Vendelinus Astronomy Newsletter

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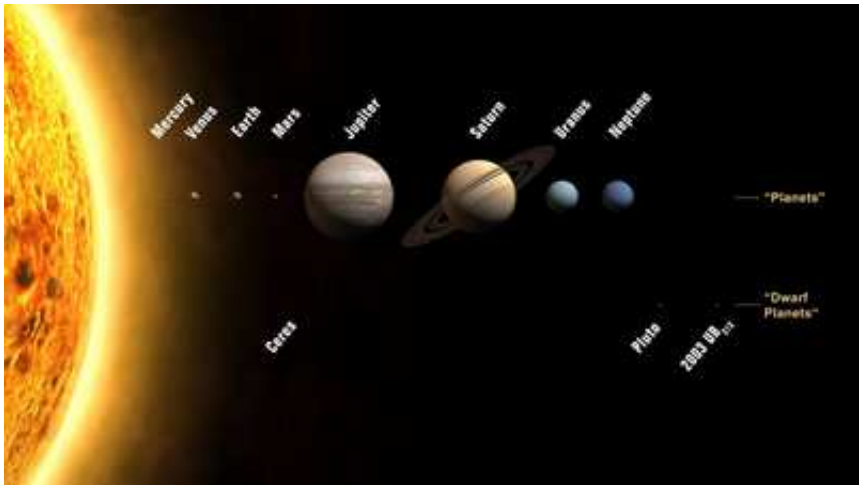

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1 Solar System

1.1 Planet Earth may have 'tilted' to keep its balance

Source: Princeton University News, August 25th, 2006 [1]

Imagine a shift in the Earth so profound that it could force our entire planet to spin on its side after a few million years, tilting it so far that Alaska would sit at the equator. Princeton scientists have now provided the first compelling evidence that this kind of major shift may have happened in our world's distant past.

By analyzing the magnetic composition of ancient sediments found in the remote Norwegian archipelago of Svalbard, Princeton University's Adam Maloof has lent credence to a 140-year-old theory regarding the way the Earth might restore its own balance if an unequal distribution of weight ever developed in its interior or on its surface.

The theory, known as true polar wander, postulates that if an object of sufficient weight – such as a supersized volcano – ever formed far from the equator, the force of the planet's rotation would gradually pull the heavy object away from the axis the Earth spins around. If the volcanoes, land and other masses that exist within the spinning Earth ever became sufficiently imbalanced, the planet would tilt and rotate itself until this extra weight was relocated to a point along the equator.

"The sediments we have recovered from Norway offer the first good evidence that a true polar wander event happened about 800 million years ago," said Maloof, an assistant professor of geosciences. "If we can find good corroborating evidence from other parts of the world as well, we will have a very good idea that our planet is capable of this sort of dramatic change."

Maloof's team, which includes researchers from Harvard University, the California Institute of Technology and the Massachusetts Institute of Technology as well as Princeton, will publish their findings in the Geological Society of America Bulletin on Friday, Aug. 25.

True polar wander is different from the more familiar idea of "continental drift," which is the inchwise movement of individual continents relative to one another across the Earth's surface. Polar wander can tip the entire planet on its side at a rate of perhaps several meters per year, about 10 to 100 times as fast as the continents drift due to plate tectonics. Though the poles themselves would still point in the same direction with respect to the solar system, the process could conceivably shift entire continents from the tropics to the Arctic, or vice versa, within a relatively brief geological time span.

While the idea that the continents are slowly moving in relation to one another is a well-known concept, the less familiar theory of true polar wander has been around since the mid-19th century, several decades before continental drift was ever proposed. But when the continents were proven to be moving under the influence of plate tectonics in the 1960s, it explained so many dynamic processes in the Earth's surface so well that true polar wander became an obscure subject.

"Planetary scientists still talk about polar wander for other worlds, such as Mars, where a massive buildup of volcanic rock called Tharsis sits at the Martian equator," Maloof said. "But because Earth's surface is constantly changing as the continents move and ocean crustal plates slide over and under one another, it's more difficult to find evidence of our planet twisting hundreds of millions of years ago, as Mars likely did while it was still geologically active."

However, the sediments that the team studied in Svalbard from 1999 to 2005 may have provided just such long-sought evidence. It is well known that when rock particles are sinking to the ocean floor to form layers of new sediment, tiny magnetic grains within the particles align themselves with the magnetic lines of the Earth. Once this rock hardens, it becomes a reliable record of the direction the Earth's magnetic field was pointing at the time of the rock's formation. So, if a rock has been spun around by a dramatic geological event, its magnetic field will have an apparently anomalous orientation that geophysicists like those on Maloof's team seek to explain.

"We found just such anomalies in the Svalbard sediments," Maloof said. "We made every effort to find another reason for the anomalies, such as a rapid rotation of the individual crustal plate the islands rest upon, but none of the alternatives makes as much sense as a true polar wander event when taken in the context of geochemical and sea level data from the same rocks."

The findings, he said, could possibly explain odd changes in ocean chemistry that occurred about 800 million years ago. Other similar changes in the ocean have cropped up in ancient times, Maloof said, but at these other times scientists

know that an ice age was to blame.

”Scientists have found no evidence for an ice age occurring 800 million years ago, and the change in the ocean at this juncture remains one of the great mysteries in the ancient history of our planet,” he said. ”But if all the continents were suddenly flipped around and their rivers began carrying water and nutrients into the tropics instead of the Arctic, for example, it could produce the mysterious geochemical changes science has been trying to explain.”

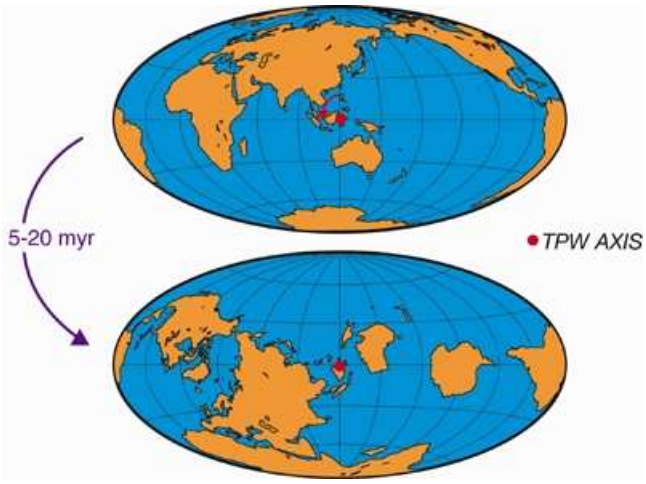

Figure 1:

Because the team obtained all its data from the islands of Svalbard, Maloof said their next priority would be to seek corroborating evidence within sediments of similar age from elsewhere on the planet. This is difficult, Maloof said, because most 800-million-year-old rocks have long since disappeared. Because the Earth’s crustal plates slide under one another over time, they take most of geological history back into the planet’s deep interior. However, Maloof said, a site his team has located in Australia looks promising.

”We cannot be certain of these findings until we find similar patterns in rock chemistry and magnetics on other continents,” Maloof said. ”Rocks of the same age are preserved in the Australian interior, so we’ll be visiting the site over the next two years to look for additional evidence. If we find some, we’ll be far more confident about this theory’s validity.”

Maloof said that true polar wander was most likely to occur when the Earth’s landmasses were fused together to form a single supercontinent, something that has happened at least twice in the distant past. But he said we should not worry about the planet going through a major shift again any time soon.

”If a true polar wander event has occurred in our planet’s history, it’s likely been when the continents formed a single mass on one side of the Earth,” he said. ”We don’t expect there to be another event in the foreseeable future, though. The Earth’s surface is pretty well balanced today.”

1.2 Cosmic Dust in Terrestrial Ice

Source: Alfred Wegener Institut, August 7th, 2006 [2]

For the last 30,000 years, our planet has been hit by a constant rain of cosmic dust particles. Two scientists from the Lamont-Doherty Earth Observatory (LDEO) at Columbia University in New York and the Alfred-Wegener-Institut (AWI) for Polar and Marine Research in Bremerhaven, Germany, have reached this conclusion after investigating the amount of the helium isotope 3He in cosmic dust particles preserved in an Antarctic ice core over the last 30,000 years. They have shown that this rare helium isotope in cosmic dust exceeds that of terrestrial dust in ice by a factor of 5,000. Moreover, measurements of the amount of 4He a helium isotope much more common on Earth in the Antarctic ice strongly suggest a change of origins in terrestrial dust between the last Ice Age and the interglacial warm period we currently live in.

In the current issue of Science, the scientists from New York and Bremerhaven for the first time present chronologically resolved measurements of the 3He and 4He flux of interplanetary and terrestrial dust particles preserved in the snow of the Antarctic. According to current estimates, about 40,000 tons of extraterrestrial matter hit the Earth every year. ”During its journey through interplanetary space, the cosmic dust is charged with helium atoms by the solar wind. At his point they are highly enriched with the rare helium isotope 3He,” explains Dr Hubertus Fischer, head of the research program ”New keys to polar climate archives” at the Alfred Wegener Institute. ”Cosmic dust particles in the size of a few micrometers enter the Earth’s atmosphere unharmed and carry their helium load unchanged to the Earth’s surface where they are, among other places, preserved in the snow and ice of the polar ice caps.” Due to the high temporal resolution uniquely to be found in ice cores, it has now been possible for the first time to determine the temporal variability of this helium flux between glacial and interglacial periods along with the 3He and 4He ratios of these exotic particles. The results are expected to have significant impact on interpretation of high-resolution climate archives, such as ice, marine and lake sediment cores.

This, however, is not all the helium isotope method has to

offer. The ratio of 4He in terrestrial dust to the dust concentration itself reveals a marked difference between the last Ice Age and the current warm period. As . Gisela Winckler, head of the working group 'Isotope Tracers and Constant Flux Proxies' at L-DEO says, "the terrestrial dust coming down on Antarctica during the Ice Age obviously is not the same as that during warm periods. This may be due to the mineral dust originating from different regional sources or to changes in weathering, the process responsible for production of dust." Both scientists now want to intensify their collaboration even further and investigate the details of this phenomenon.

EPICA Data for this study have been collected within the European Project for Ice Coring in Antarctica (EPICA). As the German partner within EPICA, Alfred Wegener Institute is responsible for the Dronning Maud Land drilling operations. The EPICA project is carried out by a consortium of ten European countries (Belgium, Denmark, France, Germany, UK, Italy, the Netherlands, Norway, Sweden and Switzerland). Coordinated under the roof of the European Science Foundation (ESF), EPICA is funded by the participating countries and the European Union. The manuscript "30,000 Years of Cosmic Dust in Antarctic Ice" will be published in Science on July 28, 2006.

1.3 ESA's Cluster mission establishes why Earth's aurorae shine

Source: ESA Press Release, August 24th, 2006 [3]

ESA's Cluster mission has established that high-speed flows of electrified gas, known as bursty bulk flows, in the Earth's magnetic field are the carriers of decisive amounts of mass, energy and magnetic perturbation towards the Earth during magnetic substorms. When substorms occur, energetic particles strike our atmosphere, causing aurorae to shine. Such colourful aurorae regularly light the higher latitudes in the northern and southern hemisphere. They are caused mostly by energetic electrons spiralling down the Earth's magnetic field lines and colliding with atmospheric atoms at about 100 kilometres altitude. These electrons come from the magnetotail, a region of space on the night-side of Earth where the Sun's wind of particles pushes the Earth's magnetic field into a long tail.

At the tail's centre is a denser region known as the plasmasheet. Violent changes of the plasmasheet are known as magnetic substorms. They last up to a couple of hours and somehow hurl electrons and other charged particles earthwards. Apart from the beautiful light show, substorms also excite the Earth's ionosphere, perturbing the reception of GPS signals and communications between the Earth and orbiting satellites.

Figure 2: *Auroral displays over Canada pictured from the International Space Station from an altitude of 400 kilometres. The Manicouagan impact crater is visible in the foreground. Credits: NASA*

A key issue about substorms has been to determine how they fling material earthwards. The so called 'Bursty Bulk Flows' (BBFs), flows of gas that travel at over 300 kilometres per second through the plasmasheet, were discovered in the 1980s and became a candidate mechanism.

Observations suggested that BBFs were relatively small and typically lasted only 10 minutes, casting doubt on whether BBFs could play a major role in the magnetic substorm phenomenon. There was also doubt as to whether BBFs took place for all substorms.

Now these doubts are challenged by a statistical study of BBFs and magnetic substorms by Dr Jinbin Cao, Key Laboratory of Space Weather, CSSAR, Beijing, China, together with American and European colleagues. Using observations of the central plasmasheet collected by three satellites of ESA's Cluster mission during July October of 2001 and 2002, Cao and colleagues found 67 substorms and 209 BBFs. When they used the observations of only one spacecraft, they found that 78 percent of substorms are accompanied by at least one BBF. However, by combined observations from three out of the four Cluster spacecraft, they discovered that 95.5 percent of substorms are accompanied by BBFs. "For the first time, it seems possible that all substorms are accompanied by BBFs", says Cao.

Another key result of this work is that the average BBF duration is longer than previously estimated. Single satellite observations confirmed past results that the BBF duration was around 10 minutes.

However, by combining the data from three of the Cluster spacecraft, the observations reveal an average duration almost twice as long: 18 minutes and 25 seconds. So again, the multiple spacecraft data offered by Cluster was found to reveal more about the Earth's magnetic environment than data collected by single spacecraft.

"These new results by the Cluster mission clearly show that multi-point observations are the key to understanding the magnetic substorm phenomenon," says Philippe Escoubet, Cluster and Double Star Project Scientist of the European Space Agency.

1.4 Rare high-altitude clouds found on Mars

Source: ESA Press Release, August 28th, 2006 [4]

Planetary scientists have discovered the highest clouds above any planetary surface. They found them above Mars using the SPICAM instrument on board ESA's Mars Express spacecraft. The results are a new piece in the puzzle of how the Martian atmosphere works. Until now, scientists had been aware only of the clouds that hug the Martian surface and lower reaches of the atmosphere. Thanks to data from the SPICAM Ultraviolet and Infrared Atmospheric Spectrometer onboard Mars Express, a fleeting layer of clouds have been discovered at an altitude between 80 and 100 kilometres. The clouds are most likely composed of carbon dioxide.

