might have set into motion the forces that power geysers on Saturn’s moon Enceladus.

”Deep inside Enceladus, our model indicates we’ve got an organic brew, a heat source and liquid water, all key ingredients for life,” said Dr. Dennis Matson, Cassini project scientist at NASA’s Jet Propulsion Laboratory, Pasadena, Calif. ”And while no one is claiming that we have found life by any means, we probably have evidence for a place that might be hospitable to life.”

Since NASA’s Voyager spacecraft first returned images of the moon’s snowy white surface, scientists have suspected Enceladus had to have something unusual happening within that shell. Cameras on NASA’s Cassini orbiter seemed to confirm that suspicion in 2005 when they spotted geysers on Enceladus ejecting water vapor and ice crystals from its south polar region. The challenge for researchers has been to figure out how this small ice ball could produce the levels of heat needed to fuel such eruptions.

A new model suggests the rapid decay of radioactive elements within Enceladus shortly after it formed may have jump-started the long-term heating of the moon’s interior that continues today. The model provides support for another recent, related finding, which indicates that Enceladus’ icy plumes contain molecules that require elevated temperatures to form.

”Enceladus is a very small body, and it’s made almost entirely of ice and rock. The puzzle is how the moon developed a warm core,” said Dr. Julie Castillo, the lead scientist developing the new model at JPL. ”The only way to achieve such high temperatures at Enceladus is through the very rapid decay of some radioactive species.”

The hot start model suggests Enceladus began as a mixed-up ball of ice and rock that contained rapidly decaying radioactive isotopes of aluminum and iron. The decomposition of those isotopes – over a period of about 7 million years – would produce enormous amounts of heat. This would result in the consolidation of rocky material at the core surrounded by a shell of ice. According to the theory, the remaining, more slowly decaying radioactivity in the core could continue to warm and melt the moon’s interior for billions of years, along with tidal forces from Saturn’s gravitational tug.

Scientists have also found the model helpful in explaining how Enceladus might have produced the chemicals in the plume, as measured by Cassini's ion and neutral mass spectrometer. Matson is lead author of a new study of the plume's composition, which appears in the April issue of the journal Icarus. Although the plume is predominantly made up of water vapor, the spectrometer also detected within the plume minor amounts of gaseous nitrogen, methane, carbon dioxide, propane and acetylene.

Scientists were particularly surprised by the nitrogen because they don't think it could have been part of Enceladus' original makeup. Instead, Matson's team suggests it is the product of the decomposition of ammonia deep within the moon, where the warm core and surrounding liquid water meet.

The thermal decomposition of ammonia would require temperatures as high as 577 degrees Celsius (1070 degrees Fahrenheit), depending on whether catalysts such as clay minerals are present. And while the long-term decay of radioactive species and current tidal forces alone cannot account for such high temperatures, with the help of the hot start model, they can.

The scalding conditions are also favorable for the formation of simple hydrocarbon chains, basic building blocks of life, which Cassini's spectrometer detected in small amounts within Enceladus' plume. The team concludes that so far, all the findings and the hot start model indicate that a warm, organic-rich mixture was produced below the surface of Enceladus and might still be present today, making the moon a promising kitchen for the cooking of primordial soup.

To gather more information about the chemistry within Enceladus, the team plans to directly measure the gas emanating from the plume during a flyby scheduled for March 2008.

1.10 Cassini Spacecraft Images Seas on Saturn's Moon Titan

Source: JPL/NASA Press Release, March 13th, 2007 [13]

Instruments on NASA's Cassini spacecraft have found evidence for seas, likely filled with liquid methane or ethane, in the high northern latitudes of Saturn's moon Titan. One such feature is larger than any of the Great Lakes of North America and is about the same size as several seas on Earth.

Cassini's radar instrument imaged several very dark features near Titan's north pole. Much larger than similar features seen before on Titan, the largest dark feature measures at least 100,000 square kilometers (39,000 square miles). Since the radar has caught only a portion of each of these features, only their minimum size is known. Titan is the second largest moon in the solar system and is about 50 percent larger than Earth's moon.

"We've long hypothesized about oceans on Titan and now with multiple instruments we have a first indication of seas that dwarf the lakes seen previously," said Dr. Jonathan Lunine, Cassini interdisciplinary scientist at the University of Arizona, Tucson.

While there is no definitive proof yet that these seas contain liquid, their shape, their dark appearance in radar that indicates smoothness, and their other properties point to the presence of liquids. The liquids are probably a combination of methane and ethane, given the conditions on Titan and the abundance of methane and ethane gases and clouds in Titan's atmosphere.

Figure 7: *This side-by-side image shows a Cassini radar image (on the left) of what is the largest body of liquid ever found on Titan's north pole, compared to Lake Superior (on the right). This close-up is part of a larger image (see Titan (T25) Viewed by Cassini's Radar - Feb. 22, 2007) and offers strong evidence for seas on Titan. These seas are most likely liquid methane and ethane. This feature on Titan is at least 100,000 square kilometers (39,000 square miles), which is greater in extent than Lake Superior (82,000 square kilometers or 32,000 square miles), which is one of Earth's largest lakes. The feature covers a greater fraction of Titan than the largest terrestrial inland sea, the Black Sea. The Black Sea covers 0.085 percent of the surface of the Earth; this newly observed body on Titan covers at least 0.12 percent of the surface of Titan. Because of its size, scientists are calling it a sea. The image on the right is from the SeaWiFS project, NASA's Goddard Space Flight Center, Greenbelt, Md.*

Cassini's visual and infrared mapping spectrometer also captured a view of the region, and the team is working to

determine the composition of the material contained within these features to test the hypothesis that they are liquid-filled.

