Vendelinus Astronomy Newsletter

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1 Solar System

1.1 The strangest known object in the Kuiper belt

Source: Mike Brown, Caltech, January 17th, 2007 [1]

2003 EL61 is one of the strangest known objects in the solar system. It is a big across as Pluto, but shaped like a cigar. Or perhaps like a football [American-style]. Or, most accurately, a foot ball that has too little air in it and has been stepped on. It spins on its axis every 4 hours like a football that has been kicked. It appears to be made almost entirely of rock, but with a glaze of ice over the surface. And it is surrounded by two satellites. Learn all about this strange object below!

What is 2003 EL61?

2003 EL61 is an object in the Kuiper belt, the region of space beyond Neptune that includes Pluto and the large planetoids Quaoar and Orcus, 2005 FY9, and the planet 2003 UB313 among others. 2003 EL61 is currently the third brightest object in this region after Pluto and 2005 FY9. It is so bright that it can readily be seen by high-end amateur telescopes equipped with CCD cameras. Other than being extremely bright, 2003 EL61 appeared at first to be typical of a type of Kuiper belt objects that astronomers call ”scattered Kuiper belt objects.” They are called ”scattered” because it is believed that they once had a close encounter with Neptune which gravitationally ”scattered” these objects onto more eccentric orbits. You can compare the orbits of the three bright newly discovered Kuiper belt objects below. 2003 EL61 and 2005 FY9 are both on similar eccentric orbits tilted by 30 degrees from the rest of the solar system. The 10th planet, 2003 UB313, is even more eccentric and tilted by 45 degrees. The black circle shows the orbit of the outer giant planet, Neptune. At this scale, the earth’s orbit would be inside of the yellow dot that depicts the sun!

How big is 2003 EL61?

Many times when objects like this are discovered we don’t actually know how big we are, just how bright they are. How bright they are tells us how much sunlight they reflect. But they could be bright and reflect a lot of sunlight because they are large or they could be bright because they are highly reflective, like a ball of snow. In the case of 2003 EL61, however, we have gotten lucky, because soon after the discovery of the objcet we discovered a moon orbiting it. By following the orbit of the moon over the course of 6 months we are able to precisely determine the mass of 2003 EL61 and its moon. The mass is about 32 percent that of Pluto. Unfortunately, the mass does not directly tell us it’s size. An object that weighs a lot can either be small and dense, like something made out of rock, or large and less dense, like something made out of ice.

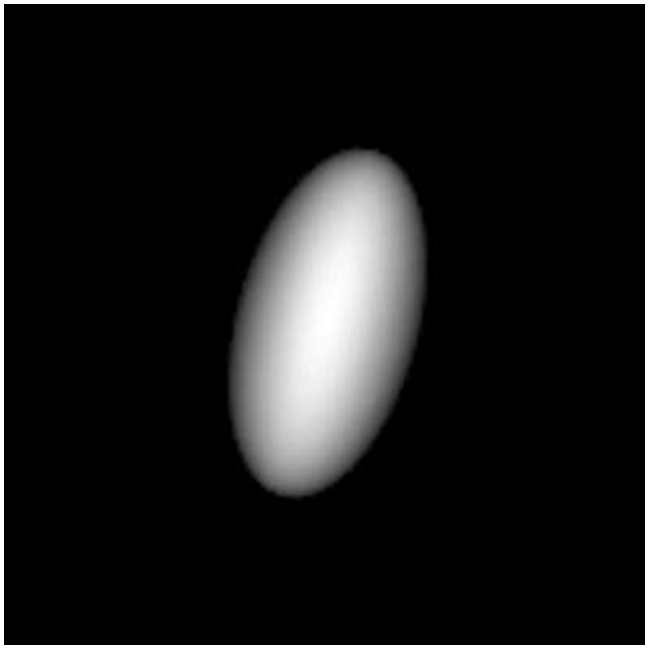

Figure 1: *Computer illustration of 2003 EL61. Image credit: Mike Brown/Caltech*

The fast spin of 2003 EL61, however, gives away its size in a somewhat complicated way. When an object spins quickly, it stretches out, much like a pizza crust tossed into the air. A denser rockier object stretches out less than a less dense lighter object. By seeing just how much 2003 EL61 stretches out due to its spin we can tell how dense it is. We find that 2003 EL61 must be made almost entirely of rock or else its very fast 4 hour spin would stretch it out even more than it is already stretched!

Once we know how much 2003 EL61 weighs and we know what 2003 EL61 is made of we can figure out how big it is. The answer is that it is as big as Pluto – along its longest dimension. Nothing else so large and so elongated or so quickly rotating is know anywhere in the solar system.

The moons of 2003 EL61

The first moon to 2003 EL61 was discovered on January 28th 2005 by observations at the Keck Observatory. The observations were obtained with a brand new high powered system at Keck which used a laser projecting out of the telescope to correct for the turbulence of the atmosphere. This system, called laser guide star adaptive optics, allows astronomers on the ground to take images with the sharpness of images obtained from space by the Hubble Space Telescope. When we observed 2003 EL61 with this new facility we immediately saw that there was a faint moon in the vicinity. From 5 observations over the span of 6 months we have precisely determined the orbit of the satellite to 2003 EL61.

A (technical) scientific paper describing the discovery of this satellite can be read in the October issue of the Astrophysical Journal Letters.

Here is an image of the satellite from the night of 30 June 2005. 2003 EL 61 is the bright object in the center and the satellite appears directly below about 0.5 arcseconds. To the south of 2003 EL61 you can also see a faint object which turns out to be a second satellite.

The second satellite is fainter than the first, but still detected in three of the five images of the first satellite. You can read the (again, technical) scientific paper describing the second satellite (and the satellite to 2003 UB313), too.