SPICAM made the discovery by observing distant stars just before they disappeared behind Mars. By looking at the effects on the starlight as it travelled through the Martian atmosphere, SPICAM built up a picture of the molecules at different altitudes. Each sweep through the atmosphere is called a profile. The first hints of the new cloud layer came when certain profiles showed that the star dimmed noticeably when it was behind the 90100 kilometre high atmospheric layer. Although this happened in only one percent of the profiles, by the time the team had collected 600 profiles, they were confident that the effect was real.

"If you wanted to see these clouds from the surface of Mars, you would probably have to wait until after sunset" says Franck Montmessin, a SPICAM scientist with Service d'Aeronomie du CNRS, Verrires-le-Buisson, France, and lead author of the results. This is because the clouds are very faint and can only be seen reflecting sunlight against the darkness of the night sky. In that respect, they look similar to the mesospheric clouds, also known as noctilucent clouds, on Earth. These occur at 80 kilometres altitude above our planet, where the density of the atmosphere is similar to that of Mars' at 35 kilometres. The newly discovered Martian clouds therefore occur in a much more rarefied atmospheric location.

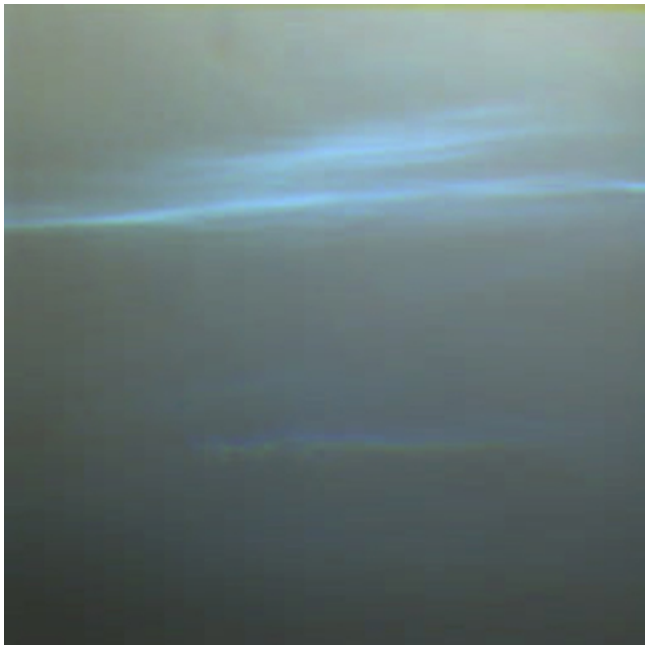

Figure 3: *Clouds on Mars*

At 90100 kilometres above the Martian surface, the temperature is just 193 Celsius. This means that the clouds are unlikely to be made of water. "We observe the clouds in super-cold conditions where the main atmospheric component CO2 (carbon dioxide), cools below its condensation point. From that we infer that they are made of carbon dioxide," says Montmessin.

But how do these clouds form? SPICAM has revealed the answer by finding a previously unknown population of minuscule dust grains above 60 kilometres in the Martian atmosphere. The grains are just one hundred nanometres across (a nanometre is one thousand-millionth of a metre).

They are likely to be the 'nucleation centres' around which crystals of carbon dioxide form to make clouds. They are either microscopic chippings from the rocks on the surface on Mars that have been blown to extreme altitudes by the winds, or they are the debris from meteors that have burnt up in the Martian atmosphere.

The new high-altitude cloud layer has implications for landing on Mars as it suggests the upper layers of Mars' atmosphere can be denser than previously thought. This will be an important piece of information for future missions, when using friction in the outer atmosphere to slow down space-

craft (in a technique called 'aerobraking'), either for landing or going into orbit around the planet.

1.5 NASA Findings Suggest Jets Bursting From Martian Ice Cap

Source: JPL/NASA News Release, August 16th, 2006 [5]

Every spring brings violent eruptions to the south polar ice cap of Mars, according to researchers interpreting new observations by NASA's Mars Odyssey orbiter.

Jets of carbon dioxide gas erupting from the ice cap as it warms in the spring carry dark sand and dust high aloft. The dark material falls back to the surface, creating dark patches on the ice cap which have long puzzled scientists. Deducing the eruptions of carbon dioxide gas from under the warming ice cap solves the riddle of the spots. It also reveals that this part of Mars is much more dynamically active than had been expected for any part of the planet.

"If you were there, you'd be standing on a slab of carbon-dioxide ice," said Phil Christensen of Arizona State University, Tempe, principal investigator for Odyssey's camera. "All around you, roaring jets of carbon dioxide gas are throwing sand and dust a couple hundred feet into the air."

You'd also feel vibration through your spacesuit boots, he said. "The ice slab you're standing on is levitated above the ground by the pressure of gas at the base of the ice."

The team began its research in an attempt to explain mysterious dark spots, fan-like markings, and spider-shaped features seen in images that cameras on Odyssey and on NASA's Mars Global Surveyor have observed on the ice cap at the Martian south pole.

The dark spots, typically 15 to 46 meters (50 to 150 feet) wide and spaced several hundred feet apart, appear every southern spring as the sun rises over the ice cap. They last for several months and then vanish – only to reappear the next year, after winter's cold has deposited a fresh layer of ice on the cap. Most spots even seem to recur at the same locations.

An earlier theory proposed that the spots were patches of warm, bare ground exposed as the ice disappeared. However, the camera on Odyssey, which sees in both infrared and visible-light wavelengths, discovered that the spots are nearly as cold as the carbon dioxide ice, suggesting they were just a thin layer of dark material lying on top of the ice and kept chilled by it. To understand how that layer is produced, Christensen's team used the camera – the Thermal Emission Imaging System – to collect more than 200 images of one area of the ice cap from the end of winter through midsummer.

Some places remained spot-free for more than 100 days, then developed many spots in a week. Fan-shaped dark markings didn't form until days or weeks after the spots appeared, yet some fans grew to half a mile in length. Even more puzzling was the origin of the "spiders," grooves eroded into the surface under the ice. The grooves converge at points directly beneath a spot.

"The key to figuring out the spiders and the spots was thinking through a physical model for what was happening," said Christensen. The process begins in the sunless polar winter when carbon dioxide from the atmosphere freezes into a layer about three feet thick on top of a permanent ice cap of water ice, with a thin layer of dark sand and dust in between. In spring, sunlight passing through the slab of carbon dioxide ice reaches the dark material and warms it enough that the ice touching the ground sublimates – turns into gas.

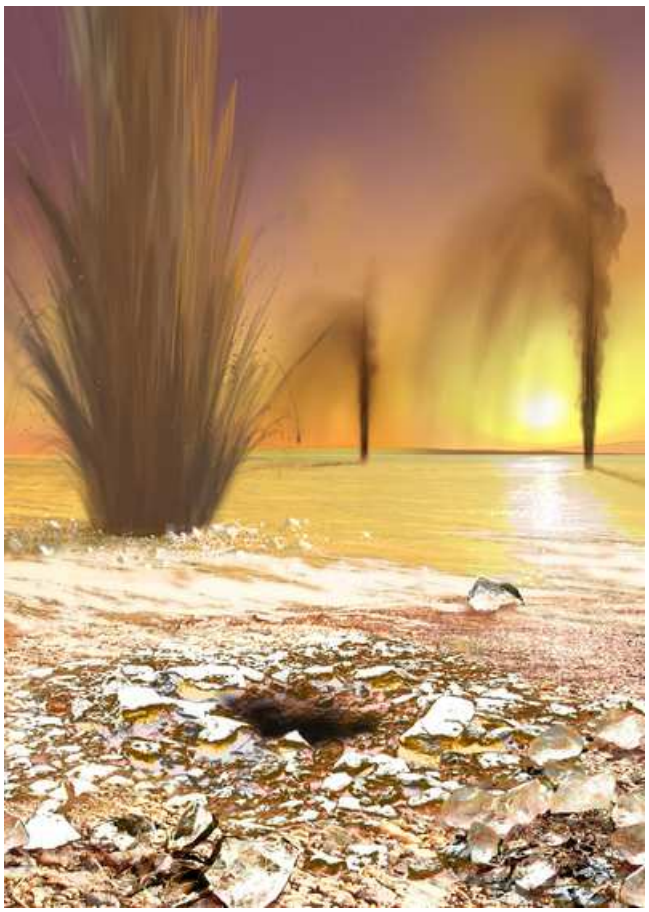

Figure 4: *Artist concept showing sand-laden jets shoot into*

the Martian polar sky. Image credit: Arizona State University/Ron Miller

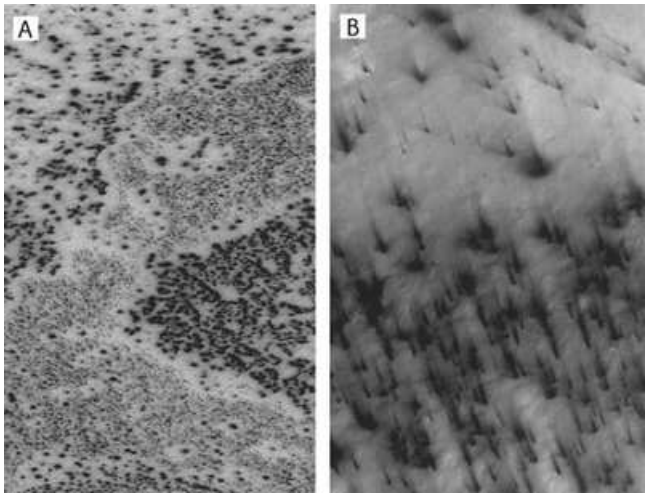

Figure 5: *Dark spots (left) and 'fans' appear to scribble dusty hieroglyphics on top of the Martian south polar cap. Image credit: NASA/JPL/Malin Space Science Systems*

Before long, the swelling reservoir of trapped gas lifts the slab and eventually breaks through at weak spots that become vents. High-pressure gas roars through at speeds of 161 kilometers per hour (100 miles per hour) or more. Under the slab, the gas erodes ground as it rushes toward the vents, snatching up loose particles of sand and carving the spidery network of grooves.

1.6 Pluto's Out of the Planet Club

Source: Universe Today, August 24th, 2006 [6]

Last year we had 9 planets. Recently we were informed it would grow to 12. Now we've only got 8. The International Astronomical Union, currently meeting in Prague, voted on August 24, 2006 to demote Pluto down from planethood status. Now Pluto, Charon, Ceres and the newly discovered 2003 UB313 (aka Xena) will merely be known as "dwarf planets". Under the new definition, planets must orbit a star, be spherical in shape, and clear out their neighbourhood of orbital debris. Pluto has failed to fulfill the third requirement, so it's out of the planet club.

It is official: The 26th General Assembly for the International Astronomical Union was an astounding success! More than 2500 astronomers participated in six Symposia, 17 Joint Discussions, seven Special Sessions and four Special Sessions. New science results were vigorously discussed, new international collaborations were initiated, plans for future facilities put forward and much more.

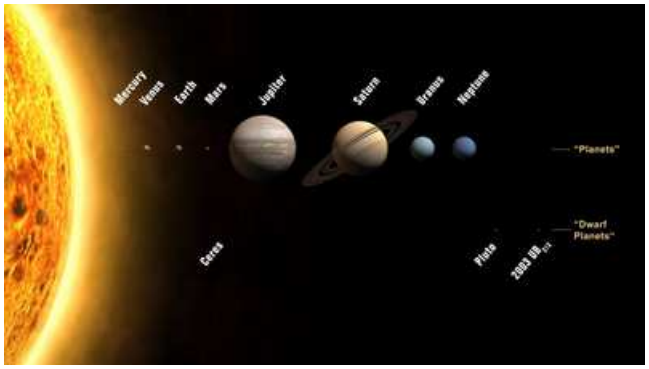

Figure 6: *The new solar system. Image credit: IAU*

In addition to all the exciting astronomy discussed at the General Assembly, six IAU Resolutions were also passed at the Closing Ceremony of the General Assembly:

1. Resolution 1 for GA-XXVI : "Precession Theory and Definition of the Ecliptic" 2. Resolution 2 for GA-XXVI: "Supplement to the IAU 2000 Resolutions on reference systems" 3. Resolution 3 for GA-XXVI: "Re-definition of Barycentric Dynamical Time, TDB" 4. Resolution 4 for GA-XXVI: "Endorsement of the Washington Charter for Communicating Astronomy with the Public" 5. Resolution 5A: "Definition of 'planet' " 6. Resolution 6A: "Definition of Pluto-class objects"

The IAU members gathered at the 2006 General Assembly agreed that a "planet" is defined as a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

This means that the Solar System consists of eight "planets" Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. A new distinct class of objects called "dwarf planets" was also decided. It was agreed that "planets" and "dwarf planets" are two distinct classes of objects. The first members of the "dwarf planet" category are Ceres, Pluto and 2003 UB313 (temporary name). More "dwarf planets" are expected to be announced by the IAU in the coming months and years. Currently a dozen candidate "dwarf planets" are listed on IAU's "dwarf planet" watchlist, which keeps changing as new objects are found and the physics of the existing candidates becomes better known.

The "dwarf planet" Pluto is recognised as an important proto-type of a new class of trans-Neptunian objects. The IAU will set up a process to name these objects.

Below are the planet definition Resolutions that were passed.

RESOLUTIONS Resolution 5A is the principal definition for the IAU usage of ”planet” and related terms.

Resolution 6A creates for IAU usage a new class of objects, for which Pluto is the prototype. The IAU will set up a process to name these objects.

IAU Resolution: Definition of a Planet in the Solar System Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particular, to the designation ’planets’. The word ’planet’ originally described ’wanderers’ that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.

RESOLUTION 5A The IAU therefore resolves that ”planets” and other bodies in our Solar System be defined into three distinct categories in the following way:

(1) A ”planet” is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

(2) A ”dwarf planet” is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape2 , (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

(3) All other objects3 except satellites orbiting the Sun shall be referred to collectively as ”Small Solar-System Bodies”.

2 Astrophysics

2.1 AKARI’s view on birth and death of stars

Source: ESA Press Release, August 30th, 2006 [7]

AKARI, the Japan Aerospace Exploration Agency (JAXA) infrared astronomical satellite with ESA participation, is continuing its survey of the sky and its mapping of our cosmos in infrared light. New exciting images recently taken by AKARI depict scenes from the birth and death of stars. AKARI’s Infrared Camera (IRC) imaged the reflection nebula IC 1396 in the constellation Cepheus (a reflection nebula is a cloud of dust which reflects the light of nearby stars). IC 1396 is a bright star-forming region located about 3000 light years from our Solar System, in a region where very massive stars several tens of times as massive as our Sun - are presently being born. Massive young stars in the central region of the image have swept out the gas and dust to the periphery of the nebula, creating a hollow shell-like structure.