The imaging cameras, which provide a global view of Titan, have imaged a much larger, irregular dark feature. The northern end of their image corresponds to one of the radar-imaged seas. The dark area stretches for more than 1,000 kilometers (620 miles) in the image, down to 55 degrees north latitude. If the entire dark area is liquid-filled, it would be only slightly smaller than Earth's Caspian Sea. The radar data show details at the northern end of the dark feature similar to those seen in earlier radar observations of much smaller, liquid-filled lakes. However, to determine if the entire dark feature is a liquid-filled basin will require investigation through additional radar flyovers later in the mission.

The presence of these seas reinforces current thinking that Titan's surface must be re-supplying methane to its atmosphere, the original motivation almost a quarter century ago for the theoretical speculation of a global ocean on Titan.

Cassini's instruments are peeling back the haze that shrouds Titan, showing high northern latitudes dotted with seas hundreds of miles across, and hundreds of smaller lakes that vary from several to tens of miles.

Due to the new discoveries, team members are re-pointing Cassini's radar instrument during a May flyby so it can pass directly over the dark areas imaged by the cameras.

For images and more information visit: [14] and [15] .

2 Astrophysics

2.1 The Delicate Trails of Star Birth

Source: Gemini Observatory Press Release, March 22nd, 2007 [16]

An image released today by the Gemini Observatory brings into focus a new and remarkably detailed view of supersonic "bullets" of gas and the wakes created as they pierce through clouds of molecular hydrogen in the Orion Nebula. The image was made possible with new laser guide star adaptive optics technology that corrects in real time for image distortions caused by Earth's atmosphere.

The Orion Nebula is a star-forming region located relatively near to us, about 1,500 light-years away. It's a young stellar nursery and shows many unusual features related to the effect of massive stars on the dense birth environment of gas and dust.

The Orion bullets were first seen in a visible-light image in 1983. By 1992, images taken at infrared wavelengths led astronomers to conclude that these clumps of gas were ejected from deep within the nebula following an unknown violent event connected with the recent formation of a cluster of massive stars there. The bullets are speeding outward from the cloud at up to 400 kilometers (250 miles) per second. This is more than a thousand times faster than the speed of sound. The name "bullet" is somewhat misleading since these objects are truly gigantic. The typical size of one of the bullet tips is about ten times the size of Pluto's orbit around the Sun. The wakes shown in the image are about a fifth of a light-year long.

Clouds of iron atoms at the tip of each bullet glow brightly (blue in the Gemini image) as they are shock-heated by friction to around 5000 degrees C (9,000 degrees F). Molecular hydrogen, which makes up the bulk of both the bullets and the surrounding gas cloud, is destroyed at the tips by the violent collisions between the high-speed bullets and the surrounding cloud. On the trailing edges of the bullets, however, the hydrogen molecules are not destroyed, but instead are heated to about 2000 degrees C (4000 degrees F). As the bullets plow through the clouds they leave behind distinctive tubular wakes (colored orange in the Gemini image). These wakes shine like bullet tracers due to the heated molecular hydrogen gas.

"What I find stunning about the new image is the detail it shows, which was blurred out in any previous studies, revealing the structure of the bullets and their trailing wakes as they run into the surrounding molecular cloud," said Michael Burton of the University of New South Wales who, along with the late David Allen (Anglo-Australian Observatory) were the first to suggest the origin of these spectacular bullets 15 years ago. "This level of precision will allow the evolution of the system to be followed over the next few years, for small changes in the structures are expected from year to year as the bullets continue their outward motion."

The bullets are relatively young, with their ages estimated to be less than a thousand years since ejection. The new Gemini adaptive optics image shows them in near-infrared light in a combination of three images using different filters. The blue features in the Gemini image correspond to the shocked regions where the iron is fluorescing. The orange regions are the glowing hydrogen molecules in the bullet's wakes. In this image, the wakes ("fingers") behind each of the iron-gas bullets are resolved into filaments for the first time ever. These might well be the actual sheaths enclosing the shock waves created as the bullets travel through the cloud.