About 10 percent of Kuiper belt objects have satellites, but until recently no other object in the Kuiper belt was known to have more than one satellite. Recently, however, 2 small satellites around Pluto were also discovered. It appears likely, now, that other Kuiper belt objects (at least large Kuiper belt objects) might also have multiple satellite systems. From the two satellites, we have learned several important things about the 2003 EL61 system. First, both satellites appear to be quite small. The larger one is perhaps 1 percent of the mass of the primary while the smaller is only 0.2 percent of the mass of the primary.

The brighter satellite is on a long period orbit, circling 2003 EL61 every 49 days, in contrast to Pluto's large satellite Charon which orbits in just 6 days. The longer orbital period of the satellite is a consequence both of the more distant orbit of the satellite from 2003 EL61 and the lower mass of 2003 EL61. The orbit is almost circular but not quite.

The fainter satellite appears to circle 2003 EL61 once every 34 days, though more observations are required to confirm this orbit.

Seen from the earth the satellite reaches a maximum distance from 2003 EL61 of about 1.5 arcseconds. This distance is just enough to enable to the satellite to be seen with telescopes even without high power laser adaptive optics systems. This fact will enable detailed studies of this fascinating small body. The fainter satellite reaches a distance of 1.0 arcseconds. While it is theoretically possible for conventional telescopes to separate the satellite from the primary we suspect that the satellite is too faint for detailed study without special techniques.

The biggest scientific benefit of the large satellite is that it allows us to calculate the mass of the system. Once we know the distance od the satellite from the primary and we know the time it take to orbit we can simply calculate the mass. A higher mass object would pull the satellite more tightly and cause it to orbit faster. Knowing the mass allows us to figure out the size, as discussed above.

Why is 2003 EL61 spinning fast, shaped like a football, made out of ice-covered rock, and surrounded by tiny satellites?

Good question. We have constructed a hypothesis which attempts to explain everything going on on 2003 EL61, but we must emphasize that this is just a hypothesis. No one has done rigorous scientific calculations to verify that the hypothesis actually works in detail, but our scientific instinct suggests that it should. This method is one of the ways in which science progresses. It is entirely possible that when detailed calculations are done it will be found that our hypothesis doesn't work, in which case we will have to start over. Even if the calculations show that our hypothesis does work it doesn't prove that this is what happened for 2003 EL61, but it begins the process of creating an understanding of the early history of the outer solar system.

The hypothesis goes like this: 4.5 billion years ago, when the solar system was in the process of forming, the object that is now 2003 EL61 was a ball made half of ice and half of rock and about the size of Pluto (much like what we think Pluto is today). Sometime early in its history, another large Kuiper belt object colllided with 2003 EL61 obliquely. This collision heated 2003 EL61 enough that most or all of the initial water was boiled off, leaving just a rock. The oblique impact caused 2003 EL61 to spin rapidly. The rapid spin elongated 2003 EL61 into the football shape we see today. The debris from the impact coalesced into the satellites, which would have been initially much closer but which have been evolving outward with time.

This story contains some elements of how we think the Earth and Moon formed: a Mars-sized body hit the proto-earth and the moon coalesced from the debris following the impact. There is also an analogy to the formation of Charon

around Pluto which was thought to have been from a Kuiper belt impact at a similar time.

One of the interesting predictions of this hypothesis is that the debris from the collision, from which the satellites formed, should have been composed predominantly of ice, rather than rock. The satellites themselves, then, should be almost purely ice. The best way to determine the composition of the satellites would be if we could determine their density. Unfortunately, the satellites are too small to measure the densities any time soon. We can, however, measure the composition of the surface of the brighter satellite. We find that it, like 2003 EL61 itself, is composed of water ice. On the satellite the water ice appears perhaps 100 percent pure. While we don't know for certain that there is not rock under the surface, we think that such pure water ice is a likely indication that there is water ice all the way down, which is consistent with our hypothesis.

Why is it called 2003 EL61?

Very soon 2003 EL61 will get a real name, much like Sedna and Quaoar and Orcus. But when first discovered these objects are only given "preliminary designations" until they are confirmed and well know. There is little need of confirmation of 2003 EL61 as it has now been seen after the fact in images from more than 50 years ago! We will thus propose a name to the International Astronomical Union and that name will become the permanent – and with luck more melodious – name of 2003 EL61.

1.2 Brightest Comet in Over Forty Years

Source: SOHO hotshot, January, 24th, 2007 [2]

Comet McNaught (C/2006 P1) has not only become the brightest comet SOHO has ever seen, but even the brightest comet observed in over forty years! The comet swung by the sun on Jan 12th - 15th, and is now emerging into the skies of the southern hemisphere. During its close encounter with our mother star, comet McNaught became a naked-eye object in broad daylight. It was discovered on August 7th, 2006 by the hugely successful comet discoverer Rob McNaught (Siding Spring Survey). At time of discovery, the comet was a very faint object, but the predicted perihelion distance (closest distance to the sun) of just 0.17 AU indicated already that the object had the potential to become very bright.

As you are probably aware, the LASCO instrument onboard SOHO has the ability to watch comets as they get extremely close to the Sun. Fortunately for us, comet McNaught has passed right through the LASCO C3 field of view! We do not know exactly the peak brightness of the comet yet, but it is definitely brighter than -3 mag! It is thus much brighter than comet NEAT or comet 96P/Machholz. In other words, comet McNaught is by far the brightest and most spectacular comet SOHO has ever seen!

The comet appeared in the field of view of SOHO's coronagraph LASCO C3 at around 02:00 UT (05:00 EDT) on January 12th. It passed its perihelion around 19:00 UT on January 12th, and exited C3's field of view at roughly 03:00UT on January 16th.