A new generation of stars is now taking place within the compressed gas in these outer shell structures. With this high-resolution and high-quality image of IC 1396, AKARI has revealed for the first time the detailed distribution of the gas and dust swept out over the entire nebula.

A comparison between a visible image of IC 1396 and AKARI’s view of the same area shows that stars being born in regions that appear dark in visible light (left), do however appear bright if observed in infrared light (right). The gas that has been swept out creates the bright filament-like structures seen in infrared in the surrounding regions. The dust in the gas is heated by the intense light coming from both the massive star at the centre of the nebula and the newly born stars in the dense gas itself, and emits infrared light.

The bright clump seen on the slightly off-centre right-hand side is known as the ’Elephant Trunk Nebula’, a star forming region too. It appears as a dark nebula in the visible light (left image), but it is very bright in the infrared. It is a clump of dense gas that was not originally blown away because of its very high density.

Many recently born stars that were previously unknown are now expected to be detected thanks to AKARI’s new image, while the detailed analysis of these data will reveal the story of the star formation in this area.

AKARI’s Far-Infrared Surveyor (FIS) instrument imaged the red giant ’U Hydrae’, a star located at about 500 light years from our Sun. AKARI’s observations have revealed very extended clouds of dust surrounding this object.

Stars with masses close to that of our Sun will expand during the later stages of their life becoming so-called ’red-giant’

stars. During the final phase of their life such stars often eject gas from their surface into interstellar space - dust is formed in the ejected gas, and this mixture of gas and dust expands and escapes from the star.

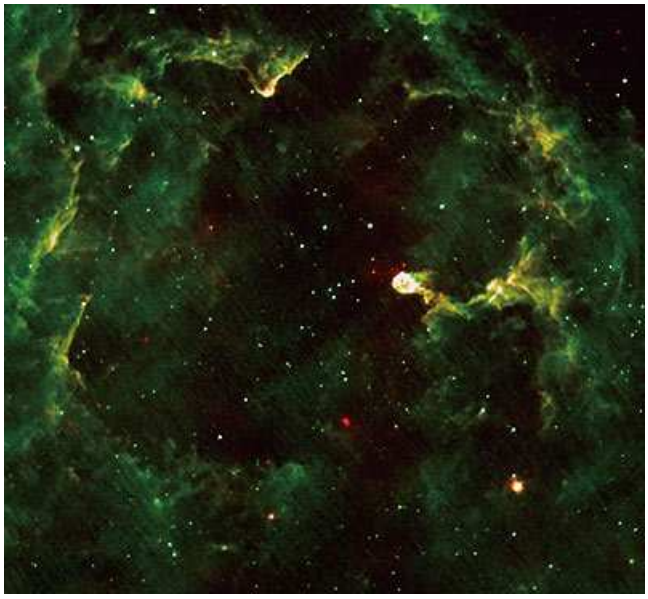

Figure 7: *This mid-infrared, false-colour composite image shows the reflection nebula IC 1396 in the constellation Cepheus, as viewed by AKARI's Infrared Camera (IRC) in its scanning mode (at 9 and 18 micrometers wavelength). IC 1396 is a bright star formation region located about 3000 light years from our Solar System, in a region where very massive (several tens of solar masses) stars are presently being born. Massive young stars in the central region of the image have swept out the gas and dust to the periphery of the nebula, creating a hollow shell-like structure.The formation of a new generation of stars is now taking place within the compressed gas in these outer shell structures. With this high-resolution and high-quality image AKARI has revealed for the first time the detailed distribution of the gas and dust swept out over the entire nebula. Many recently born stars that were previously unknown are now expected to be detected thanks to this new image, while detailed analysis of these data will reveal the story of the star formation in this area. Credits: JAXA*

AKARI's superior quality and high-resolution imaging allowed the clear detection of a shell-like dust cloud surrounding U Hydrae at a distance of about 0.3 light years from the central star, implying that a short and violent ejection of mass took place in the star about 10 000 years ago.

2.2 NASA's Spitzer Reveals New Wonders in the Familiar Orion Nebula

Source: Harvard-Smithsonian Center for Astrophysics Press Release, August 14th, 2006 [8]

The Orion nebula is one of the most famous and easily viewed deep-sky sights. Located in the sword of Orion the Hunter, this distant cloud of gas and dust holds hundreds of young stars. At its center, a cluster of four bright, massive stars known as the Trapezium bathes the entire 30 light-year-wide nebula with powerful radiation, lighting the surrounding gas. Even a modest telescope reveals billowing ripples of matter gleaming eerily across the vastness of space.

A new image taken by the Infrared Array Camera (IRAC) aboard NASA's Spitzer Space Telescope shows the Orion nebula in a new light. The striking color-coded picture reveals pinkish swirls of dust speckled with stars-some of which are orbited by disks of planet-forming dust.

"When I first got a look at the image, I was immediately struck by the intricate structure in the nebulosity, and in particular, the billowing clouds of the gigantic ring extending from the Orion Nebula," said Tom Megeath of the University of Toledo, Ohio, who spearheaded the research while on the staff of the Harvard-Smithsonian Center for Astrophysics.

Located about 1,450 light-years from Earth, the Orion nebula holds special significance for researchers as the nearest region of massive star formation and the nearest populous cluster of very young stars.

"Most stars form in crowded environments like Orion, so if we want to understand how stars form, we need to understand the Orion nebula star cluster," explained Lori Allen of the Harvard-Smithsonian Center for Astrophysics (CfA). Allen is working with Megeath on a long-term, multiwavelength study of Orion using a variety of ground- and space-based observatories.

Figure 8: *This image composite compares infrared and visible views of the famous Orion nebula and its surrounding cloud, an industrious star-making region located near the hunter constellation's sword. The picture at left was taken with the Infrared Array Camera on board NASA's Spitzer Space Telescope, and the picture at right is from the National Optical Astronomy Observatory, headquartered in Tucson, Ariz. Above the Orion nebula, where the massive stars have not yet ejected much of the obscuring dust, the visible image appears dark with only a faint glow. In contrast, the infrared view penetrates the dark lanes of dust, revealing bright swirling clouds and numerous developing stars that have shot out jets of gas (green). This is because infrared light can travel through dust, whereas visible light is stopped short by it. Image credit: NASA/JPL-Caltech/Univ. of Toledo/NOAO*

Approximately 10,000 IRAC exposures were combined to create the full image of the Orion cloud complex-the collection of interstellar gas clouds that includes the Orion nebula.

Spitzer unearthed nearly 2,300 planet-forming disks in the Orion cloud complex. The disks are too small and distant to be resolved by most visible-light telescopes; however, Spitzer easily detects the infrared glow of their warm dust. Each disk has the potential to form planets and its own solar system.

2.3 Hubble Identifies Stellar Companion to Distant Planet

Source: Hubble News, August 8th, 2006 [9]

NASA's Hubble Space Telescope has for the first time identified the parent star of a distant planet discovered through gravitational microlensing.

Microlensing occurs when a foreground star amplifies the light of a background star that momentarily aligns with it. The particular character of the light magnification can reveal clues to the nature of the foreground star and any associated planets. However, without conclusively identifying and characterizing the foreground star, a unique determination of the properties of the accompanying planet is difficult.

Hubble's sharp vision is ideally suited to identify the parent star, or "host star," for planets found in our galaxy through microlensing. The leader of the Hubble team, David Bennett of the University of Notre Dame, Ind., said "the identification of the host star is critical for a complete understanding of the planets discovered by microlensing."

The newly discovered host star, catalogued as OGLE-2003-BLG-235L/MOA-2003-BLG-53L, has a planet companion that was discovered in 2003 through ground-based gravitational microlensing observations. This technique takes advantage of the random motions of stars, which are generally too small to be noticed without precise measurements. If one star, however, passes precisely (or nearly precisely) in front of another star, the gravity of the foreground star acts like a giant lens, magnifying the light from the background star.

A planetary companion around the foreground star can produce additional brightening of the background star. This additional brightening can reveal the planet, which is otherwise too faint to be seen by telescopes. The duration of the microlensing event is several months, and the extra brightening due to a planet lasts a few hours to a couple of days. The ground-based microlensing data had indicated a combined system of foreground and background stars plus a planet. However, it took the acuity of Hubble to discern in the light from the foreground band background star by making follow-up observations two years after the microlens event. This allowed for a definitive determination of the characteristics of the planet's parent star.

Figure 9: *This is an artist's concept of a gas giant planet orbiting a red dwarf K star*

The sharp Hubble images allowed the research team to separate out the background source star from its neighbors in the very crowded star field in the direction of the center of our galaxy. The star appeared to be about 20 percent brighter than expected. This additional brightness is most likely from the foreground lens star, which hosts the planet. Although the Hubble images were taken nearly two years after the lensing event, the source and lens stars were still so close together on the sky that they essentially appeared as one star.

Nevertheless, Hubble observations were precise enough to distinguish the slight offset in the positions of the two stars. Hubble can't resolve the two stars, but, by taking multiple images through different colored filters, Hubble's Advanced Camera for Surveys can record a color offset in the overlapping light of the two stars. This is possible because the foreground star is a different color from the background star. At present, the foreground star is offset by 0.7 milliarcseconds (the angular width of a dime seen 3,000 miles away) from the background source star. Follow-up observations with Hubble in the coming years should reveal an increasing gap between the foreground and background stars.

Researchers noted that the newly discovered host star is more massive, and therefore hotter, than expected for a random field star in our galaxy. It is 63 percent the mass of the Earth's sun, while the average star has only 30 percent of the sun's mass. The host star identification also enabled the determination of its distance at 19,000 light-years and the planet's mass of 2.6 Jupiter masses. The characteristics of the lensing event show that the planet is in a Jupiter-sized orbit around its parent red star.

Understanding the types of host stars around which remote planets orbit is fundamental to improving theoretical models of planet formation. The popular core-accretion model predicts that giant planets grow from small rocky seed objects in a disk of debris around a star. Since more massive disks are expected around more massive stars, it follows that gas giant planets will rarely form around low-mass stars.

The Hubble observations are consistent with the core accretion model, especially if additional future microlensing detections of other star-planet systems continue to reveal massive host stars for gas giant planets.

2.4 The 'Planemo' Twins

Source: ESO Press Release, August 4th, 2006 [10]

Astronomers Discover Double Planetary Mass Object

The cast of exoplanets has an extraordinary new member. Using ESO's telescopes, astronomers have discovered an approximately seven-Jupiter-mass companion to an object that is itself only twice as hefty. Both objects have masses similar to those of extra-solar giant planets, but they are not in orbit around a star - instead they appear to circle each other. The existence of such a double system puts strong constraints on formation theories of free-floating planetary mass objects.

Ray Jayawardhana of the University of Toronto (Canada) and Valentin D. Ivanov of ESO report the discovery in the August 3 issue of Science Express, the rapid online publication service of the journal Science.

"This is a truly remarkable pair of twins - each having only about one percent the mass of our Sun," said Jayawardhana. "Its mere existence is a surprise, and its origin and fate a bit of a mystery."

Roughly half of all Sun-like stars come in pairs. So do about a sixth of brown dwarfs, 'failed stars' that have less than 75

Jupiter masses and are unable to sustain nuclear fusion in their cores. During the past five years, astronomers have identified a few dozen of even smaller free-floating planetary mass objects, or planemos, in nearby star forming regions. Oph 162225-240515, or Oph1622 for short, is the first planemo found to be a double.

The researchers discovered the companion candidate in an optical image taken with ESO's 3.5-m New Technology Telescope at La Silla, Chile. They decided to take optical spectra and infrared images of the pair with ESO's 8.2-m Very Large Telescope to make sure that it is a true companion, instead of a foreground or background star that happens to be in the same line of sight. These follow up observations indeed confirmed that both objects are young, at the same distance, and much too cool to be stars. This suggests the two are physically associated.

By comparing to widely used theoretical models, Jayawardhana and Ivanov estimate that the companion is about seven times the mass of Jupiter, while the more massive object comes in at about 14 times Jupiter's mass. The newborn pair, barely a million years old, is separated by about six times the distance between the Sun and Pluto, and is located in the Ophiuchus star-forming region approximately 400 light years away.

Planets are thought to form out of discs of gas and dust that surround stars, brown dwarfs, and even some free-floating planetary mass objects (see ESO 19/06). But, "it is likely that these planemo twins formed together out of a contracting gas cloud that fragmented, like a miniature stellar binary," said Jayawardhana. "We are resisting the temptation to call it a 'double planet' because this pair probably didn't form the way that planets in our Solar system did," added Ivanov.

Oph1622B is only the second or third directly imaged planetary mass companion to be confirmed spectroscopically (see ESO 23/04 [1]), and the first one around a primary that is itself a planetary mass object. What's more, its existence poses a challenge to a popular theoretical scenario, which suggests that brown dwarfs and free-floating planetary mass objects are embryos ejected from multiple proto-star systems. Since the two objects in Oph1622 are so far apart, and only weakly bound to each other by gravity, they would not have survived such a chaotic birth.

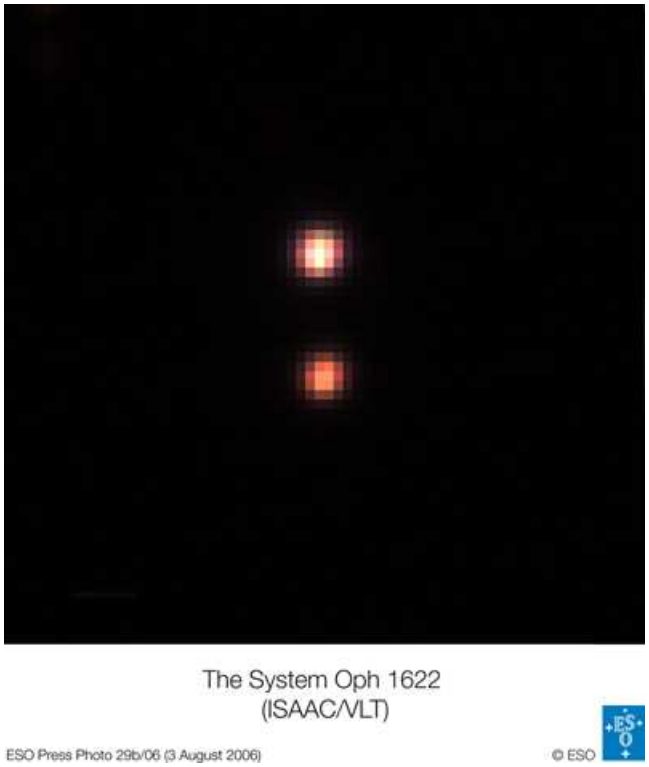

Figure 10: *Near-infrared image of the system Oph 162225-240515AB, obtained with ISAAC on ESO's Very Large Telescope. North is up and East is to the left. The apparent separation is less than 2 arcseconds, corresponding to 242 times the distance between the Earth and the Sun (242 astronomical units) at the distance of the system, 400 light-years.*

"Recent discoveries have revealed an amazing diversity of worlds out there. Still, the Oph1622 pair stands out as one of the most intriguing, if not peculiar," said Jayawardhana. "Now we're curious to find out whether such pairs are common or rare. The answer could shed light on how free-floating planetary-mass objects form," added Ivanov.