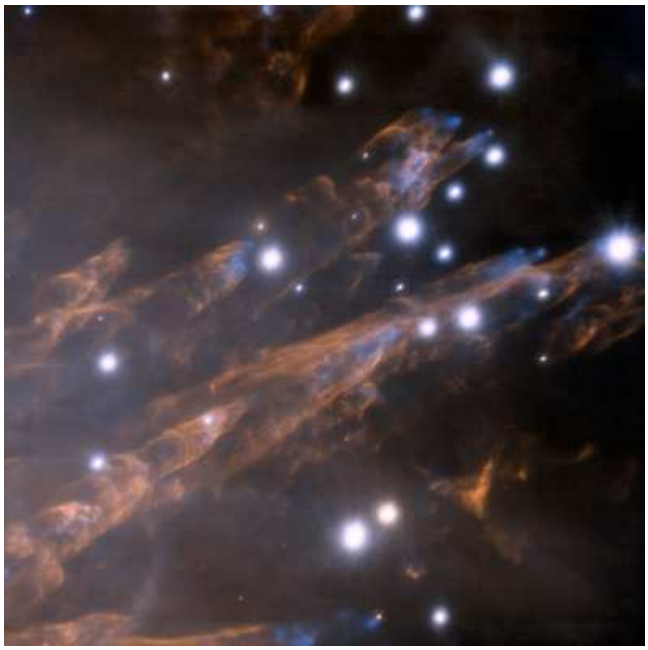

Figure 8: *This composite image at infrared wavelengths was obtained using the Gemini North laser guide star system in conjunction with the ALTAIR adaptive optics system and the NIRI near-infrared imager. The image shows the Orion "bullets" as blue features and represents the light emitted by hot iron (Fe) gas. The light from the wakes, shown in orange, is from excited hydrogen gas. The images were taken at f/14 through the Fe II, H2 1-0 and K-band filters and then combined into one color composite image. The field of view of this image is about 50 arcseconds across and structure on 0.1 arcsecond (2 pixel) scales is visible.*

The exceptional resolution of the new image was made possible by adaptive optics technology in place at Gemini Observatory. With a laser guide star as a reference and a rapidly deformable mirror for real-time correction, astronomers can compensate for most of the atmospheric distortions that blur the near-infrared image of a star whose light reaches the telescope's primary mirror. The system deploys a yellow/orange solid-state sodium laser that produces the artificial guide star by exciting and causing a small column of sodium gas about 90 kilometers (56 miles) up in our atmosphere to glow. The artificial star it creates becomes a reference star for the adaptive optics system, and allows it to determine how the atmosphere distorts the incoming near-infrared starlight.

2.2 Star Family Seen Through Dusty Fog

Source: ESO Press Release, March 13th, 2007 [17]

Images made with ESO's New Technology Telescope at La Silla by a team of German astronomers reveal a rich circular cluster of stars in the inner parts of our Galaxy. Located 30,000 light-years away, this previously unknown closely-packed group of about 100,000 stars is most likely a new globular cluster.

Star clusters provide us with unique laboratory conditions to investigate various aspects of astrophysics. They represent groups of stars with similar ages, chemical element abundances and distances. Globular clusters, in particular, are fossils in the Milky Way that provide useful information. With ages of about 10 billion years, they are among the oldest objects in our Galaxy - almost as old as the Universe itself. These massive, spherical shaped star clusters are therefore witnesses of the early, mysterious ages of the Universe.

"Moreover, the properties of globular clusters are deeply connected with the history of their host galaxy," says Dirk Froebrich from the University of Kent, and lead-author of the paper presenting the results. "We believe today that galaxy collisions, galaxy cannibalism, as well as galaxy mergers leave their imprint in the globular cluster population of any given galaxy. Thus, when investigating globular clusters we hope to be able to use them as an acid test for our understanding of the formation and evolution of galaxies," he adds.

In our own Galaxy about 150 globular clusters are known, each containing many hundreds of thousands of stars. In contrast to their smaller and less regularly shaped siblings - open clusters - globular clusters are not concentrated in the galactic disc; rather they are spherically distributed in the galactic halo, with increasing concentration towards the centre of the Galaxy. Until the mid 1990s, globular clusters were identified mostly by eye - from visual inspection

of photographic plates. However, these early searches are likely to have missed a significant number of globular clusters, particularly close to the disc of the Galaxy, where dense clouds of dust and gas obscure the view. In the early times of extragalactic astronomy this area was called the 'Zone of Avoidance' because extragalactic stellar systems appeared to be very rare in this part of the sky.

Searching for the missing globular clusters in our Galaxy requires observations in the infrared, because infrared radiation is able to penetrate the thick 'galactic fog'. Using modern, sensitive infrared detectors, this is now possible.

Completing the census is not only a challenge for its own sake, as finding new globular clusters is useful for several additional reasons. For example, analysing their orbits allows astronomers to draw conclusions about the distribution of mass in the Galaxy. Star clusters can therefore be used as probes for the large-scale structure of the Milky Way.

"It has been estimated that the region close to the Galactic Centre might contain about 10 so far unknown globular clusters and we have started a large campaign to unveil and characterise them," explains Helmut Meusinger, from the Thringer Landessternwarte Tautenburg, Germany, and part of the team.

The astronomers carried out a systematic and automated large-scale (14,400 square degrees) search for globular cluster candidates in the entire Galactic Plane, based on the near-infrared Two Micron All Sky Survey (2MASS). Eventually, only about a dozen candidate objects remained.

The astronomers observed these candidates with the SofI instrument attached to ESO's New Technology Telescope (NTT) at La Silla (Chile), taking images through three different near-infrared filters. The new images are ten times deeper and have a much better angular resolution than the original 2MASS images, thereby allowing the astronomers to resolve at least partly the dense accumulation of stars in the globular cluster candidates.

One of these candidates had the number 1735 in the list of Froebrich, Scholz, and Raftery, and is therefore denoted as FSR 1735.