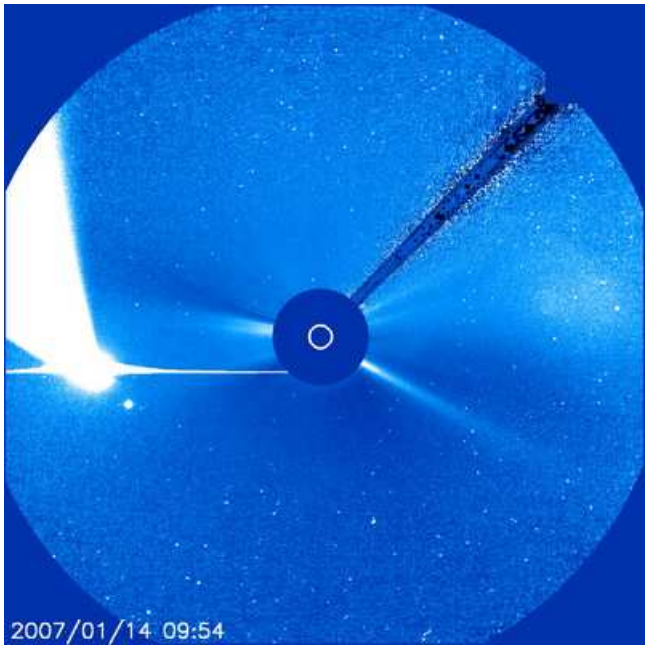

Figure 2: *Comet McNaught*

Since LASCO was built to observe the faint solar corona, its exposure times are not tuned to handle objects as bright as this extraordinary comet. In fact, comet McNaught is so bright that it saturates the CCD camera so that "bleeding" occurs along pixel rows. There is a bright horizontal streak on either side of the comet's head, because the charge leaks easier along the direction in which the CCD image is read out by the associated electronics.

The lower the magnitude number, the brighter the object. The brightest stars in the sky are categorized as zero or first magnitude. Negative magnitudes are reserved for the most brilliant objects: the brightest star is Sirius (-1.4); the full Moon is -12.7; the Sun is -26.7.

1.3 Gas Giants Form Quickly

Source: Spitzer Press Release, January 8th, 2007 [3]

Gas-giant planets like Jupiter and Saturn form soon after their stars do, according to new research.

Observations from NASA's Spitzer Space Telescope show that gas giants either form within the first 10 million years of a sun-like star's life, or not at all. The study offers new evidence that gas-giant planets must form early in a star's history. The lifespan of sun-like stars is about 10 billion years.

Ilaria Pascucci of the University of Arizona Steward Observatory in Tucson led a team of astronomers who conducted the most comprehensive search for gas around 15 different sun-like stars, most with ages ranging from 3 million to 30 million years.

The scientists used Spitzer's heat-seeking infrared eyes to search for warm gas in the inner portions of star systems, an area comparable to the zone between Earth and Jupiter in our own solar system.

In addition, Pascucci, team member Michael Meyer of the UA Steward Observatory and their colleagues probed for cold gas in the outer regions of these star systems with the Arizona Radio Observatory's 10-meter Submillimeter Telescope (SMT) on Mount Graham, Ariz. The outer zones of these star systems are analogous to the region around Saturn's orbit and beyond in our own solar system.

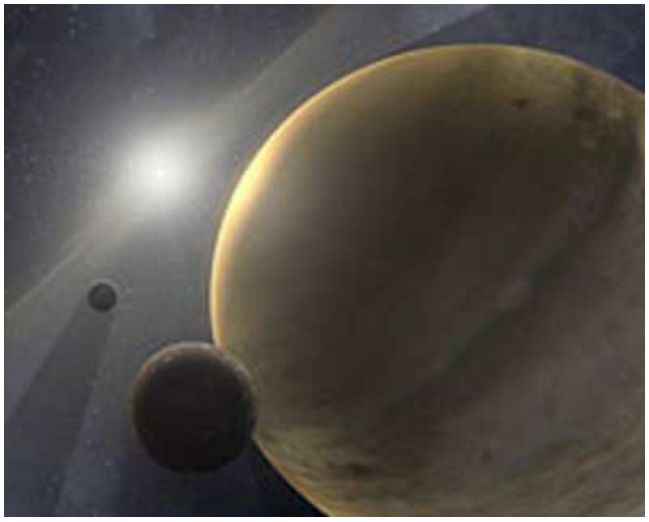

Figure 3:

All of the stars in the study – including those as young as a few million years – have less than 10 percent of Jupiter's mass in gas swirling around them, Pascucci said.

"This indicates that gas giant planets like Jupiter and Saturn have already formed in these young solar system analogs, or they never will," Meyer said.

Astronomers suspect that gas around a star may also be important for sending terrestrial, or rocky, planets like Earth into relatively circular orbits as they form. If Earth had a highly elliptical orbit rather than relatively circular one, its temperature swings would be so extreme that humans and other complex organisms might not have evolved.

Many of the sun-like star systems in the study don't currently contain enough gas to send developing rocky planets into circular orbit, Pascucci said. One possibility is that terrestrial planets around these stars have highly elliptical orbits that hinder the development of complex life. Another possibility is that some mechanism other than gas moves the terrestrial planets into circular orbits once they are fully formed. "Our observations tested only the effect of gas," Pascucci said.

2 Astrophysics

2.1 Famous Space Pillars Feel the Heat of Star's Explosion

Source: Spitzer Press Release, January 9th, 2007 [4]

The three iconic space pillars photographed by NASA's Hubble Space Telescope in 1995 might have met their demise, according to new evidence from NASA's Spitzer Space Telescope.

A new, striking image from Spitzer shows the intact dust towers next to a giant cloud of hot dust thought to have been scorched by the blast of a star that exploded, or went supernova. Astronomers speculate that the supernova's shock wave could have already reached the dusty towers, causing them to topple about 6,000 years ago. However, because light from this region takes 7,000 years to reach Earth, we won't be able to capture photos of the destruction for another 1,000 years or so.

Spitzer's view of the region shows the entire Eagle nebula, a vast and stormy community of stars set amid clouds and steep pillars made of gas and dust, including the three well-known "Pillars of Creation."