2.5 "Hourglass Figure" Points to Magnetic Field's Role in Star Formation

Source: Harvard-Smithsonian Centre for Astrophysics Press Release, August 10th, 2006 [11]

Long predicted by theory, the Smithsonian's Submillimeter Array has found the first conclusive evidence of an hourglass-shaped magnetic field in a star formation region. Measurements indicate that material in the interstellar cloud is dense enough to allow it to gravitationally collapse, warping the magnetic field in the process.

Astronomers Josep Girart (Institute of Space Studies of Catalonia, Spanish National Research Council), Ramprasad Rao (Institute of Astronomy and Astrophysics, Academia Sinica), and Dan Marrone (Harvard-Smithsonian Center for Astrophysics) studied the protostellar system designated NGC 1333 IRAS 4A. This system of two protostars is located approximately 980 light-years from Earth in the direction of the constellation Perseus.

They reported their findings in the August 11 issue of the journal Science.

"We selected this system because previous work had offered tantalizing hints of an hourglass-shaped magnetic field," explained Marrone. "The Submillimeter Array offered the resolution and sensitivity we needed to confirm it."

NGC 1333 IRAS 4A is part of the Perseus molecular cloud complex - a collection of gas and dust holding as much mass as 130,000 suns. This region is actively forming stars. Its proximity to Earth and young age make the Perseus complex an ideal laboratory for studying star formation.

Theorists predict that collapsing molecular cloud cores - the seeds of star formation - have to overcome the support provided by their magnetic field in order to form stars. In the process, the competition between gravity pulling inward and magnetic pressure pushing outward was expected to produce a warped, hourglass pattern to the magnetic field within these collapsed cores.

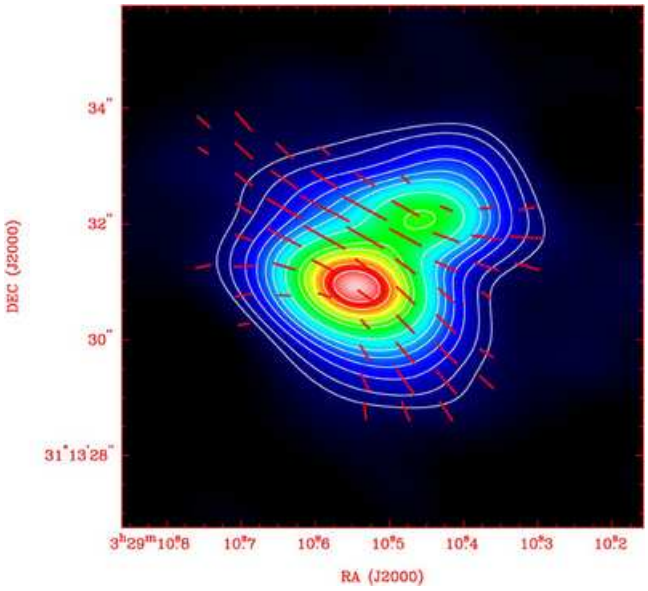

Figure 11: *The protostellar system NGC 1333 IRAS 4A is the first textbook example of an hourglass-shaped magnetic field (shown by dashed red lines on this color-coded submillimeter image) in a star formation region. The pear-shaped green and red region marks the locations of two still-forming stars. Gravity is pulling the gas and dust of this interstellar cloud clump inward, warping the magnetic field in the process. Taken with the Smithsonian's Submillimeter Array, this image is about 7 arcseconds on a side, which translates to a physical size of 2,700 astronomical units (using a distance to the system of 980 light-years). Image credit: J. Girart (CSIC-IEEC), R. Rao (ASIAA) and D. Marrone (CfA)*

Using the Array, Marrone and his colleagues observed dust emission from IRAS 4A. Because the magnetic field aligns the dust grains in the cloud core, the team could measure the magnetic field's geometry and estimate its strength by measuring the polarization of the dust emission.

"With the special polarization capabilities of the SMA we see the shape of the field directly. This is the first textbook example of theoretically predicted magnetic structure," said Rao.

The data indicate that, in the case of IRAS 4A, magnetic pressure is more influential than turbulence in slowing star formation within the cloud core. The same likely is true for similar cloud cores elsewhere.

Despite the moderating influence of the magnetic field, IRAS 4A is dense enough for gravitational collapse to continue. Approximately a million years in the future, two sun-like stars will shine where only a dust-cloaked cocoon lies today.

2.6 A Sub-Stellar Jonah

Source: ESO Press Release, August 3rd, 2006 [12]

Brown Dwarf Survives Being Swallowed

Using ESO's Very Large Telescope, astronomers have discovered a rather unusual system, in which two planet-size stars, of different colours, orbit each other. One is a rather hot white dwarf, weighing a little bit less than half as much as the Sun. The other is a much cooler, 55 Jupiter-masses brown dwarf.

"Such a system must have had a very troubled history", said Pierre Maxted, lead author of the paper that reports the study in this week's issue of Nature. "Its existence proves that the brown dwarf came out almost unaltered from an episode in which it was swallowed by a red giant."

The two objects, separated by less than 2/3 of the radius of the Sun or only a few thousandths of the distance between the Earth and the Sun, rotate around each other in about 2

hours. The brown dwarf [1] moves on its orbit at the amazing speed of 800 000 km/h!

The two stars were not so close in their past. Only when the solar-like star that has now become a white dwarf [1] was a red giant, did the separation between the two objects diminish drastically. During this fleeting moment, the giant engulfed its companion. The latter, feeling a large drag similar to trying to swim in a bath full of oil, spiralled in towards the core of the giant. The envelope of the giant was finally ejected, leaving a binary system in which the companion is in a close orbit around a white dwarf.

”Had the companion been less than 20 Jupiter masses, it would have evaporated during this phase”, said Maxted.”

The brown dwarf shouldn’t rejoice too quickly to have escaped this doom, however. Einstein’s General Theory of Relativity predicts that the separation between the two stars will slowly decrease.

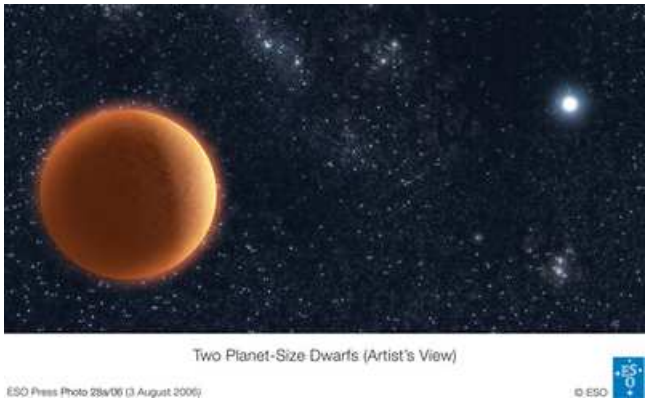

Figure 12: *Two Planet-Size Dwarfs (Artist’s View)*

”Thus, in about 1.4 billion years, the orbital period will have decreased to slightly more than one hour”, said Ralf Napiwotzki, from the University of Hertfordshire (UK) and co-author of the study. ”At that stage, the two objects will be so close that the white dwarf will work as a giant ”vacuum cleaner”, drawing gas off its companion, in a cosmic cannibal act.”

The low mass companion to the white dwarf (named WD0137-349) was found using spectra taken with EMMI at ESO’s New Technology Telescope at La Silla. The astronomers then used the UVES spectrograph on ESO’s Very Large Telescope to record 20 spectra and so measure the period and the mass ratio.

2.7 Hubble Sees Faintest Stars in a Globular Cluster

Source: Hubble News, August 17th, 2006 [13]

NASA’s Hubble Space Telescope has uncovered what astronomers are reporting as the dimmest stars ever seen in any globular star cluster. Globular clusters are spherical concentrations of hundreds of thousands of stars.

These clusters formed early in the 13.7-billion-year-old universe. The cluster NGC 6397 is one of the closest globular star clusters to Earth. Seeing the whole range of stars in this area will yield insights into the age, origin, and evolution of the cluster.

Although astronomers have conducted similar observations since Hubble was launched, a team led by Harvey Richer of the University of British Columbia, Vancouver, is reporting that it has at last unequivocally reached the faintest stars. Richer’s team announced its findings today at the 2006 International Astronomical Union General Assembly in Prague, Czech Republic, and in the August 18 edition of Science.

”We have run out of hydrogen-burning stars in this cluster. There are no fainter such stars waiting to be discovered. We have discovered the lowest-mass stars capable of supporting stable nuclear reactions in this cluster. Any less massive ones faded early in the cluster’s history and by now are too faint to be observed,” said Richer.

Hubble’s Advanced Camera for Surveys completed a census of two distinct stellar populations in NGC 6397. Hubble surveyed the faintest red dwarf stars, which fuse hydrogen in their cores like our sun, and the dimmest white dwarfs, which are the burned-out relics of normal stars.

The light from these faint stars is as dim as the light produced by a birthday candle on the Moon seen from Earth. NGC 6397 is 8,500 light-years away from Earth. Analyzing the burned-out remnants of stars that died long ago, Hubble showed that the dimmest white dwarfs have such low temperatures that they are undergoing a chemical change in their atmospheres that makes them appear bluer rather than redder as they cool. This phenomenon had been predicted, but never observed.

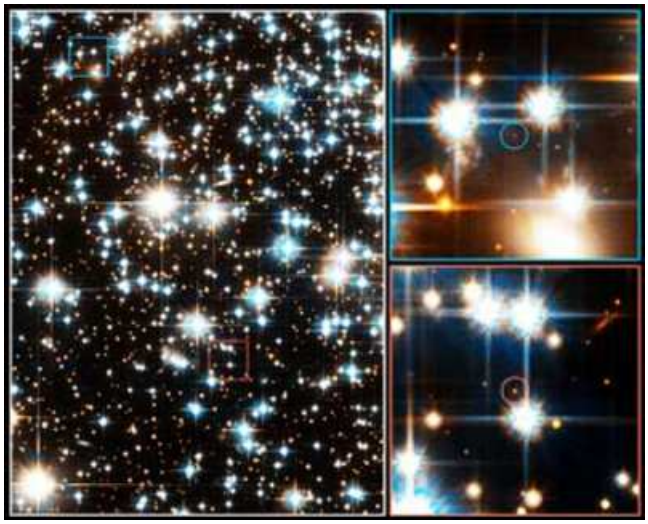

Figure 13: *Credit: NASA, ESA, and H. Richer (University of British Columbia)*

These white dwarfs are the relics of stars up to eight times as massive as the sun, which have exhausted the fuel capable of supporting nuclear reactions in their cores. Stars that were initially even more massive died as supernovae very early in the cluster's life, leaving behind neutron stars, black holes or no debris at all.

Astronomers have used white dwarfs in globular clusters as a measure of the universe's age. The universe must be at least as old as the oldest stars. White dwarfs cool down at a predictable rate the older the dwarf, the cooler it is, making it a perfect "clock" that has been ticking for almost as long as the universe has existed. Richer and his team are using the same age-dating technique to calculate the cluster's age. NGC 6397 is currently estimated to be nearly 12 billion years old.

A globular cluster's dimmest stars have eluded astronomers because their light is too feeble. Richer's team used Hubble's Advanced Camera to probe deep within the cluster for nearly five days to capture the faint stars. The camera's resolution is so sharp that it is capable of isolating cluster stars in this crowded cluster field, enabling cluster members to be distinguished from foreground and background stars. The cluster stars move together as the cluster orbits the Milky Way Galaxy, and Hubble was able to pinpoint which stars were moving with the cluster. The Hubble team used this technique together with archival Hubble images taken as much as a decade earlier to make sure they had a pure sample of cluster stars.

2.8 Supernova Remnant Cassiopeia A

Source: Hubble News, August 29th, 2006 [14]

A new image taken with NASA's Hubble Space Telescope provides a detailed look at the tattered remains of a supernova explosion known as Cassiopeia A (Cas A). It is the youngest known remnant from a supernova explosion in the Milky Way. The new Hubble image shows the complex and intricate structure of the star's shattered fragments.

The image is a composite made from 18 separate images taken in December 2004 using Hubble's Advanced Camera for Surveys (ACS), and it shows the Cas A remnant as a broken ring of bright filamentary and clumpy stellar ejecta. These huge swirls of debris glow with the heat generated by the passage of a shockwave from the supernova blast. The various colors of the gaseous shards indicate differences in chemical composition. Bright green filaments are rich in oxygen, red and purple are sulfur, and blue are composed mostly of hydrogen and nitrogen.

A supernova such as the one that resulted in Cas A is the explosive demise of a massive star that collapses under the weight of its own gravity. The collapsed star then blows its outer layers into space in an explosion that can briefly outshine its entire parent galaxy. Cas A is relatively young, estimated to be only about 340 years old. Hubble has observed it on several occasions to look for changes in the rapidly expanding filaments.

In the latest observing campaign, two sets of images were taken, separated by nine months. Even in that short time, Hubble's razor-sharp images can observe the expansion of the remnant. Comparison of the two image sets shows that a faint stream of debris seen along the upper left side of the remnant is moving with high speed - up to 31 million miles per hour (fast enough to travel from Earth to the Moon in 30 seconds!).