"The unique images we have obtained reveal that the nebulous appearance of the cluster in previous images is in fact due to a large number of faint stars," says Froebrich. "The images show a beautiful, rich, and circular accumulation of stars."

Figure 9: *Colour-composite image of the newly discovered globular cluster candidate FSR 1735 in the inner parts of the Milky Way. The cluster is the circular regions of stars and enhanced brightness in the centre of the image. The image is based on data obtained through three near-infrared filters (J, H, and K), for a total exposure time of 225 seconds per filter. The SofI instrument on ESO's NTT was used. The image size is about 5 x 5 arcmin. North is up and East is to the left. The final image processing was done by Henri Boffin (ESO).*

From a detailed analysis of the properties of the cluster, the astronomers arrive at the conclusion that the cluster is about 30,000 light-years away from us and only 10,000 light-years away from the Galactic Centre, close to the Galactic Plane.

"All the evidence supports the interpretation that FSR 1735 is a new globular cluster in the inner Milky Way," says Aleks Scholz, from the University of St Andrews, UK, and another member of the team. "However, to be sure, we now need to measure the age of the cluster accurately, and this requires still deeper observations."

The cluster is about 7 light-years wide (slightly less than twice the distance between the Sun and its nearest star, Proxima Centauri) but contains about 100,000 stars for a total estimated mass of 65,000 times the mass of the Sun. The stars

contain between 5 and 8 times less heavy elements than the Sun.

”On its way to our Solar System, the light coming from the stars in the FSR 1735 cluster has to penetrate a thick cloud of dust and gas,” says Meusinger. ”This is one of the reasons why this cluster was hard to find in previous surveys.”

”Is this now the last missing globular cluster in our galaxy?,” asks Scholz. ”We really can’t be sure. The opaque interiors of the Milky Way may well have more surprises in store.”

2.3 Gamma-Ray Burst Challenges Theory

Source: NASA News, March 8th, 2007 [18]

In a series of landmark observations gathered over a period of four months, NASA’s Swift satellite has challenged some of astronomers’ fundamental ideas about gamma-ray bursts (GRBs), which are among the most extreme events in our universe. GRBs are the explosive deaths of very massive stars, some of which eject jets that can release in a matter of seconds the same amount of energy that the sun will radiate over its 10-billion-year lifetime.

When GRB jets slam into nearby interstellar gas, the resulting collision generates an intense afterglow that can radiate brightly in X-rays and other wavelengths for several weeks. Swift, however, has monitored a GRB whose afterglow remained visible for more than 125 days in the satellite’s X-ray Telescope (XRT).

Swift’s Burst Alert Telescope (BAT) detected the GRB in the constellation Pictor on July 29, 2006. The XRT picked up GRB 060729 (named for its date of detection) 124 seconds after BAT’s detection. Normally, the XRT monitors an afterglow for a week or two until it fades to near invisibility. But for the July 29 burst, the afterglow started off so bright and faded so slowly that the XRT could regularly monitor it for months, and the instrument was still able to detect it in late November. The burst’s distance from Earth (it was much closer than many GRBs) was also a factor in XRT’s ability to monitor the afterglow for such an extended period.

The slow fading of the X-ray afterglow has several important ramifications for our understanding of GRBs. ”It requires a larger energy injection than what we normally see in bursts, and may require continuous energy input from the central engine,” says astronomer Dirk Grupe of Penn State University, University Park, Penn., and lead author of an international team that reports these results in an upcoming issue of the Astrophysical Journal.

One possibility is that the GRB’s central engine was a magnetar a neutron star with an ultra-powerful magnetic field. The magnetar’s magnetic field acts like a brake, forcing the star’s rotation rate to spin-down rapidly. The energy of this spin-down can be converted into magnetic energy that is continuously injected into the initial blast wave that triggered the GRB. Calculations by paper coauthor Xiang-Yu Wang of Penn State show that this energy could power the observed X-ray afterglow and keep it shining for months.

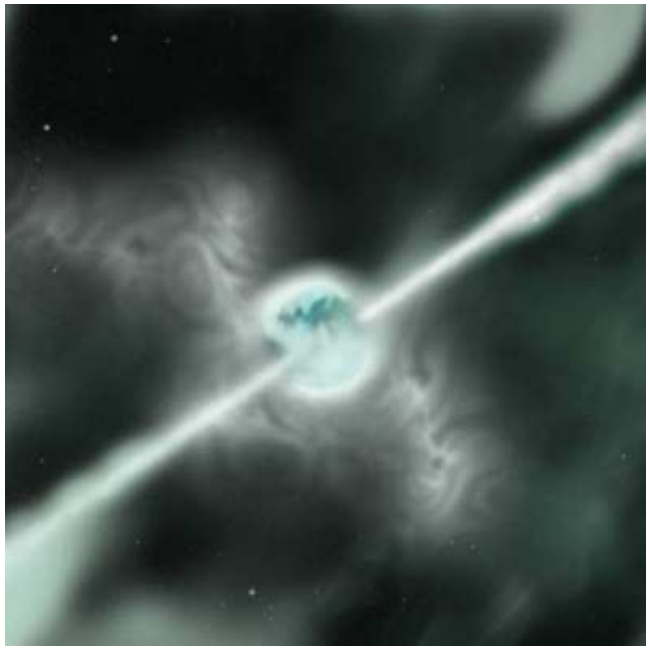

Figure 10: *The outer envelope of the star explodes outward, causing a supernova. Credit: Phil Plait SSU NASA E/PO; Images: Aurore Simonnet SSU NASA E/PO*

A burst observed on January 10, 2007, also suggests that magnetars power some GRBs. GRB 070110’s X-ray afterglow remained nearly constant in brightness for 5 hours, then faded rapidly more than tenfold. In another paper submitted to the Astrophysical Journal, an international group led by Eleonora Troja of the INAFIASF of Palermo, Italy, proposes that a magnetar best explains these observations.