"I remember seeing a photograph of these pillars more than a decade ago and being inspired to become an astronomer," said Nicolas Flagey of The Institut d'Astrophysique Spatiale in France. "Now, we have discovered something new about this region we thought we understood so well." Flagey, a visiting graduate student at NASA's Spitzer Science Center at the California Institute of Technology in Pasadena, presented the results today at the American Astronomical Society meeting in Seattle.

Astronomers have long predicted that a supernova blast wave would mean the end for the popular pillars. The region is littered with 20 or so stars ripe for exploding, so it was only a matter of time, they reasoned, before one would blow up. The new Spitzer observations suggest one of these stellar time bombs has in fact already detonated, an event humans most likely witnessed 1,000 to 2,000 years ago as an unusually bright star in the sky.

Whenever the mighty pillars do crumble, gas and dust will be blown away, exposing newborn stars that were forming inside. A new generation of stars might also spring up from the dusty wreckage.

Figure 4:

Spitzer is a space telescope that detects infrared, longer-wavelength light that our eyes cannot see. This allows the observatory to both see the dust and see through it, depending on which infrared wavelength is being observed. In Spitzer's new look at the Eagle nebula, the three pillars appear small and ghostly transparent. They are colored green in this particular view. In the largest of the three columns, an embedded star is seen forming inside the tip.

Above the pillars is the enormous cloud of hot dust, colored red in the picture, which astronomers think was seared by the blast wave of a supernova explosion. Flagey and his team say evidence for this scenario comes from similarities observed between this hot dust and dust around known supernova remnants. The dust also appears to have a shell-like shape, implying that a supernova blast wave is traveling outward and sculpting it.

The mysterious dust was first revealed in previous images from the European Space Agency's Infrared Space Observatory, but Spitzer's longer-wavelength infrared instrument was able to tentatively match the dust to a supernova event.

"Something else besides starlight is heating this dust," said Dr. Alberto Noriega-Crespo, Flagey's advisor at the Spitzer Science Center. "With Spitzer, we now have the missing long-wavelength infrared data that are giving us an answer."

2.2 Hubble Probes Layer-cake Structure of Alien World's Atmosphere

Source: Hubble News, January 31st, 2007 [5]

The powerful vision of NASA's Hubble Space Telescope has allowed astronomers to study for the first time the layer-cake structure of the atmosphere of a planet orbiting another star. Hubble discovered a dense upper layer of hot hydrogen gas where the super-hot planet's atmosphere is bleeding off into space.

The planet, designated HD 209458b, is unlike any world in our solar system. It orbits so close to its star and gets so hot that its gas is streaming into space, making the planet appear to have a comet-like tail. This new research reveals the layer in the planet's upper atmosphere where the gas becomes so heated it escapes, like steam rising from a boiler.

"The layer we studied is actually a transition zone where the temperature skyrockets from about 1,340 degrees Fahrenheit (1,000 Kelvin) to about 25,540 degrees (15,000 Kelvin), which is hotter than the Sun," said Gilda Ballester of the University of Arizona in Tucson, leader of the research team. "With this detection we see the details of how a planet loses its atmosphere."

The findings by Ballester, David K. Sing of the University of Arizona and the Institut d'Astrophysique de Paris, and Floyd Herbert of the University of Arizona will appear Feb. 1 in a letter to the journal Nature.

The Hubble data show how intense ultraviolet radiation from the host star heats the gas in the upper atmosphere, inflating the atmosphere like a balloon. The gas is so hot that it moves very fast and escapes the planet's gravitational pull at a rate of 10,000 tons a second, more than three times the rate of water flowing over Niagara Falls. The planet, however, will not wither away any time soon. Astronomers estimate its lifetime is more than 5 billion years.

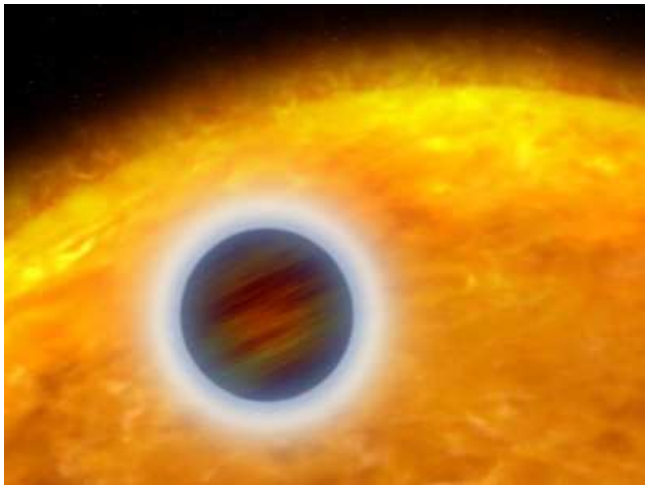

Figure 5: *This artist's illustration shows an extrasolar planet orbiting very close to its host star. The planet designated HD 209458b, is about the size of Jupiter. Unlike Jupiter, the planet is so hot that its atmosphere is "puffed up." Starlight is heating the planet's atmosphere, causing hot gas to escape into space, like steam rising from a boiler.*

The scorched planet is a big puffy version of Jupiter. In fact, it is called a "hot Jupiter," a large gaseous planet orbiting very close to its parent star. Jupiter might even look like HD 209458b if it were close to the Sun, Ballester said.

The planet completes an orbit around its star every 3.5 days. It orbits 4.7 million miles from its host, 20 times closer than the Earth is to the Sun. By comparison, Mercury, the closest planet to our Sun, is 10 times farther away from the Sun than HD 209458b is from its star. Unlike HD 209458b, Mercury is a small ball of iron with a rocky crust.

"This planet's extreme atmosphere could yield insights into the atmospheres of other hot Jupiters," Ballester said.

Although HD 209458b does not have a twin in our solar system, it has plenty of relatives beyond our solar system. About 10 to 15 percent of the more than 200 known extrasolar planets are hot Jupiters. A recent Hubble survey netted 16 hot Jupiter candidates in the central region of our Milky Way Galaxy, suggesting that there may be billions of these gas-giant star huggers in our galaxy.