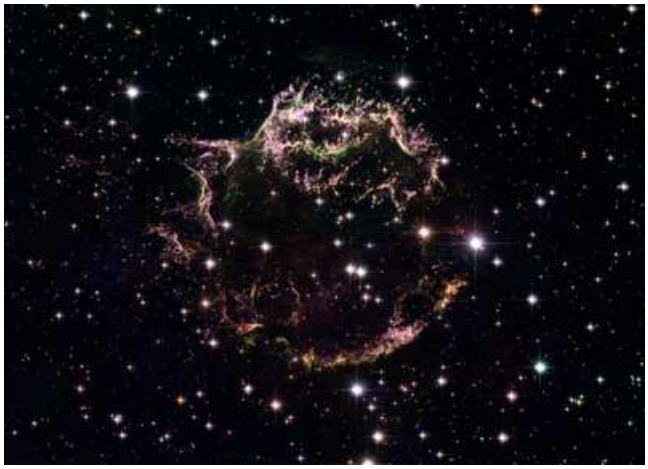

Figure 14: *Credit: NASA, ESA, and the Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration*

Cas A is located ten thousand light-years away from Earth in the constellation of Cassiopeia. Supernova explosions are the main source of elements more complex than oxygen, which are forged in the extreme conditions produced in these events. The analysis of such a nearby, relatively young and fresh example is extremely helpful in understanding the evolution of the universe.

2.9 Astronomers Use Supercomputers to Study Atoms Linked to Black Holes

Source: Ohio State Research News, August 23rd, 2006 [15]

Super-hot atoms in space hold the key to an astronomical mystery, and an Ohio State University astronomer is leading an effort to study those atoms here on Earth.

Anil Pradhan, professor of astronomy, and his team have used supercomputers to perform the most precise energy calculations ever made for these atoms and their properties. As a result, astronomers – in particular, those hunting black holes – will have a better idea of what they are looking at when they examine faraway space matter using X-ray telescopes.

The results appear in the September issue of the Journal of Physics B: Atomic, Molecular and Optical Physics. And while the paper's subject matter is highly technical, it tells a story that weaves together atomic physics, Einstein's theory of relativity, cutting-edge astronomical observations, and some of the world's fastest supercomputers.

Astronomers have spied seas of super-hot atoms in plasma form, circling the centers of very bright galaxies, called active galactic nuclei. The plasma is thought to be a telltale sign of a black hole; the black hole itself is invisible, but any material spiraling into it should be very hot, and shine brightly with X-rays.

Before anyone can prove definitively whether active galaxies contain black holes, astronomers need to measure the energy levels of the excited atoms in the plasma very precisely, and match the measurements with what they know about atomic physics.

Assuring the accuracy of atomic data doesn't sound like the most exciting job in astronomy, Pradhan admitted – but it is fundamentally important.

"Most astronomers take it for granted that the atomic data they are referencing are correct – they have to, in order to interpret their observations," he said.

For 30 years, the professor of astronomy has worked on the problem. The new, high-resolution X-ray data gathered by NASA's Chandra X-ray Observatory and the European Space Agency's X-ray Multi-mirror Mission-Newton satellite spurred him on. Believing that such high-quality observations demanded good atomic data, he and his team – which is also led by Ohio State senior research scientist Sultana Nahar – decided to make the most precise atomic calculations possible.

After years of writing computer codes and thousands of hours of computing time at the Ohio Supercomputer Center, they calculated the energy levels of high-temperature atoms ranging from carbon to iron – the atoms found in these plasmas.

Some of the previously accepted values for these atoms had acknowledged error rates from 30 percent to as high as factors of two or three. With the new calculations reported in this study, the error for all the atoms has been reduced to a few percent.

This means that from now on, when astronomers record X-ray images of objects in space, they will have a much better idea of what atoms make up the material they are looking at, and the physical conditions inside that object.

The atom that most black-hole hunters are interested in is iron, and that's where Einstein's general theory of relativity comes in.

The immense gravity of a black hole should, according to relativity, distort the X-ray signal as seen from Earth, particularly for iron atoms. The signal is a spectrum, and looks like a series of lines, with each atom having its own line. One line in particular, called the iron K-alpha line, appears broadened for X-rays emanating from the center of active

galaxies, and it is often cited as a key indication of a black hole.

Thirteen years ago, Pradhan, Nahar, and their colleagues began a study called the Iron Project. Their goal, in part, is to find out why the iron K-alpha line is broadened and what the implications are for X-ray astronomy.

"The most direct observation of a black hole is considered to be the iron K-alpha line," Pradhan said. "So it's very important to find out whether it's been broadened because there is a black hole nearby, or if there is some other cause."

He is hopeful that astronomers will apply his new data to studies of the iron K-alpha line and help solve the mystery.

2.10 NASA Galaxy Hunter: Huge Black Holes Stifle Star Formation

Source: JPL/NASA Press Release, August 23rd, 2006 [16]

Supermassive black holes in some giant galaxies create such a hostile environment, they shut down the formation of new stars, according to NASA Galaxy Evolution Explorer findings published in the August 24 issue of Nature.

The orbiting observatory surveyed more than 800 nearby elliptical galaxies of various sizes. An intriguing pattern emerged: the more massive, or bigger, the galaxy, the less likely it was to have young stars. Because bigger galaxies are known to have bigger black holes, astronomers believe the black holes are responsible for the lack of youthful stars.

"Supermassive black holes in these giant galaxies create unfriendly places for stars to form," said Dr. Sukyoung K. Yi of Yonsei University in Seoul, Korea, who led the research team. "If you want to find lots of young stars, look to the smaller galaxies."

Previously, scientists had predicted that black holes might have dire consequences for star birth, but they didn't have the tools necessary to test the theory. The Galaxy Evolution Explorer, launched in 2003, is well-suited for this research. It is extremely sensitive to the ultraviolet radiation emitted by even low numbers of young stars.

Black holes are monstrous heaps of dense matter at the centers of galaxies. Over time, a black hole and its host galaxy will grow in size, but not always at the same rate.

Yi and his collaborators found evidence that the black holes in elliptical galaxies bulk up to a critical mass before putting a stop to star formation. In other words, once a black hole reaches a certain size relative to its host galaxy, its harsh effects become too great for new stars to form. According to this "feedback" theory, the growth of a black hole slows the development of not only stars but of its entire galaxy.

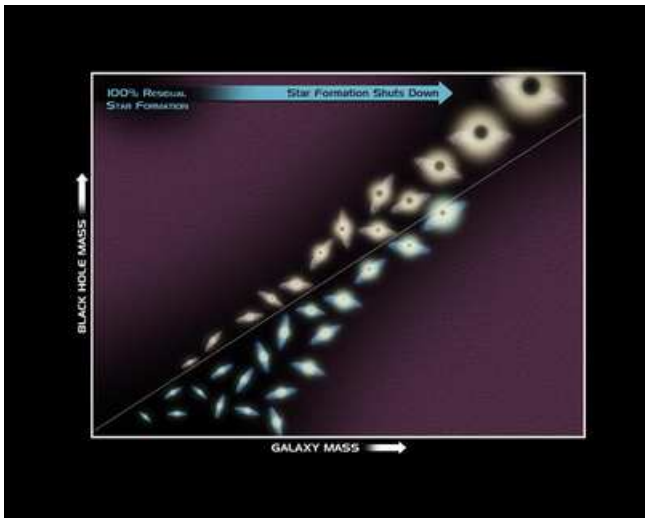

Figure 15: *The Galaxy Evolution Explorer observed the following trend: the biggest galaxies and black holes (shown in upper right corner) are more likely to have no observable star formation (red) than the smaller galaxies with smaller black holes. This is evidence that black holes can create environments unsuitable for stellar birth. Image credit: NASA/JPL-Caltech/Yonsei University*

How does a black hole do this? There are two possibilities. First, jets being blasted out of black holes could blow potential star-making fuel, or gas, out of the galaxy center, where stars tend to arise.

The second theory relates to the fact that black holes drag surrounding gas onto them, which heats the gas. The gas becomes so hot that it can no longer clump together and collapse into stars.

2.11 Mystery of Quintuplet Stars in Milky Way Solved

Source: Rochester Institute of Technology News Release, August 17th, 2006 [17]

For the first time, scientists have identified the cluster of Quintuplet stars in the Milky Way's galactic center, next to the super massive black hole, as massive binary stars nearing the end of their life cycle, solving a mystery that had dogged astronomers for more than 15 years.

The nature of the stars was not entirely clear until now. In a paper published in the Aug. 18 issue of Science, co-authors Peter Tuthill of the University of Sydney and Donald Figer

of Rochester Institute of Technology show that the Quintuplet cluster consists of young massive binary stars that produce large amounts of dust. Their data reveal that five bright red stars are nearing the end of their ”short” lives of approximately 5 million years. These quickly evolving stars burn fast and bright, but die younger than fainter stars, which live for billions of years. The study captures the Quintuplet stars just before disintegrating in supernovae explosions.

Using advanced imaging techniques on the world’s biggest telescope at the W.M. Keck Observatory in Hawaii, the scientists captured the stars at the highest attainable resolution for the instrument, far exceeding the capability of the Hubble Space Telescope, which imaged the cluster a decade ago. The extra-resolution gives scientists a new glimpse of the dust plumes surrounding the stars and the swirling spirals Tuthill likened to pinwheels when he identified the first one in 1999 elsewhere in the galaxy.

”Only a few pinwheels are known in the galaxy,” Figer says. ”The point is, we’ve found five all next to each other in the same cluster. No one has seen anything like this before.”

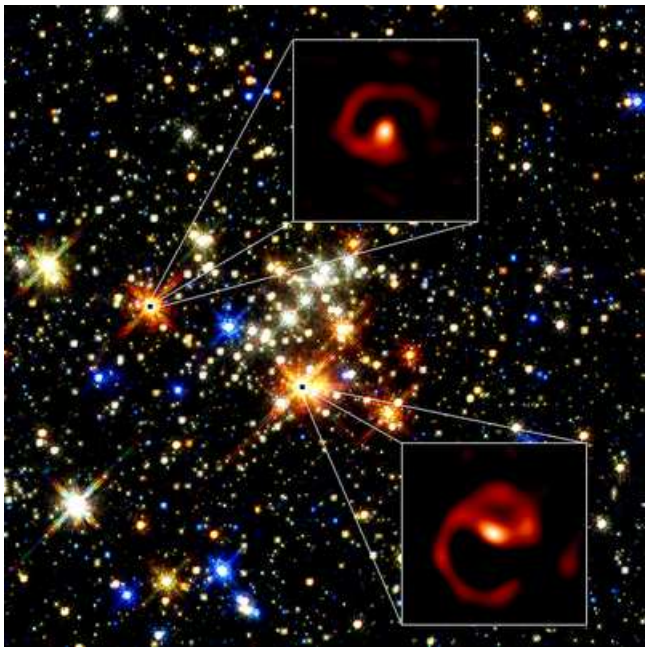

Figure 16: *A Yin and Yang in the Galactic Center. High-resolution infrared images of the dusty pinwheel nebulae are shown inset overlaid on a Hubble Space Telescope image of the Quintuplet cluster. Each of the five bright red stars is now thought to be a pinwheel nebula. Image Credit: Peter Tuthill (Sydney U.), Keck Observatory, Donald Figer (RIT).*

According to Figer, the swirling dust in pinwheel stars is key to the presence of the most evolved massive stars and points to the presence of pairs of stars. The geometry of the plume allows scientists to measure the properties of the binary stars, including the orbital period and distance.

”The only way that pinwheels can form is if they have two stars, swirling around each other. The stars are so close that their winds collide, forming dust in a spiral shape, just like water sprayed from a garden hose of a twirling sprinkler,” Figer says. ”A single star wouldn’t be able to produce the dust and wouldn’t have the spiral outflow.”

An earlier study by Figer in 1996 claimed the Quintuplet cluster consists of evolved massive stars that produce dust. Figer’s research could not be confirmed until now with the use of the Keck telescope.

”If you want to understand star formation, you have to understand if they are forming alone or if they have partners,” Figer says. ”The answer gives us a clue as to whether stars form alone or with companions.”

2.12 Stars Too Old to be Trusted?

Source: ESO Press Release, August 10th, 2006 [18]

A possible Stellar Solution to the Cosmological Lithium Problem

Analysing a set of stars in a globular cluster with ESO’s Very Large Telescope, astronomers may have found the solution to a critical cosmological and stellar riddle. Until now, an embarrassing question was why the abundance of lithium produced in the Big Bang is a factor 2 to 3 times higher than the value measured in the atmospheres of old stars. The answer, the researchers say, lies in the fact that the abundances of elements measured in a star’s atmosphere decrease with time.

”Such trends are predicted by models that take into account the diffusion of elements in a star”, said Andreas Korn, lead-author of the paper reporting the results in this week’s issue of the journal Nature. ”But an observational confirmation was lacking. That is, until now.”

Lithium is one of the very few elements to have been produced in the Big Bang. Once astronomers know the amount of ordinary matter present in the Universe, it is rather straightforward to derive how much lithium was created in the early Universe. Lithium can also be measured in the oldest, metal-poor stars, which formed from matter similar to the primordial material. But the cosmologically predicted value is too high to reconcile with the measurements made in the stars. Something is wrong, but what?

Diffusive processes altering the relative abundances of elements in stars are well known to play a role in certain classes of stars. Under the force of gravity, heavy elements will tend to sink out of visibility into the star over the course of billions of years.

”The effects of diffusion are expected to be more pronounced in old, very metal-poor stars”, said Korn. ”Given their greater age, diffusion has had more time to produce sizeable effects than in younger stars like the Sun.”

The astronomers thus set up an observational campaign to test these model predictions, studying a variety of stars in different stages of evolution in the metal-poor globular cluster NGC 6397. Globular clusters are useful laboratories in this respect, as all the stars they contain have identical age and initial chemical composition. The diffusion effects are predicted to vary with evolutionary stage. Therefore, measured atmospheric abundance trends with evolutionary stage are a signature of diffusion.

Figure 17: *Targets of FLAMES-UVES in Globular Cluster NGC 6397*

Eighteen stars were observed for between 2 and 12 hours with the multi-object spectrograph FLAMES-UVES on ESO’s Very Large Telescope. The FLAMES spectrograph is ideally suited as it allows astronomers to obtain spectra of many stars at a time. Even in a nearby globular cluster like NGC 6397, the unevolved stars are very faint and require rather long exposure times.

The observations clearly show systematic abundance trends along the evolutionary sequence of NGC 6397, as predicted by diffusion models with extra mixing. Thus, the abundances measured in the atmospheres of old stars are not, strictly speaking, representative of the gas the stars originally formed from.

”Once this effect is corrected for, the abundance of lithium measured in old, unevolved stars agrees with the cosmologically predicted value”, said Korn. ”The cosmological lithium discrepancy is thus largely removed.”

”The ball is now in the camp of the theoreticians,” he added. ”They have to identify the physical mechanism that is at the origin of the extra mixing.”