”People have thought for a long time that GRBs are black holes being born, but scientists are now thinking of other possibilities,” says Swift principal investigator Neil Gehrels of NASA’s Goddard Space Flight Center in Greenbelt, Md., a co-author on both studies.

Another surprising result from GRB 060729 is that the X-ray afterglow displayed no sharp decrease in brightness over the 125-day period that it was detected by the XRT. Using widely accepted theory, Grupe and his colleagues conclude that the angle of the GRB’s jet must have been at least 28 de-

grees wide. In contrast, most GRB jets are thought to have very narrow opening angles of only about 5 degrees. "The much wider opening angle seen in GRB 060729 suggests a much larger energy release than we typically see in GRBs," says Grupe.

2.4 New Panorama Reveals More Than a Thousand Black Holes

Source: Chandra Press Release, March 12th, 2007 [19]

By casting a wide net, astronomers have captured an image of more than a thousand supermassive black holes. These results give astronomers a snapshot of a crucial period when these monster black holes are growing, and provide insight into the environments in which they occur.

The new black hole panorama was made with data from NASA's Chandra X-ray Observatory, the Spitzer Space Telescope and ground-based optical telescopes. The black holes in the image are hundreds of millions to several billion times more massive than the sun and lie in the centers of galaxies.

Material falling into these black holes at high rates generates huge amounts of light that can be detected in different wavelengths. These systems are known as active galactic nuclei, or AGN.

"We're trying to get a complete census across the Universe of black holes and their habits," said Ryan Hickox of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Mass. "We used special tactics to hunt down the very biggest black holes."

Instead of staring at one relatively small part of the sky for a long time, as with the Chandra Deep Fields – two of the longest exposures obtained with the observatory – and other concentrated surveys, this team scanned a much bigger portion with shorter exposures. Since the biggest black holes power the brightest AGN, they can be spotted at vast distances, even with short exposures.

"With this approach, we found well over a thousand of these monsters, and have started using them to test our understanding of these powerful objects," said co-investigator Christine Jones, also of the CfA.

The new survey raises doubts about a popular current model in which a supermassive black hole is surrounded by a doughnut-shaped region, or torus, of gas. An observer from Earth would have their view blocked by this torus by different amounts, depending on the orientation of the torus.

According to this model, astronomers would expect a large sample of black holes to show a range of absorption of the radiation from the nuclei. This absorption should range from completely exposed to completely obscured, with most in-between. Nuclei that are completely obscured are not detectable, but heavily obscured ones are.

"Instead of finding a whole range, we found nearly all of the black holes are either naked or covered by a dense veil of gas," said Hickox. "Very few are in between, which makes us question how well we know the environment around these black holes."

This study found more than 600 obscured and 700 unobscured AGN, located between about six to 11 billion light years from Earth. They were found using an early application of a new search method. By looking at the infrared colors of objects with Spitzer, AGN can be separated from stars and galaxies. The Chandra and optical observations then verify these objects are AGN. This multi-wavelength method is especially efficient at finding obscured AGN.

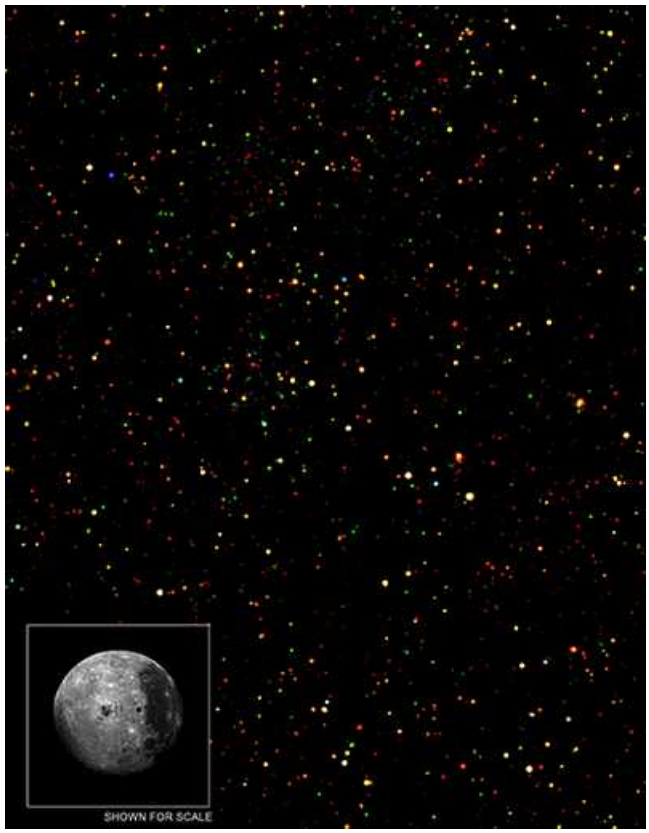

Figure 11:

"These results are very exciting, using two NASA Great Ob-

servatories to find and understand the largest sample of obscured supermassive black holes ever found in the distant universe", said co-investigator Daniel Stern, of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

The Chandra image is the largest contiguous field ever obtained by the observatory. At 9.3 square degrees, it is over 40 times larger than the full moon seen on the night sky and over 80 times larger than either of the Chandra Deep Fields. This survey, taken in a region of the Bootes constellation, involved 126 separate pointings of 5,000-second Chandra exposures each. The researchers combined this with data obtained from Spitzer, and Kitt Peak's 4-meter Mayall and the MMT 6.5-meter optical telescopes, both located outside Tuscon, Ariz., from the same patch of sky.

3 Space missions

3.1 SpaceX's Falcon 1 Briefly Reaches Space

Source: SpaceX Press Release, March 27th, 2007 [20]

Having had several days to examine the data, the second test launch of Falcon 1 is looking increasingly positive. Post flight review of telemetry has verified that oscillation of the second stage late in the mission is the only thing that stopped Falcon 1 from reaching full orbital velocity. The second stage was otherwise functioning well and even deployed the satellite mass simulator ring at the end of flight! Actual final velocity was 5.1 km/s or 11,000 mph, whereas 7.5 km/s or 17,000 mph is needed for orbit. Altitude was confirmed to be 289 km or 180 miles, which is certainly enough for orbit and is about where the Space Shuttle enters its initial parking orbit.

This confirms the end of the test phase for Falcon 1 and the beginning of the operational phase. The next Falcon 1 flight will carry the TacSat 1 satellite for the US Navy, with a launch window that begins in September, followed by Razaksat for the Malaysian Space Agency in November. Beyond that, we have another nine missions on manifest for F1 and F9. Note, the first F9 mission will also be a test flight and the three NASA F9/Dragon missions are all test flights for Dragon.

Telemetry shows that engine shutdown occurred only about a minute and a half before schedule (roughly T + 7.5 mins), due to the oscillations causing propellant to slosh away from the sump. When the liquid level in the tank was low, this effectively starved the engine of propellant. A disproportionate amount of the velocity gain occurs in the final few minutes of flight, when the stage is very light, which is why the velocity difference is greater than just linearly subtracting 1.5 mins from the burn time.

Except for a few blips here and there, we have now cleaned up the raw data feed and recovered video and telemetry for the entire mission well past 2nd stage shutdown. Including all the launch pad video and ground support equipment data, we have somewhere close to a terabyte of information to review. This was far too much to send over the T1 satellite link from Kwaj and had to be brought over in person after the flight. Given that a number of our engineers have only just returned from Kwaj, please consider this still a preliminary analysis:

In a nutshell, the data shows that the increasing oscillation of the second stage was likely due to the slosh frequency in the liquid oxygen (LOX) tank coupling with the thrust vector control (engine steering) system. This started out as a pitch-yaw movement and then transitioned into a corkscrewing motion. For those that aren't engineers, imagine holding a bowl of soup and moving it from side to side with small movements, until the entire soup mass is shifting dramatically. Our simulations prior to flight had led us to believe that the control system would be able to damp out slosh, however we had not accounted for the perturbations of a contact on the stage during separation, followed by a hard slew to get back on track.

The nozzle impact during stage separation occurred due to a much higher than expected vehicle rotation rate of about 2.5 deg/sec vs. max expected of 0.5 deg/sec. As the 2nd stage nozzle exited the interstage, the first stage was rotating so fast that it contacted the niobium nozzle. There was no apparent damage to the nozzle, which is not a big surprise given that niobium is tough stuff.

The unexpectedly high rotation rate was due to not knowing the shutdown transient of the 1st stage engine (Merlin) under flight conditions. The actual shutdown transient had a very high pitch over force, causing five times the max expected rotation rate.

We definitely intend to have both the diagnosis and cure vetted by third party experts, however we believe that the slosh issue can be dealt with in short order by adding baffles to our 2nd stage LOX tank and adjusting the control logic. Either approach separately would do the trick (eg. the Atlas-Centaur tank has no baffles), but we want to ensure that this problem never shows up again. The Merlin shutdown transient can be addressed by initiating shutdown at a much lower thrust level, albeit at some risk to engine reusability. Provided we have a good set of slosh baffles, even another nozzle impact at stage separation would not pose a significant flight risk, although obviously we will work hard to avoid that.

I will be posting another DemoFlight 2 post launch update within a week, which will include a list of all subsystems color coded for status: green = good, yellow = cause for concern, red = flight failure if unchanged, black = untested. Of the hundreds of subsystems on the rocket, only the 2nd stage LOX tank slosh baffles are clearly red right now, but that could change with further analysis. As much as is reasonably possible (subject to ITAR and proprietary info), SpaceX will provide full disclosure with respect to the findings of the mission review team.