HD 209458b is one of the most intensely studied extrasolar planets because it is one of the few known alien worlds that can be seen passing in front of, or transiting, its star, causing the star to dim slightly. In fact, the gas giant is the first such alien world discovered to transit its star. HD 209458b is 150 light-years from Earth in the constellation Pegasus.

The planet's transits allow astronomers to analyze the structure and chemical makeup of the gas giant's atmosphere by sampling the starlight that passes through it. The effect is similar to finding fingerprints on a window by watching how sunlight filters through the glass.

Previous Hubble observatoins revealed oxygen, carbon, and sodium in the planet's atmosphere, as well as a huge hydrogen upper atmosphere with a comet-like tail. These landmark studies provided the first detection of the chemical makeup of an extrasolar planet's atmosphere.

2.3 Astronomers Map a Hypergiant Star's Massive Outbursts

Source: Hubble News, January 8th, 2007 [6]

Using NASA's Hubble Space Telescope and the W.M. Keck Observatory, Kameula, Hawaii, astronomers have learned that the gaseous outflow from one of the brightest supersized stars in the sky is more complex than originally thought.

The outbursts are from VY Canis Majoris, a red supergiant star that is also classified as a hypergiant because of its very high luminosity. The eruptions have formed loops, arcs, and knots of material moving at various speeds and in many different directions. The star has had many outbursts over the past 1,000 years as it nears the end of its life.

A team of astronomers led by Roberta Humphreys of the University of Minnesota used NASA's Hubble Space Telescope and the W.M. Keck Observatory to measure the motions of the ejected material and to map the distribution of the highly polarized dust, which reflects light at a specific orientation. The polarized light shows how the dust is distributed. Astronomers combined the Hubble and Keck information to produce a three-dimensional image of the matter emitted from VY Canis Majoris.

"We thought mass loss in red supergiants was a simple, spherical, and uniform outflow, but in this star it is very complex," Humphreys said. "VY Canis Majoris is ejecting large amounts of gas at a prodigious rate and is consequently one of our most important stars for understanding the high-mass loss episodes near the end of massive star evolution. During the outbursts, the star loses about 10 times more mass than its normal rate.

"With these observations, we have a complete picture of the motions and directions of the outflows, and their spatial distribution, which confirms their origin from eruptions at different times from separate regions on the star."

Humphreys and her collaborators presented their findings today (Jan. 8) at the American Astronomical Society meeting in Seattle, Wash.

Astronomers have studied VY Canis Majoris for more than a century. The star is located 5,000 light-years away. It is 500,000 times brighter and about 30 to 40 times more massive than the Sun. If the Sun were replaced with the bloated VY Canis Majoris, its surface could extend to the orbit of Saturn.

Images with Hubble's Wide Field and Planetary Camera 2 revealed for the first time the complexity of the star's ejecta. The first images provided evidence that the brightest arcs and knots were created during several outbursts. The random orientations of the arcs also suggested that they were produced by localized eruptions from active regions on the star's surface.

With spectroscopy obtained using the Keck Telescope, Humphreys and her team learned more about the shape, motion, and origin of the star's outflow. Line of sight velocities, measured from the spectra, showed that the arcs and knots were expanding relative to the star. With recently obtained Hubble images, the group measured the ejecta's motions across the line of sight.

The team found that the numerous arcs, loops, and knots were moving at different speeds and in various directions, confirming they were produced from separate events and from different locations on the star.

The astronomers also used the measurements to determine when the outbursts happened. The outermost material was ejected about 1,000 years ago, while a knot near the star may have been ejected as recently as 50 years ago.

The arcs and knots represent massive outflows of gas probably ejected from large star spots or convective cells on the star's surface, analogous to the Sun's activity with sunspots and prominences associated with magnetic fields, but on a vastly larger scale. Magnetic fields have been measured in VY Canis Majoris's ejecta that correspond to field strengths on its surface comparable to the magnetic fields on the Sun. These measurements show that the supergiant star's magnetic fields would supply sufficient energy for these massive outflows.

Figure 6: *These NASA Hubble Space Telescope images show the outflow from one of the brightest hypergiant stars in the sky, VY Canis Majoris. The image on the left, taken with Hubble's Wide Field and Planetary Camera 2, reveal its complex circumstellar ejecta, with arcs, filaments, and knots of material formed by the massive outflows. This image provided the first evidence that the brightest arcs and knots were created during several outbursts. The random orientations of the arcs also suggested they were produced by localized eruptions from active regions on the star's surface. This is composite picture from separate images taken in blue, green, red, and near-infrared light. The image at right, taken with the Advanced Camera for Surveys, was made with polarizing filters to show how the dust ejected by the star is distributed in three-dimensional space. The light from the star becomes polarized when it is reflected off the dust. The dust formed around the star and was driven into space. To see the polarized light, astronomers used a polarizing filter, which lets through only light vibrating in one direction and blocks out light vibrating in other directions. Astronomers assembled this picture from separate images taken at three different polarization angles, colored red, green, and blue.*

The astronomers used the measurements to map the velocity and direction of the outflows with respect to the embedded star. When combined with the dust distribution map, they also determined the location of the arcs and knots, yielding the three-dimensional shape of VY Canis Majoris and its ejecta.

"With these observations, we may have captured a short-lived phase in the life of a massive star," Humphreys said. "The most luminous red supergiants may all eventually experience high-mass loss episodes like VY Canis Majoris before ending their lives."

The typical red supergiant phase lasts about 500,000 years. A massive star becomes a red supergiant near the end of its life, when it exhausts the hydrogen fuel at its core. As the core contracts under gravity, the outer layers expand, the star gets 100 times larger, and it begins to lose mass at a higher rate. VY Canis Majoris has probably already shed about half of its mass, and it will eventually explode as a supernova.

2.4 Hubble Sees Star Cluster "Infant Mortality"

Source: Hubble News, January 10th, 2007 [7]

Astronomers using NASA's Hubble Space Telescope have found that young stellar nurseries, called open star clusters, have very short lives.