2.13 Surprising New Telescope Observations Shake Up Galactic Formation Theories

Source: University of Colorado News Release, August 14th, 2006 [19]

A heavy form of hydrogen created just moments after the Big Bang has been found to exist in larger quantities than expected in the Milky Way, a finding that could radically alter theories about star and galaxy formation, says a new international study led by the University of Colorado at Boulder.

CU-Boulder astrophysicist Jeffrey Linsky said new data gathered by NASA’s Far Ultraviolet Spectroscopic Explorer, or FUSE, satellite, shows why deuterium appears to be distributed unevenly in the Milky Way Galaxy. It apparently has been binding to interstellar dust grains, changing from an easily detectable gaseous form to an unobservable solid form, said Linsky, a fellow of JILA, a joint institute of CU-Boulder and the National Institute of Standards and Technology.

The FUSE deuterium study, six years in the making, solves a 35-year-old mystery concerning the distribution of deuterium in the Milky Way while posing new questions about how stars and galaxies are made, according to the research team. A paper on the subject by a team of international researchers led by Linsky is being published in the Aug. 20 issue of The Astrophysical Journal.

”Since the 1970s, we have been unable to explain why deuterium levels vary all over the place,” said Linsky. ”The answer we found is as unsettling as it is exciting.”

Since deuterium – a hydrogen isotope containing a proton and a neutron – is believed burned and lost forever during star formation, scientists think the amount of deuterium present in the universe is ”pure” and serves as a tracer for star creation and galaxy building over billions of years, said Linsky. While primordial deuterium in the distant, early universe has been measured at concentrations of about 27 parts per million hydrogen atoms, measurements by FUSE and NASA’s Copernicus satellite have shown a ”patchy” distribution of the element in the Milky Way galaxy, often at far lower levels.

In 2003, Princeton University’s Bruce Draine, a co-author on the new study, developed a model showing that deuterium, when compared to hydrogen, might preferentially bind to interstellar dust grains. The observations by FUSE – which can detect the telltale spectral fingerprints of deuterium in the ultraviolet energy range – strongly support the theory, according to The Astrophysical Journal paper authors.

”Where there are high concentrations of interstellar dust in the galaxy, we see lower concentrations of deuterium gas with FUSE,” said Linsky. ”And where there is less interstellar dust, we are measuring higher levels of deuterium gas.”

In relatively undisturbed areas of the universe – like regions around Earth’s sun, for example – deuterium atoms systematically ”leave” the gas phase and replace normal hydrogen atoms in dust grains, said Linsky. When a pocket of the universe is disturbed by events like a supernova shock wave or violent activity triggered by nearby hot stars, the dust grains are vaporized, releasing deuterium atoms back into a gas, which has been measured by FUSE, the researchers said.

Scientists assumed from astrophysical theories that at least one-third of the primordial deuterium present in the Milky Way was destroyed over time as it cycled through the stars, said Linsky. But according to the new FUSE findings, the present-day deuterium abundance is less than 15 percent below the primordial values.

”This implies that either significantly less material has been converted to helium and heavier elements in stars or that much more primordial gas has rained down onto the galaxy over its lifetime than had been thought,” said Linsky. ”In either case, our models of the chemical evolution of the Milky Way will have to be revised significantly to explain this important new result.”

Launched in 1999, FUSE is a NASA Explorer mission developed in cooperation with the French and Canadian Space Agencies and by Johns Hopkins University, CU-Boulder and the University of California, Berkeley. CU-Boulder’s Center for Astrophysics and Space Astronomy designed and built the mission’s 9 million dollars spectrograph, which collects and funnels UV light from the satellite’s four telescopes.

2.14 Direct Proof of Dark Matter

Source: Chandra Press Release, August 21st, 2006 [20]

Dark matter and normal matter have been wrenched apart by the tremendous collision of two large clusters of galaxies. The discovery, using NASA’s Chandra X-ray Observatory and other telescopes, gives direct evidence for the existence of dark matter.

”This is the most energetic cosmic event, besides the Big Bang, which we know about,” said team member Maxim Markevitch of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

These observations provide the strongest evidence yet that most of the matter in the universe is dark. Despite considerable evidence for dark matter, some scientists have proposed alternative theories for gravity where it is stronger on intergalactic scales than predicted by Newton and Einstein, removing the need for dark matter. However, such theories cannot explain the observed effects of this collision.

”A universe that’s dominated by dark stuff seems preposterous, so we wanted to test whether there were any basic flaws in our thinking,” said Doug Clowe of the University of Arizona at Tucson, and leader of the study. ”These results are direct proof that dark matter exists.”

n galaxy clusters, the normal matter, like the atoms that make up the stars, planets, and everything on Earth, is primarily in the form of hot gas and stars. The mass of the hot gas between the galaxies is far greater than the mass of the stars in all of the galaxies. This normal matter is bound in the cluster by the gravity of an even greater mass of dark matter. Without dark matter, which is invisible and can only be detected through its gravity, the fast-moving galaxies and the hot gas would quickly fly apart.

The team was granted more than 100 hours on the Chandra telescope to observe the galaxy cluster 1E0657-56. The cluster is also known as the bullet cluster, because it contains a spectacular bullet-shaped cloud of hundred-million-degree gas. The X-ray image shows the bullet shape is due to a wind produced by the high-speed collision of a smaller cluster with a larger one.

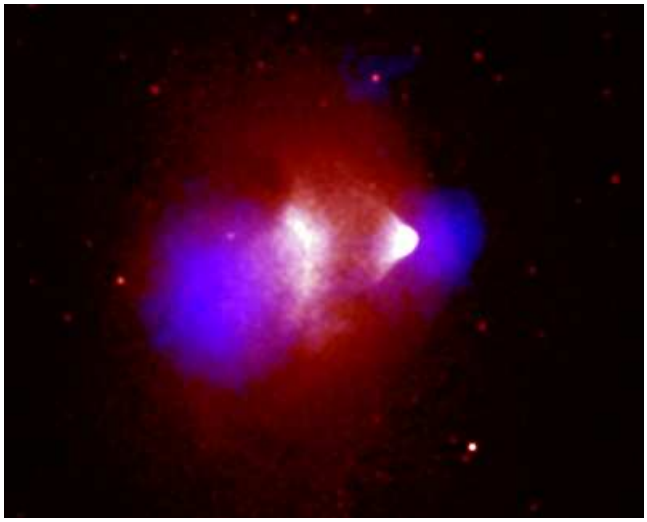

Figure 18: *Chandra X-ray Image of 1E 0657-56*

Dark matter and normal matter have been wrenched apart by the tremendous collision of two large clusters of galaxies. Never previously seen, this discovery, made with NASA's Chandra X-ray Observatory and other telescopes, gives direct evidence for the existence of dark matter. Scale: Full-field image is 13.5 x 10.6 arcmin (Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.)

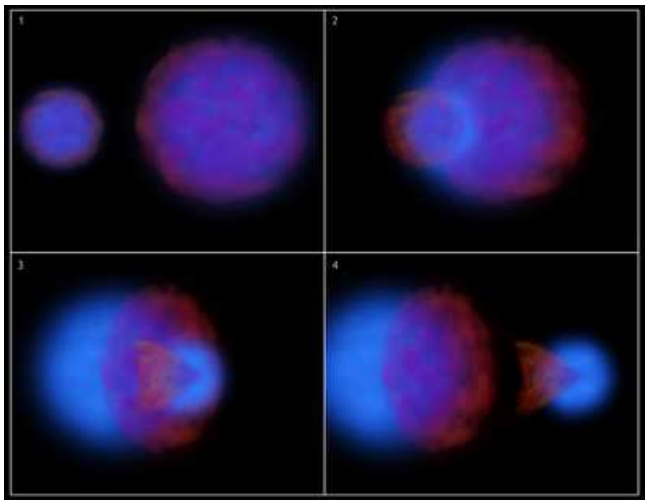

Figure 19: *4-Panel Illustrations of Cluster Collision*

These stills show four stages from an artist's representation of the huge collision that is taking place in the bullet cluster. Hot gas, containing most of the normal matter in the cluster, is shown in red and dark matter is shown in blue. During the collision the hot gas in each cluster is slowed and distorted by a drag force, similar to air resistance. A bullet-shaped cloud of gas forms in one of the clusters. In contrast, the dark matter is not slowed by the impact because it does not interact directly with itself or the gas except through gravity. Therefore, the dark matter clumps from the two clusters move ahead of the hot gas, producing the separation of the dark and normal matter seen in the image.

In addition to the Chandra observation, the Hubble Space Telescope, the European Southern Observatory's Very Large Telescope and the Magellan optical telescopes were used to determine the location of the mass in the clusters. This was done by measuring the effect of gravitational lensing, where gravity from the clusters distorts light from background galaxies as predicted by Einstein's theory of general relativity.

The hot gas in this collision was slowed by a drag force, similar to air resistance. In contrast, the dark matter was not slowed by the impact, because it does not interact directly with itself or the gas except through gravity. This produced the separation of the dark and normal matter seen in the data. If hot gas was the most massive component in the clusters, as proposed by alternative gravity theories, such a separation would not have been seen. Instead, dark matter is required.

"This is the type of result that future theories will have to take into account," said Sean Carroll, a cosmologist at the University of Chicago, who was not involved with the study. "As we move forward to understand the true nature of dark matter, this new result will be impossible to ignore."

This result also gives scientists more confidence that the Newtonian gravity familiar on Earth and in the solar system also works on the huge scales of galaxy clusters.

"We've closed this loophole about gravity, and we've come closer than ever to seeing this invisible matter," Clowe said.

2.15 Cosmic stocktake reveals what's left of big bang

Source: Australian National University Communications, August 18th, 2006 [21]

The Universe has guzzled its way through about 20 per cent of its normal matter, or original fuel reserves, according to findings from a survey of the nearby Universe by an international team of astronomers involving researchers at The Australian National University.

The survey, to be released at the General Assembly of the International Astronomical Union in Prague today, revealed

that about 20 per cent of the normal matter or fuel that was produced by the Big Bang 14 billion years ago is now in stars, a further 0.1 per cent lies in dust expelled from massive stars (and from which solid structures like the Earth and humans are made), and about 0.01 per cent is in supermassive black holes.

The survey data, which forms a 21st century database called the Millennium Galaxy Catalogue, was gathered from over 100 nights of telescope time in Australia, the Canary Islands and Chile, and contains over ten thousand giant galaxies, each of these containing 10 million to 1000 billion stars.

According to the survey leader Dr Simon Driver of St Andrews University, Scotland, the remaining material is almost completely in gaseous form lying both within and between the galaxies, forming a reservoir from which future generations of stars may develop.

”I guess the simplest prognosis is that the Universe will be able to form stars for a further 70 billion years or so after which it will start to go dark,” said Dr Driver. ”However, unlike our stewardship of the Earth the Universe is definitely tightening its belt with a steady decline in the rate at which new stars are forming.”

Dr Alister Graham, an astronomer at The Australian National University who worked on the survey, said that the team of researchers were able determine how much of matter is in the stars through a ’cosmic stocktake.’

”We needed to measure the stellar mass within a representative volume of the local Universe. This required accurate and complete distance information for all the galaxies of stars that we imaged. This is where the Australian telescopes played a key role,” Dr Graham said.

One of the unique aspects of this program was the careful separation of a galaxy’s stars into its central bulge component and surrounding disc-like structure. This allowed the researchers to determine that, on average, roughly half of the stars in galaxies reside in discs and the other half in bulges.

”Measuring the concentration of stars in each galaxy’s bulge is what enabled us to determine their central super-massive black hole masses,” said Dr Graham. ”Some of these are up to one million billion times more massive than the Earth. Once we had these masses it was a simple task of summing them up to determine how much of the Universe’s matter is locked away in black holes at the centres of galaxies.”

Dr Graham said next-generation telescopes such as the Giant Magellan Telescope, currently in production, will enable astronomers to directly measure black hole masses in galaxies ten times further away and thus ten times further back in time. ”In effect, we’ll soon be able to observe how galaxies and their black holes evolved into what we see around us today.”

2.16 Chandra Independently Determines Hubble Constant

Source: Chandra Press Release, August 8th, 2006 [22]

A critically important number that specifies the expansion rate of the Universe, the so-called Hubble constant, has been independently determined using NASA’s Chandra X-ray Observatory. This new value matches recent measurements using other methods and extends their validity to greater distances, thus allowing astronomers to probe earlier epochs in the evolution of the Universe.

”The reason this result is so significant is that we need the Hubble constant to tell us the size of the Universe, its age, and how much matter it contains,” said Max Bonamente from the University of Alabama in Huntsville and NASA’s Marshall Space Flight Center (MSFC) in Huntsville, Ala., lead author on the paper describing the results. ”Astronomers absolutely need to trust this number because we use it for countless calculations.”

The Hubble constant is calculated by measuring the speed at which objects are moving away from us and dividing by their distance. Most of the previous attempts to determine the Hubble constant have involved using a multi-step, or distance ladder, approach in which the distance to nearby galaxies is used as the basis for determining greater distances.

The most common approach has been to use a well-studied type of pulsating star known as a Cepheid variable, in conjunction with more distant supernovae to trace distances across the Universe. Scientists using this method and observations from the Hubble Space Telescope were able to measure the Hubble constant to within 10%. However, only independent checks would give them the confidence they desired, considering that much of our understanding of the Universe hangs in the balance.

By combining X-ray data from Chandra with radio observations of galaxy clusters, the team determined the distances to 38 galaxy clusters ranging from 1.4 billion to 9.3 billion light years from Earth. These results do not rely on the traditional distance ladder. Bonamente and his colleagues find the Hubble constant to be 77 kilometers per second per megaparsec (a megaparsec is equal to 3.26 million light years), with an uncertainty of about 15%.

This result agrees with the values determined using other techniques. The Hubble constant had previously been found to be 72, give or take 8, kilometers per second per megaparsec based on Hubble Space Telescope observations. The new Chandra result is important because it offers the independent confirmation that scientists have been seeking and fixes the age of the Universe between 12 and 14 billion years.