The Difference Between a Test Flight and an Operational Satellite Mission

There seems to be a lot of confusion in the media about what constitutes a success. The critical distinction is that a test flight has many gradations of success, whereas an operational satellite mission does not. Although we did our best at SpaceX to be clear about last week's launch, including naming it DemoFlight 2 and explicitly not carrying a satellite, a surprising number of people still evaluated the test launch as though it were an operational mission.

This is neither fair nor reasonable. Test flights are used to gather data before flying a "real" satellite and the degree of success is a function of how much data is gathered. The problem with our first launch is that, although it taught us a lot about the first stage, ground support equipment and launch pad, we learned very little about the second stage, apart from the avionics bay. However, that first launch was still a partial success, because of what we learned and, as shown by flight two, that knowledge was put to good use: there were no flight critical issues with the first stage on flight two.

Figure 12: *Falcon 1 DemoFlight 2- Red-hot nozzle with Earth's curvature in the background*

The reason that flight two can legitimately be called a near complete success as a test flight is that we have excellent data throughout the whole orbit insertion profile, including well past second stage shutdown, and met all of the primary objectives established beforehand by our customer (DARPA/AF). This allows us to wrap up the test phase of the Falcon 1 program and transition to the operational phase, beginning with the TacSat mission at the end of summer. Let me be clear here and now that anything less than orbit for that flight or any Falcon 1 mission with an operational satellite will unequivocally be considered a failure.

This is not "spin" or some clever marketing trick, nor is this distinction an invention of SpaceX – it has existed for decades. The US Air Force made the same distinction a few years ago with the demonstration flight of the Delta IV Heavy, which also carried no primary satellite. Although the Delta IV Heavy fell materially short of its target velocity and released its secondary satellites into an abnormally low altitude, causing reentry in less than one orbit, it was still correctly regarded by Boeing and the Air Force as a successful test launch, because sufficient data was obtained to transition to an operational phase.

It is perhaps worth drawing an analogy with more commonplace consumer products. Before software is released, it is beta tested in non-critical applications, where bugs are worked out, before being released for critical applications, although some companies have been a little loose with this rule. :) Cars go through a safety and durability testing phase before being released for production. Rockets may involve rocket science, but are no different in this regard.

3.2 Proposed Mission Will Return Sample from Near-Earth Object

Source: NASA News, March 9th, 2007 [21]

A menacing lump of rock and dust in space called 101955 (1999 RQ36) would barely be noticed except for two crucial facts: First, "It's a treasure trove of organic material, so it holds clues to how Earth formed and life got started," said Joseph Nuth of NASA's Goddard Space Flight Center, Greenbelt, Md. Second, it regularly crosses Earth's orbit, so it might impact us someday.

Nuth is Project Scientist for the proposed OSIRIS mission, which will "return a pristine sample of the scientifically priceless asteroid RQ36 to Earth for in-depth study," said University of Arizona Lunar and Planetary Laboratory (LPL) Director Michael Drake, Principal Investigator for the proposed mission. The mission will be the first to return a sample of an asteroid to Earth. NASA Goddard is managing the project. Lockheed Martin is building the flight system, the sampling mechanism, and the sample return capsule. Lockheed Martin is also performing spacecraft operations.

The OSIRIS team recently won a 1.2 million dollars award from NASA to develop a more detailed engineering study of how the mission will accomplish its scientific objectives. OSIRIS will launch in 2011, acquire a sample of RQ36 in 2013, and return it to Earth in 2017.

OSIRIS is both a mythological figure and an acronym. "O" stands for the scientific theme, origins. "SI" is for spectral interpretation, or taking images of the NEO at wavelengths that will reveal its composition. "RI," or resource identification, is surveying the asteroid for such useful resources as water and metals. "S" stands for security, learning how to predict the detailed motion of Earth-approaching asteroids.

"OSIRIS of Egyptian mythology is the god of life and fertility, the god who taught Egyptians agriculture," said Dante Lauretta, OSIRIS Deputy Principal Investigator, also with the University of Arizona. "There's an analogy to the proposed 21st century space mission. We're looking at the kind of object that we think brought life to Earth; that is, objects that seeded Earth with early biomolecules, the precursors of life."

Returning a sample to Earth will allow for a much more comprehensive study of the NEO, according to the team. "The equipment in my lab is small, merely desk-sized, but that's not easy to fly. Let alone the enormous synchrotrons, which dwarf cars and are impossible to fly," said Jason Dworkin, also of NASA Goddard, who is the Deputy Project Scientist and a Co-Investigator on OSIRIS. "Furthermore, there are also a lot of steps to prepare a sample. That would all have to be automated and work perfectly on a spacecraft."

"Also, you can't respond to surprises with the limited equipment on board a spacecraft," added Nuth. "About thirty years ago, the Viking landers scooped up a sample of Martian dirt and tested it for signs of microscopic life. The results were contradictory, and ever since then, there's been a controversy over whether there really was life or whether it was just some kind of exotic chemical reaction. If instead we were able to return samples to Earth, we could have tested the sample in other ways. And when technology improves, we just take samples out and test with the latest equipment. That's what we'll be able to do with the sample returned by OSIRIS."