Hubble's Advanced Camera for Surveys gleaned these new observations during a "Where's Waldo" search for blue stars tossed out of their open cluster "nest" in the nearby galaxy known as NGC 1313.

Only Hubble has the resolution needed to distinguish individual stars in galaxies at NGC 1313's distance about 14 million light-years.

Astronomers have long known that young or "open" star clusters must eventually disrupt and dissolve into the host galaxy. They simply don't have enough gravity to hold them together, unlike their much more massive cousins, the globular star clusters.

Before Hubble, astronomers have had very few observational clues. It's been difficult to observe exactly how star clusters dissolve due to the fact that they are easily lost in the cluttered star field background of the host galaxy.

A team led by Anne Pellerin of the Space Telescope Science Institute in Baltimore used Hubble to observe the barred spiral galaxy NGC 1313 and found that a large number of very young massive blue (B-type) stars are not associated with compact star clusters anymore. B stars burn out quickly due to the quick rate at which they use up hydrogen fuel.

Because B stars have very short lives (a few tens of millions of years), the presence of a large number of massive B-type stars suggests to astronomers that star clusters may dissolve very rapidly, within 25 million years. This is brief compared to the lifetime of the galaxy, which is measured in billions of years.

The rapid disintegration of open clusters is reinforced by the fact that the team found that the B stars are significantly

more spread in the galaxy than even the more massive O-type. The O stars are so short lived (a few million years or even less), they explode as supernovae before they can be scattered outside the cluster.

In fact, the supernovae explosions of O stars could be the reason for a cluster's rapid disintegration, say researchers. Supernovae are capable of blasting out residual dust and gas from star formation inside a cluster. This could abruptly leave an open cluster with too little mass to gravitationally hold together for very long. In this scenario, the cluster stars drift off as other stars in the galaxy gravitationally tug on them.

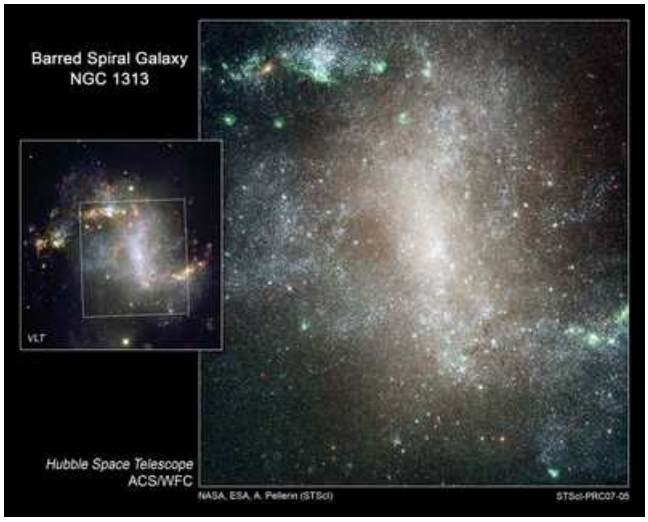

Figure 7: *This is a view of the barred spiral galaxy NGC 1313 taken with the the European Southern Observatory's Very Large Telescope (VLT) in Chile on Dec. 16, 2003 through various broad-band (B, R, z) and narrow-band filters (H-alpha, [o I], [O III]). The color composited image was made by assigning B to the blue channel, [O I] and [O III] to the green channel, and R, z, and H-alpha to the red channel. This gives many of the nebulous shells along the outer spiral arms a yellow/red hue. The outline of the central region indicates the area observed with Hubble's Advanced Camera for Surveys. Credit: H. Boffin (FORS/VLT/ESO). [Right] This is a NASA Hubble Space Telescope image of the central region of the barred spiral galaxy NGC 1313. Hubble was used to resolve stars within the galaxy to do a census of various classes of stars distributed across the galaxy. The observations show that hot blue stars (of class B) are widely scattered across the galaxy. This is evidence of "infant mortality" in which the young, so-called open clusters where stars are born, quickly became gravitationally "unglued" and scattered their resident stars into the galaxy. NGC 1313 is 50,000 light-years across and lies 14 million light-years away in the southern constellation of Reticulum.*

Previous research based on the Hubble images of the Antennae galaxies, a colliding pair of galaxies, showed that 90 percent of the clusters are dissolved in this way during the first 10 million years of their existence. However, NGC 1313 is the first example of this happening in a normal spiral galaxy.

By using the analogy of star formation in open clusters in NGC 1313, we can infer that stars formed in a similar manner in the Milky Way, and so can help us better understand the way the Sun was formed.

2.5 Some Rare Abnormal Stars may have White Dwarf Parents to Blame

Astronomers have announced the discovery of huge quantities of an unusual variety of oxygen in two very rare types of stars. The finding suggests that the origin of these oddball stars may lie in the physics behind the mergers of white dwarf star pairs.

The unusual stars are known as hydrogen-deficient (HdC) and R Coronae Borealis (RCB) stars. Both types have almost no hydrogen - an element that makes up about 90% of most stars. Surprisingly, they contain up to a thousand times more of the isotope oxygen-18 than normal stars like our Sun. The discovery of abnormal quantities of oxygen-18 is based on near-infrared spectroscopic observations from the Gemini Near-Infrared Spectrograph (GNIRS) on the 8-meter Gemini-South telescope in Chile.

The findings were presented today at the 209th meeting of the American Astronomical Society in Seattle Washington by a team consisting of: Dr. Geoffrey C. Clayton (Louisiana State University, Baton Rouge, LA), Dr. Thomas R. Geballe (Gemini Observatory, Hilo, HI), Dr. Falk Herwig (Keele University, UK) and Dr. Christopher Fryer (Los Alamos National Laboratory, Los Alamos, NM), and Dr. Martin Asplund (Mount Stromlo Observatory, Australia).