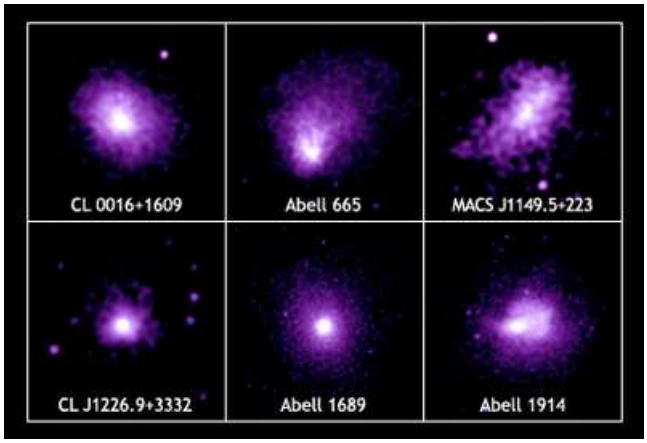

Figure 20: *Chandra X-ray Images of Galaxy Clusters*

"These new results are entirely independent of all previous methods of measuring the Hubble constant," said team member Marshall Joy also of MSFC.

The astronomers used a phenomenon known as the Sunyaev-Zeldovich effect, where photons in the cosmic microwave background (CMB) interact with electrons in the hot gas that pervades the enormous galaxy clusters. The photons acquire energy from this interaction, which distorts the signal from the microwave background in the direction of the clusters. The magnitude of this distortion depends on the density and temperature of the hot electrons and the physical size of the cluster. Using radio telescopes to measure the distortion of the microwave background and Chandra to measure the properties of the hot gas, the physical size of the cluster can be determined. From this physical size and a simple measurement of the angle subtended by the cluster, the rules of geometry can be used to derive its distance. The Hubble constant is determined by dividing previously measured cluster speeds by these newly derived distances.

This project was championed by Chandra's telescope mirror designer, Leon Van Speybroeck, who passed away in 2002. The foundation was laid when team members John Carlstrom (University of Chicago) and Marshall Joy obtained careful radio measurements of the distortions in the CMB radiation using radio telescopes at the Berkeley-Illinois-Maryland Array and the Caltech Owens Valley Radio Observatory. In order to measure the precise X-ray properties of the gas in these distant clusters, a space-based X-ray telescope with the resolution and sensitivity of Chandra was required.

"It was one of Leon's goals to see this project happen, and it makes me very proud to see this come to fruition," said Chandra Project Scientist Martin Weisskopf of MSFC.

2.17 Astronomers Crunch Numbers, Universe GetS Bigger

Source: University of Ohio Press Release, August 3rd, 2006 [23]

That intergalactic road trip to Triangulum is going to take a little longer than you had planned.

An Ohio State University astronomer and his colleagues have determined that the Triangulum Galaxy, otherwise known as M33, is actually about 15 percent farther away from our galaxy than previously measured.

This finding implies that the Hubble constant, a number that astronomers rely on to calculate a host of factors – including the size and age of the universe – could be significantly off the mark as well.

That means that the universe could be 15 percent bigger and 15 percent older than any previous calculations suggested.

The astronomers came to this conclusion after they invented a new method for calculating intergalactic distances, one that is more precise and much simpler than standard methods. Kris Stanek, associate professor of astronomy at Ohio State, and his coauthors describe the method in a paper to appear in the Astrophysical Journal (astro-ph/0606279).

In 1929, Edwin Hubble formulated the cosmological distance law that determines the Hubble constant. Scientists have disagreed about the exact value of the constant over the years, but the current value has been accepted since the 1950s. Astronomers have discovered other cosmological parameters since then, but the Hubble constant and its associated methods for calculating distance haven't changed.

"The Hubble constant used to be the one parameter that we knew pretty well, and now it's lagging behind. Now we know some things quite a bit better than we know the Hubble constant," Stanek said. "Ten years ago, we didn't even know that dark energy existed. Now we know how much dark energy there is – better than we know the Hubble constant, which has been around for almost 80 years."

Still, Stanek said he and his colleagues didn't start this work in order to change the value of the Hubble constant. They just wanted to find a simpler way to calculate distances.

To calculate the distance to a faraway galaxy using the Hubble constant, astronomers have to work through several complex steps of related equations, and incorporate distances to closer objects, such as the Large Magellanic Cloud.

"In every step you accumulate errors," Stanek said. "We wanted an independent measure of distance – a single step that will one day help with measuring dark energy and other things."

The new method took 10 years to develop. They studied M33 in optical and infrared wavelengths, checking and rechecking measurements that are normally taken for granted. They used telescopes of all sizes, from fairly small 1-meter telescopes to the largest in the world – the 10-meter telescopes at the Keck Observatory in Hawaii .

"Technologically, we had to be on the cutting edge to make this work, but the basic idea is very simple," he said.

They studied two of the brightest stars in M33, which are part of a binary system, meaning that the stars orbit each other. As seen from Earth, one star eclipses the other every five days.

They measured the mass of the stars, which told them how bright those stars would appear if they were nearby. But the stars actually appear dimmer because they are far away. The difference between the intrinsic brightness and the apparent brightness told them how far away the stars were – in a single calculation.

To their surprise, the distance was 15 percent farther than they expected: about 3 million light-years away, instead of 2.6 million light-years as determined by the Hubble constant.

If this new distance measurement is correct, then the true value of the Hubble constant may be 15 percent smaller – and the universe may be 15 percent bigger and older – than previously thought.

Figure 21: *Credit: NASA/JPL-Caltech/GALEX*

"Our margin of error is now 6 percent, which is actually pretty good," Stanek said. Next, they may do the same calculation for another star system in M33, to reduce their error further, or they may look at the nearby Andromeda galaxy. The kind of binary systems they are looking for are relatively rare, he said, and getting all the necessary measurements to repeat the calculation would probably take at least another two years.

3 Space missions

3.1 Mariner Meteor Mystery, Solved?

Source: Science@NASA, August 23rd, 2006 [24]

On July 14, 1965, Mariner 4 swooped over Mars. It was a moment of high drama. Six other probes had already tried to reach Mars and failed–most malfunctioning before they even left Earth. Since the days of H.G. Wells (The War of the Worlds, 1898), people had been hearing about life on Mars and they were ready to see the canals and cities. But the wait was becoming excruciating.

With flawless precision, Mariner 4 dipped less than 10,000 km above the planet's surface and took 22 pictures. Mars was covered with desert sand and ancient craters. No cities.

No canals. No Martians. No one would ever look at the red planet the same way again.

Most histories of the mission end right there, with Mariner 4 buzzing Mars"the first spacecraft to visit the red planet"–and throwing cold water on a lot of good science fiction. But there's more to the story. After the flyby, something strange happened to Mariner 4, setting the stage for a 40-year mystery:

Fast-forward to September 15, 1967. Mariner 4 was cruising the dark emptiness between Earth and Mars. Having shot past Mars in '65 without enough fuel to turn around and go back, there was nothing else to do. All was quiet. Fuel was running low. Soon, Mariner 4 would fade into history.

That's when the meteor storm hit.

Figure 22: *An artist's rendering of Mariner 4*

"For about 45 minutes the spacecraft experienced a shower of meteoroids more intense than any Leonid meteor storm we've ever seen on Earth," according to Bill Cooke, the head of NASA's Meteoroid Environment Office in Huntsville, AL. The impacts ripped away bits of insulation and temporarily changed the craft's orientation in space. "It was a complete surprise."

Think about it. Out in the "emptiness" between Earth and Mars, a region of space astronauts are going cross one day if NASA's Vision for Space Exploration comes to fruition, lurks a dark stream of meteoroids capable of producing a shower more intense than anything we've seen in centuries of sky watching on Earth. "Until Mariner 4 stumbled onto it," says Cooke, "we had no idea it was there."

For almost 40 years the source of the shower remained a mystery. But now, meteor expert Paul Wiegert of the University of Western Ontario may have cracked the case. The culprit, he believes, is a "dark comet" named D/1895 Q1 (Swift) or "D/Swift" for short.

"Comet D/Swift was first seen in August 1895 by the prolific comet hunter Lewis A. Swift," says Wiegert. Swift discovered or co-discovered more than a dozen comets, including 109P/Swift-Tuttle, the source of the well-known Perseid meteor shower. Unlike his other comets, however, "D/Swift quickly vanished. The comet was last spotted in February 1896 heading out of the inner Solar System, and it has never been seen since, even though its orbit indicates it should come back and brighten every 5 years or so."

(Note that the prefix D/ indicates a lost or broken-up comet, one that was well-observed on one or more occasions, but which failed to reappear as expected.)

What happened to D/Swift? "The comet may have disintegrated," says Wiegert. Comets are notoriously fragile and sometimes a little sunlight is all it takes to make them crumble. Comet D/Swift probably overheated when it passed by the sun in 1895 and later fell apart.

D/Swift was mostly forgotten until last year when Bill Cooke wondered if "some old D/ comet" might be responsible for the Mariner 4 episode. Comets, especially disrupted comets, leave a stream of debris in their wake as they orbit the sun. If Mariner 4 passed through such a stream, "it would have been sandblasted."

He asked Wiegert, a friend and colleague, to look into it. Wiegert began to examine old comet data andvoil"Mariner 4 was close to the orbit of Comet D/Swift at the time of the meteor encounter."

Amazingly, Mariner 4 was not merely close to the comet's orbit, it may have been close to the comet itself. "According to our calculations, the [possibly shattered] nucleus of D/Swift was only 20 million kilometers from the spacecraft." As distances go in the solar system, that's nearby.

"It's like in Star Trek when Enterprise stumbles across a comet in the middle of deep space. Of course, that's crazy," says Cooke. "Space is so big, the chances of running across a comet are almost nil." Yet this may be what happened to Mariner 4.

Mariner's cameras weren't turned on at the time, so a comet could've passed by unnoticedexcept for the jostling of comet dust. Telescopes on Earth saw nothing, but that's no surprise. An old, shattered nucleus wouldn't necessarily glow. It all makes sense.

Case closed?

Wiegert still has doubts. "The complicating factor is that, because D/Swift was seen for only a short time in 1895-96, its orbit is not terribly well-known. Our extrapolations could be wrong. We're in the process of collecting more observations from 19th century archives and re-analyzing them. Soon, I hope there will be enough information to convict or acquit Comet D/Swift."

This investigation may lead to others. "The space between Earth and Mars is probably criss-crossed by old debris streams," says Cooke. Wiegert's methods can be used to find some of them, "so the next meteor storm won't be such a surprise."

3.2 NASA Names Orion Contractor

Source: NASA Press Release, August 31th, 2006 [25]

Lessons from the past are guiding NASA's next step into the future, as the space agency prepares to replace the space shuttle with an Apollo-style vehicle for human explorers.

The vehicle is Orion, named for one of the brightest and most recognizable star formations in the sky. It will be a multi-purpose capsule – the central member of a family of spacecraft and shuttle-derived launchers that NASA's Constellation Program is developing to carry astronauts back to the moon and later to Mars. The first flight with astronauts aboard is planned for no later than 2014. Orion's first flight to the moon is planned for no later than 2020.

In what amounts to one of the most significant NASA procurements in more than 30 years, two industry teams, Northrop Grumman/Boeing and Lockheed Martin, spent the past 13 months refining concepts, analyzing requirements and sketching designs for Orion. On Thursday, managers of NASA's Exploration Systems Mission Directorate revealed that Lockheed Martin Corp. of Bethesda, Md., has been chosen to build it.

Versatility will be Orion's trademark. It is being designed to fly to the moon, but could also be used to service the International Space Station in low-Earth orbit. "Our intent is to keep the destination focusing the design but we are not excluding the possibility of using Orion for other things, such as de-orbiting the Hubble Space Telescope in the 2020s or making a trek to an asteroid," said Jeff Hanley, who manages the Constellation Program from the Johnson Space Center in Houston.

Orion improves on the best features of Project Apollo and the Space Shuttle Program, increasing the likelihood of success. "Going with known technology and known solutions lowers the risk" said Neil Woodward, director of the integration office in the Exploration Systems Mission Directorate at NASA Headquarters in Washington. Although Orion borrows its shape and aerodynamic performance from Apollo, the new capsule's updated computers, electronics, life support, propulsion and heat protection systems represent a marked improvement over legacy systems. We're pushing the technological edge, but only where it makes sense," says Woodward.

Unlike the winged space shuttle orbiter, which is mounted beside its external fuel tank and boosters for liftoff, Orion will be placed on top of its booster to protect it from ice, foam, and other launch system debris during ascent. Placing the spacecraft on top of the launch vehicle also allows the addition of an abort system that can separate capsule and crew from the booster in an emergency.

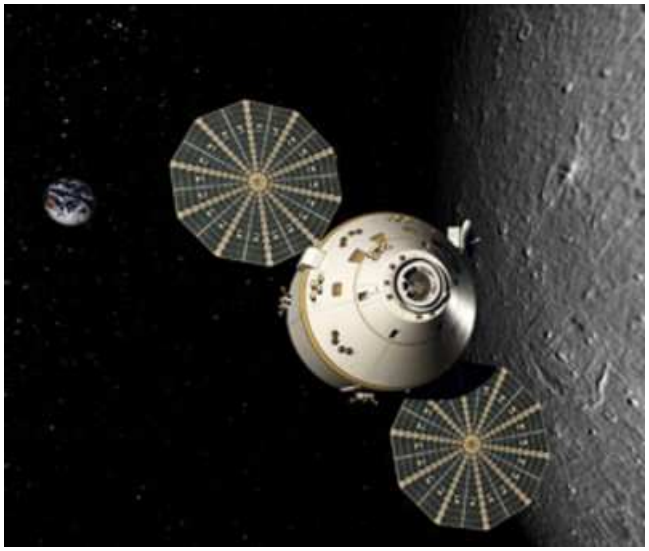

Figure 23: *Orion in lunar orbit. Image credit: Lockheed Martin Corp.*

Among the most obvious improvements is the command module's size. Measuring 16.5 feet in diameter, Orion will have more than 2.5 times the interior volume of the three-seat Apollo capsules that carried astronaut crews to the moon for missions lasting only several hours to several days in the late 1960s and early 1970s. Orion will be crucial for developing a sustained human presence on the moon. It will be able to carry four astronauts to the moon and support missions of up to six months.

"You don't get the chance to build a new human spacecraft every day," said Skip Hatfield, the Orion project manager in Houston. "This is a wonderful opportunity for NASA to

learn from the things we've done in the past, take the best of those activities, and blend them together using the latest methods of manufacturing and management to make a system that will enable us to go out and explore beyond low-Earth orbit."

Hatfield and Hanley noted that NASA is leveraging the talent and resources of the entire agency in the design and development of Orion. While Constellation Program management resides at Johnson, all 10 of the agency's field centers are making important contributions.