OSIRIS samples will be available to the world-wide community, so people with diverse skills and techniques can offer unique insights. "The Stardust mission returned samples of comet Wild 2 with a total weight of just a tenth of a milligram, but it is enough to be analyzed by researchers all over the world," said Dworkin. "OSIRIS will return 150 grams – about five ounces. We'll take it apart almost atom by atom. It will keep a lot of people busy for a long time."

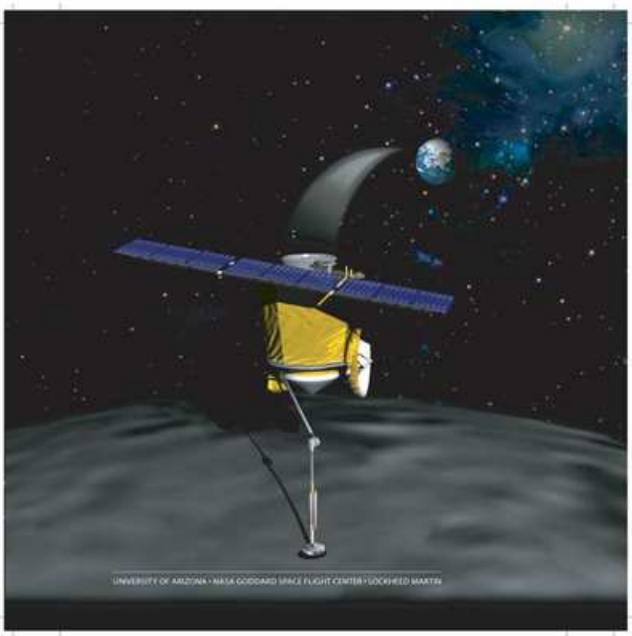

Figure 13: *This is an artist's concept of the OSIRIS spacecraft taking a sample of asteroid RQ36. Credit: NASA/U. of Arizona*

The mission will also help to better track the orbits of asteroids that might hit Earth by accurately measuring the "Yarkovsky effect" for the first time. The Yarkovsky effect is a small push on an asteroid that happens when the asteroid absorbs sunlight and emits heat. The small push adds up over time, and it is uneven due to an asteroid's various surface materials, wobble, and rotation. There's no sure way to predict an Earth-approaching asteroid's orbit unless you can factor in how the Yarkovsky effect will change that orbit, according to the team. "It's like trying to make a complex, banking shot in a game of pool with someone shaking the table and kicking the legs," said Nuth.

RQ36 is roughly 580 meters in diameter, or about two-fifths of a mile. It orbits between about 83 million and 126 million miles from the sun, swinging within about 280,000 miles of Earth orbit, or roughly 40,000 miles more distant than the moon. The International Astronomical Union's Minor Planet Center has officially classified RQ36 as a "potentially hazardous asteroid."

"It doesn't present any near-term hazard, but the small Yarkovsky push over hundreds of orbits may eventually be enough to cause an 'oops'," said Nuth.

4 Internet websites

[1] http://www.nasa.gov/centers/marshall/news/news/releases/2007/07-031.html
[2] http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_23-3-2007-10-0-14?newsid=8473
[3] http://www.soton.ac.uk/ses/news/2007/mar/09bMar2007.shtml
[4] http://www.berkeley.edu/news/media/releases/2007/03/29_antiope.shtml
[5] http://www.eso.org/outreach/press-rel/pr-2007/pr-11-07.html
[6] http://pluto.jhuapl.edu/gallery/missionPhotos/pages/032207.html
[7] http://saturn.jpl.nasa.gov/news/press-release-details.cfm?newsID=735
[8] http://www.nasa.gov/cassini
[9] http://saturn.jpl.nasa.gov
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[18] http://www.nasa.gov/centers/goddard/news/topstory/2007/gammaburst_challenge.html
[19] http://chandra.harvard.edu/press/07_releases/press_031207.html
[20] http://www.spacex.com/updates.php#demoflight_2_launch_update_12
[21] http://www.nasa.gov/centers/goddard/news/topstory/2007/osiris.html

5 About Vendelinus and this newsletter

Vendelinus is the adult amateur astronomy section of the Europlanetarium in Genk, Belgium. It is also a Flemish Amateur-astronomy Club (VVS).The club exists officially since January 2000 and is named after the Limburg astronomer Gottfried Wendelen (1580-1667) born in Herk de Stad.

More information can be found at:

Europlanetarium, Planetariumweg 19, B-3600 Genk, tel:089/307990 / fax: 089/307991

E-mail: Tony Dethier, antoine.dethier@skynet.be

Website: http://users.pandora.be/lode.stevens/vendelinus/volks.html

The primary function of the Vendelinus Astronomy Newsletter is to provide our members monthly with an overview of the latest astronomical news, copied, pasted and packaged into one newsletter, so that they don't have to scan through the websites themselves. Because the contents consists of the original press releases, the language is English. The newsletter appears monthly at the beginning of the month and gives and overview of news from the previous month. It comes in two formats: as plain text and as a PDF document. In the latter format, colour figures are included. The newsletter is available by email (if I agree to include you in my mailing list) and on the web at:

http://www.warwick.ac.uk/go/erwin_verwichte/amateur/vndnews/

Erwin Verwichte