Prompted by the discovery, the team roughly simulated the nuclear reactions that would occur during a merger of two types of white dwarfs, an idea originally proposed for the origin of RCB stars in 1984 by Prof. Ronald F. Webbink (University of Illinois). According to Clayton conditions had to be just right to yield the oxygen-18 observed in these stars. 'It's like the porridge in Goldilocks and the Three Bears. During the merger process, when nuclear reactions were taking place, the temperature was neither too hot, nor

too cold, but just right for the production of large amounts of oxygen-18.'

One of the challenges in understanding these stars is how oxygen-18 can be formed from nitrogen in the star while maintaining more normal amounts of the isotope oxygen-16 made from the star's preexisting carbon. 'It's really the ratio of oxygen-18 to oxygen-16 that is important and in these stars that ratio is very lopsided. Although we need to do more precise modeling, it appears that the white dwarf merger theory might just allow this to occur,' said Clayton.

RCB stars are a small group of carbon-rich supergiants that undergo spectacular declines in brightness at irregular intervals, typically a few years in duration, before returning to their initial brightnesses. It is now thought that carbon grains intermittently condensing in the gas ejected by the star are responsible for dimming the star's light. On the other hand, the HdC stars, although resembling the RCB stars in their elemental abundances, do not eject gas and thus do not make dust or appear to vary in brightness.

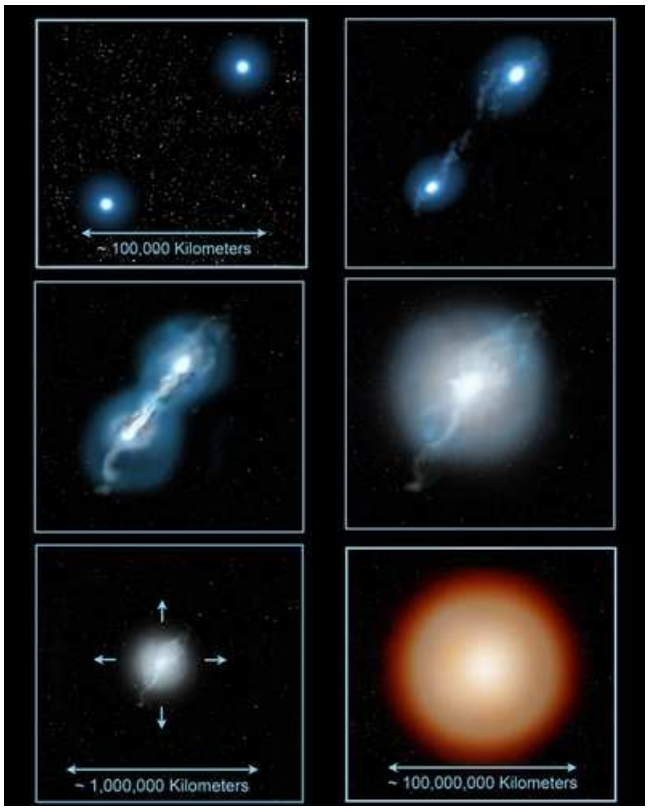

Figure 8: *A pair of white dwarf stars in a close binary system are brought ever closer to each other, either by magnetic braking or gravitational wave emission, until one of the stars is disrupted and then merges with the other star. The gas becomes hot enough for nuclear reactions to take place. The energy produced causes the new merged star to expand and become a supergiant star, about a thousand times larger than the white dwarfs that formed it.*

An alternative theory to the merging of white dwarf pairs, originally proposed by Icko Iben (University of Illinois), is that oxygen-18 rich stars could be formed when a single star on the verge of becoming a white dwarf undergoes a final flash of thermonuclear burning near its surface. This inflates the star to supergiant size and cools off its outer atmosphere.

'This final-flash model is a tempting explanation because two stars known as V605 Aquilae and Sakurai's Object have recently been discovered going through the final flash phase where they resembled RCB stars in abundances, temperature, and brightness,' said team member Geballe. 'However, both of these stars are now known to have spent only a few years in this phase and given this extremely short period as cool supergiants this makes it unlikely that they can account for even the small number of RCB stars currently known in the Milky Way Galaxy.' These stars are so rare that a total of only 55 HdC and RCB stars have been identified in our galaxy.

'The properties and antics of these weird stars have been the subject of intense observation and discussion for generations of astronomers,' said Geballe. 'This discovery should help us pinpoint how the combination of two degenerate stars is different than the sum of their parts.'

2.6 First Planet-Forming Disk Found in the Environment of a Dying Star

Source: W.M. Keck Observatory Press Release, January 9th, 2007 [8]

Astronomers generally assume that the dusty disks where planets form are found around young stars in stellar nurseries. Now, for the first time, a protoplanetary disk has been found in the environment of a dying star.

A team of astronomers is reporting today at the winter meeting of the American Astronomical Society that material from the dying star Mira A is being captured into a disk around Mira B, its companion. Michael Ireland of the California Institute of Technology and his coauthors, John Monnier from the University of Michigan, Peter Tuthill from the University of Sydney, and Richard Cohen from the W.M. Keck Observatory, say that the finding implies that there should be many similar undiscovered systems in the solar

neighborhood, providing a myriad of new places to look for young extrasolar planets.

Located 350 light years away in the constellation of Cetus, Mira (christened the ”Miracle star”) first shook the foundations of the astronomy world 400 years ago with its changing brightness: visible to the naked eye for about 1 month at a time, becoming 1,000 times fainter and disappearing from view, only to re-appear again on an 11 month cycle.

”When looking at one of the most celebrated and well-studied stars in the galaxy, I was amazed to find something new and unexpected!” said Ireland. ”The discovery not only changes the way we think about a star that’s important historically, but also how we’ll look at similar stars in the future.”

Although Mira was once a star very similar to the sun, it is now in its death throes as it loses its dusty outer layers at a rate of one Earth-mass every seven years. If Mira were a single star, all this material would travel into outer space. However, like two out of every three star systems, Mira has a companion star that orbits around it, in this case with a period of about 1,000 years. This companion, Mira B, has a gravitational field that catches nearly one percent of the material lost from Mira A.