The contract with Lockheed Martin has a seven-year base valued at about 3.9 billion dollars for design, development, testing and evaluation of the new spacecraft. Production and sustaining engineering activities are contract options worth more than 4 billion dollars through 2019.

3.3 U.S. Space Pioneer, UI Professor James A. Van Allen Dies

Source: University of Iowa News Release, August 9th, 2006 [26]

Dr. James A. Van Allen, U.S. space pioneer and Regent Distinguished Professor of Physics in the University of Iowa College of Liberal Arts and Sciences, died Wednesday morning, Aug. 9, 2006, of heart failure at University of Iowa Hospitals and Clinics. He was 91.

The UI will hold a public memorial service for Van Allen at 3 p.m. Sunday, Sept. 10, in Hancher Auditorium on the UI campus in Iowa City, Iowa. Everyone is welcome to attend, and the family will greet attendees following the service.

Thoughts and memories may be shared with the Van Allen family through a special Webpage created by Gay & Ciha Funeral and Cremation Service of Iowa City. Also, the UI Foundation has established a James Van Allen Scholarship Fund. More information is available at [27]

Though he retired from active teaching in 1985, Van Allen continued to monitor data from Pioneer 10 throughout the spacecraft's 1972-2003 operational lifetime and serve as an interdisciplinary scientist for the Galileo spacecraft, which reached Jupiter on Dec. 7, 1995.

The highlight of Van Allen's long and distinguished career was his use of UI-built instruments carried aboard the first successful U.S. satellite, Explorer 1, in 1958 to discover bands of intense radiation – later known as the Van Allen radiation belts – surrounding the Earth. It came at the height of the U.S.-Soviet space race and literally put the United States on the map in the field of space exploration.

Among the other accomplishments of which he was most proud was his 1973 first-ever survey of the radiation belts of Jupiter using the Pioneer 10 spacecraft and his 1979 discovery and survey of Saturn's radiation belts using data from the Pioneer 11 spacecraft. Ever a critic of manned space flight, Van Allen the scientist described himself as "a member of the loyal opposition" when it came to discussions of big-budget space programs, declaring that space science could be done better and more cheaply when left to remote-controlled, unmanned spacecraft. NASA's move toward cheaper, more focused unmanned spacecraft during the 1990s was, at least in part, a result of Van Allen's advocacy.

"Jim Van Allen was my friend and role model," said UI Interim President Gary Fethke. "He represented the very image of a superb faculty member. His teaching prowess was legendary, his research was defining, and his collegiality and service were unmatched. I will always be grateful for his kindness to my family and to me, and I will always be inspired and motivated by his complete dedication to the University of Iowa. I will miss him greatly. On behalf of the entire University community, I extend our sympathies to the Van Allen family."

UI Provost Michael Hogan said, "James Van Allen was one of the university's most influential and best-regarded scholars of all time. Yet he remained the most unassuming and caring man. We will all miss him deeply."

Tom Boggess, chair of the Department of Physics and Astronomy, said his entire department was saddened by the news of Van Allen's death.

"We offer our deepest sympathies to his family," Boggess said. "For decades, Dr. Van Allen has been an inspiration and a role model to our faculty, staff, and students. His dedication to science and discovery, as well as to teaching and public service were unmatched. In so many ways, Dr. Van Allen defined our department. He will be sorely missed."

Iowa Gov. Tom Vilsack also remembered Van Allen's contributions as a scientist and as a human being.

"Jim Van Allen was a good friend of our family," Vilsack said. "His loss saddens Christie and me. His passing is a sad day for science in America and the world. He was a great teacher and mentor. His love for the University was as limitless as the universe he explored with such passion and energy. He will be missed."

Born in Mount Pleasant on Sept. 7, 1914, Van Allen was valedictorian of his high school class in 1931, and received his bachelor's degree in physics, summa cum laude, from

Iowa Wesleyan College in 1935. While an undergraduate at Iowa Wesleyan, he assisted the senior scientist of the second Byrd Expedition (1934-35) to Antarctica in preparing seismic and magnetic experimental equipment. (In 2004, the American Polar Society commemorated his work by presenting Van Allen with its Honors of the Society award.) He earned his master's and doctorate from the University of Iowa in 1936 and 1939, respectively.

From 1940 through 1942, he helped develop radio proximity fuzes – detonators to increase the effectiveness of antiaircraft fire – for the defense of ships. Sponsored by the National Defense Research Council, his work was conducted at the Carnegie Institution of Washington and at the Applied Physics Laboratory of Johns Hopkins University. In November 1942, he was commissioned as a naval officer, and he served 16 months on various ships in the South Pacific Fleet as assistant staff gunnery officer.

In 1946, Van Allen returned to the Applied Physics Laboratory where he organized and directed a team to conduct high-altitude experimental work using V2 and Aerobee rockets, and, in 1951, he accepted a Guggenheim research fellowship at the Brookhaven National Laboratory.

Later in 1951, Van Allen became professor and head of the University of Iowa Department of Physics and Astronomy, a position he held until he retired from teaching in 1985. During the 1950s, he and his graduate students used the UI football practice field to launch rockets and "rockoons" – rockets carried aloft by balloons – to conduct cosmic ray experiments above the atmosphere. A highlight of that work was the 1953 discovery of electrons believed to be the driving force behind the aurora. In 1956, he proposed the use of U.S. satellites for cosmic-ray investigations and through "preparedness and good fortune," he later wrote, the experiment was selected as the principal payload for the first flight of a four-stage Jupiter C rocket.

Van Allen played an important role in planning the 1957-58 International Geophysical Year (IGY) and carried out shipboard expeditions to Greenland and southward to the Ross Sea off the coast of Antarctica in 1957. IGY culminated in the Jan. 31, 1958 launch of Explorer 1 and its scientific payload. Van Allen's instruments included a Geiger counter, which provided information that regions of intense radiation surround the Earth. The discovery marked the birth of the research field of magnetospheric physics, an enterprise that grew to involve more than 1,000 investigators in more than 20 countries.

In 1974 People Magazine listed Van Allen as one of the top 10 teaching college professors in the country. His former graduate students list among their accomplishments experiments on NASA's Pioneer 10 and 11, Voyager 1 and 2, Galileo and Cassini spacecraft.

Van Allen joined the American Geophysical Union (AGU) in 1948 and served as the organization's president from 1982 until 1984. He has received the AGU's highest honors, including the John A. Fleming Award in 1963 for eminence in geophysics and the William Bowie Medal in 1977 for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Also, in 1962 Van Allen became the second recipient of the Daniel and Florence Guggenheim International Astronautical Award presented by the International Academy of Astronautics for noteworthy contributions to astronautics, and in March 2006 he received the 2006 Smithsonian National Air and Space Museum Trophy for lifetime achievement.

In 1994, Van Allen received the 1994 Gerard P. Kuiper Prize from the Division of Planetary Sciences of the American Astronomical Society "in recognition of his many contributions to the field of planetary science, both through his investigations of planetary magnetospheres and through his advocacy of planetary exploration." Also in 1994, he was presented with a lifetime achievement award by NASA on the occasion of his 80th birthday and the American Geophysical Union's 75th anniversary.

Van Allen's many other awards and honors include membership in the National Academy of Sciences since 1959 and the National Medal of Science, the nation's highest honor for scientific achievement, presented in 1987 by President Reagan in ceremonies at the White House. In 1989, he received the Crafoord Prize, awarded by the Royal Swedish Academy of Sciences in Stockholm and presented by the King of Sweden. The Crafoord Prize is the highest award the Academy can bestow for research in a number of scientific fields and, for space exploration, is the equivalent of the Nobel Prize.

Perhaps his proudest achievement as an educator was leaving his mark on 34 doctoral students, 47 master's degree students and, especially, the numerous undergraduates who enjoyed his classes. In a February 2004 interview he said, "I taught 'General Astronomy' for 17 years, and it was my favorite course. I spent one or two hours preparing for each lecture because I had a genuine enthusiasm for the course. Today, I run into people all the time who say, 'You don't remember me, but I took your course in 1985.' Many former students tell me how much they enjoyed the course."

Figure 24:

Van Allen is survived by his wife, Abigail Fithian Halsey II Van Allen, his five children – Cynthia Van Allen Schaffner of New York City; Dr. Margot Van Allen Cairns of Vancouver, British Columbia; Sarah Van Allen Trimble of Washington, D.C.; Thomas Van Allen of Aspen, Colo.; and Peter Van Allen of Philadelphia – and seven grandchildren.

3.4 NASA Funds Development of Destiny: The Dark Energy Space Telescope

Source: NOAO News Release, August 3rd, 2006 [28]

A team led by the National Optical Astronomy Observatory (NOAO) and NASA's Goddard Space Flight Center has been selected by NASA to develop a concept for a space mission to characterize the mysterious "Dark Energy" that permeates the Universe and causes its expansion to accelerate.

Known as Destiny, the Dark Energy Space Telescope, the small spacecraft would detect and observe more than 3,000 supernovae over its two-year primary mission to measure the expansion history of the Universe, followed by a year-long survey of 1,000 square-degrees of the sky at near-infrared wavelengths to measure how the large-scale distribution of matter in the Universe has evolved since the Big Bang. Used together, the data from these two surveys will have 10 times the sensitivity of current ground-based projects to explore the properties of Dark Energy, and will provide data critical to understanding the origin of Dark Energy, which is poorly explained by existing physical theories.

"Destiny's strength is that it is a simple, low-cost mission designed to attack the puzzling problem of Dark Energy directly with high statistical precision," said Tod R. Lauer, the Principal Investigator for Destiny and an astronomer at NOAO. "We build upon grism technology used in the Hubble Space Telescope's Advanced Camera for Surveys to help us provide spectra of the supernovae as well as images. Spectra are critical to diagnosing the properties of the supernova, but are very difficult to obtain with more traditional cameras. Destiny's grism camera, however, will take simultaneous spectra of all objects in its field. This is a major advantage of our approach, which greatly increases the ability to detect and characterize these distant stellar explosions."

The discovery of a mysterious force now known as Dark Energy was announced in 1998 by two independent teams of astronomers who were studying distant supernovae as a way to measure how the expansion rate of the Universe has changed over time. These teams (both of whom used NOAO telescopes in Chile to discover the supernovae) were surprised to discover that, rather than slowing down, as had been expected, the expansion rate of the Universe is actually speeding up as the Universe ages. To explain this surprising phenomenon, scientists have been forced to conclude that the Universe contains not only ordinary matter and dark (invisible) matter, but also an ingredient called Dark Energy that permeates all of space and propels this expansion. Understanding the origin and properties of Dark Energy is probably the most outstanding problem in cosmology today.

"Destiny is designed to exploit two complementary pathssupernovae and large scale distribution of matterto measure Dark Energy in a manner that is less susceptible to unknowns than any single technique," said Dominic J. Benford of NASA Goddard, the Deputy Principal Investigator for Destiny.

The Destiny team has strong connections to the state of Ari-

zona, with members in Tucson at NOAO, the University of Arizona's astronomy department and Lunar and Planetary Laboratory, and several astronomers and space scientists from Arizona State University. Other team members (including several that were part of the original discovery of Dark Energy) are based at the Space Telescope Science Institute, Harvard University, Texas A&M, the University of California, Davis, Michigan State University, the University of Chicago, and the Carnegie Observatories.

Figure 25:

Lauer joined the staff of NOAO in 1990. He was a member of the instrument team for the first Wide-Field and Planetary Camera aboard the Hubble Space Telescope, and was deeply involved in its calibration and early operations. Lauer has continued to be a frequent user of Hubble. In 1992, he received a NASA Exceptional Scientific Achievement Medal for his early work with the instrument. His research covers diverse topics ranging from searching for black holes at the centers of galaxies to the large scale structure of the Universe.

Destiny is one concept for JDEM, the Joint Dark Energy Mission, which NASA and the Department of Energy have jointly proposed to characterize Dark Energy. The Department of Energy's Los Alamos National Laboratory is a partner in the Destiny mission.

If Destiny is ultimately selected to achieve the JDEM scientific goals, the spacecraft and its 1.65-meter telescope would be launched by a Delta IV or Atlas V expendable rocket into a stable orbit at the second Earth-Sun Lagrangian point as soon as 2013. This location allows for stable and continuous operation of the instrument. Initially Destiny would continuously observe two patches of the sky for distant supernovae. Destiny's observations are planned to coordinate closely with those from current large ground-based telescopes and emerging facilities such as the Large Synoptic Survey Telescope (LSST).

4 Internet websites

[1] http://www.princeton.edu/main/news/archive/S15/64/72A37/index.xml?section=newsreleases
[2] http://www.awi-bremerhaven.de/AWI/Presse/PM/pm06-2.hj/060728Cosmic[3] http://www.esa.int/esaCP/SEMRKHZ7QQE_index_0.html
[4] http://www.esa.int/SPECIALS/Mars_Express/SEMC4JZ7QQE_0.html
[5] http://www.jpl.nasa.gov/news/news.cfm?release=2006-100
[6] http://www.universetoday.com/2006/08/24/plutos-out-of-the-planet-club/
[7] http://www.esa.int/esaCP/SEM4TU5LARE_index_0.html
[8] http://www.cfa.harvard.edu/press/pr0622.html
[9] http://hubblesite.org/newscenter/newsdesk/archive/releases/2006/38/full/
[10] http://www.eso.org/outreach/press-rel/pr-2006/pr-29-06.html
[11] http://www.cfa.harvard.edu/press/pr0621.html
[12] http://www.eso.org/outreach/press-rel/pr-2006/pr-28-06.html
[13] http://hubblesite.org/newscenter/newsdesk/archive/releases/2006/37/full/
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[15] http://researchnews.osu.edu/archive/ionspace.htm
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[18] http://www.eso.org/outreach/press-rel/pr-2006/pr-30-06.html
[19] http://www.colorado.edu/news/releases/2006/253.html
[20] http://chandra.harvard.edu/press/06_releases/press_082106.html

[21] http://info.anu.edu.au/mac/Media/Media_Releases/_2006/_August/_180806universefuel.asp
[22] http://chandra.harvard.edu/press/06_releases/press_080806.html
[23] http://researchnews.osu.edu/archive/biguni.htm
[24] http://science.nasa.gov/headlines/y2006/23aug_mariner4.htm
[25] http://www.nasa.gov/mission_pages/constellation/orion/orion_contract.html
[26] http://itsnt166.iowa.uiowa.edu/uns-archives/2006/august/080906van-allen-death.html
[27] http://www.givetoiowa.org/vanallen
[28] http://www.noao.edu/outreach/press/pr06/pr0610.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