By using specialized high-contrast techniques at the 10-meter Keck I telescope in Hawaii and the 8-meter Gemini South telescope in Chile, Ireland’s team discovered heat radiation coming not from Mira B itself, but also from a location offset from Mira B by a distance equivalent to Saturn’s orbit.

”Observing Mira in the infrared is like staring straight down the barrel of one of the brightest searchlights in the galaxy. It came as a real revelation to see this faint mote of dust, harboring all the possibilities of new worlds in formation, against the hostile environment of the Red Giant,” said Tuthill.

Monnier agreed, saying ”Our new imaging method at Keck is revealing new details that were thought to be impossible to detect due to the blurring by atmospheric turbulence. In this case – the ”detail” we discovered is potentially a whole new class of planetary system in formation!”

The intense radiation from Mira A, 5,000 times brighter than the sun, heats the edge of the disk to about Earth’s temperature and causes it to glow in the infrared. The researchers were able to show that the material was indeed the edge of a disk and not just a ”clump” in the wind from Mira A. By modeling the way that this system captures the outflow from Mira A, the researchers were also able to confirm that Mira B is simply an ordinary star like the sun, although about half as massive.

Figure 9: *A false-color image of the Mira star system. Blue represents data obtained with the Hubble Space Telescope and red and green represent ground-based data obtained at the W. M. Keck Observatory in Hawaii and the Gemini South Observatory in Chile. Mira B glows blue. The dust outflow from the bright star Mira A (right) has a green, nearly transparent color from silicate dust. The red color near the companion star, Mira B is caused by heating of the opaque edge of the disk from Mira A. Credit: Michael Ireland, Caltech*

The key part of this result is what will happen when Mira A finishes its death throes and becomes a white dwarf in about one million years. The disk-creating process will have finished and the disk itself will be capable of forming new planets. ”The expected abundance of this kind of system means a new way to find planets that we know are young around stars like our sun, ” Ireland says.

Astronomers associate the death of a star with the death of its planetary system. Here, the opposite is happening. ”An aging star is laying the foundation for a new generation of planets, ” says Ireland. ”This is Greek tragedy on a cosmic scale.”

Similar systems could be discovered and studied by future telescopes such as the Thirty Meter Telescope

2.7 Seven or Eight Dwarf Galaxies Discovered Orbiting the Milky Way

Source: Penn State Press Release, January 9th, 2007 [9]

An international team of scientists, which includes a Penn State astronomer, has discovered seven – and perhaps eight – dwarf galaxies orbiting Earth’s home galaxy, the Milky Way. The discovery will be announced today, 9 January

2007, during a press conference at the American Astronomical Society's meeting in Seattle, Washington. The galaxies were discovered as part of the Sloan Digital Sky Survey (SDSS-II), the most ambitious survey of the sky ever undertaken.

"These dwarf galaxies have been captured by the gravity of the Milky Way and most eventually will merge with our own galaxy," explains Penn State Professor of Astronomy and Astrophysics Donald Schneider, a coauthor of the investigation. "The discovery of these dwarf galaxies demonstrates the unexpected power of large astronomical surveys like the Sloan Digital Sky Survey, which originally was designed to investigate objects millions and billions of light years from Earth, not to discover faint companions of our own galaxy." Schneider is the Chairman of the Sloan Digital Sky Survey (SDSS) Quasar Science Group and the SDSS Scientific Publications Coordinator.

According to Daniel Zucker of Cambridge University in the United Kingdom, one of the research team's leaders, theories predict that there should be tens to hundreds more dwarf galaxies yet to be discovered in the "Local Group" of galaxies, which includes the Milky Way. "In less than a year, we have used SDSS-II data to find seven new Milky Way dwarf satellites," Zucker says. "We've just discovered an eighth new dwarf, but we're not yet sure this one is a Milky Way satellite." The SDSS team has found almost as many new Milky Way satellites as were detected in the previous 70 years. Only a handful were known before the SDSS-II survey.

Dwarf galaxies contain, at most, a few million stars. The new dwarfs have some unusual properties. "They're more like Hobbits than dwarfs," comments Zucker's coinvestigator Vasily Belokurov, also of Cambridge, "since they are smaller and fainter than most previously known satellites. Several of the newly discovered systems appear to be on the verge of disruption – probably by the tidal gravity of the Milky Way – and the 'Ursa Major II' dwarf already seems to be in several pieces. "They look as though they're being ground up," notes Belokurov. Other lead members of the discovery team include Mark Wilkinson, Mike Fellhauer, and Gerry Gilmore of Cambridge University, and Jelte De Jong and Hans-Walter Rix of the Max Planck Institute for Astronomy.

Current theories of galaxy assembly suggest that many – perhaps all – of the stars in the halo and thick disk of the Milky Way originated in smaller dwarf galaxies, which were dissolved when they merged into the Milky Way itself. "The new dwarfs are really just the crumbs from the galactic feast," says Zucker. "Most of the merging happened early on – billions of years ago – and what we're seeing here are the leftovers."

The SDSS-II is a unique resource for finding Milky Way satellites because its deep, multi-color imaging allows detection of much fainter systems than previously were visible. The new objects are found using sophisticated computer algorithms that troll the digital data to find groupings of related stars. Because the SDSS-II covers only a fifth of the sky, astronomers expect that there are many more undiscovered dwarf galaxies in the universe.

The seven new Milky Way satellites all lie in the area of sky surveyed by the SDSS-II around the North Galactic Pole. There are two new dwarfs in the constellation of Canes Venatici (the Hunting Dogs), one in Bootes (the Herdsman), one in Leo (the Lion), one in Coma Berenices (Bernice's Hair), one in Ursa Major (the Great Bear) and one in Hercules.

The eighth and newest discovery may be the most intriguing. Named Leo T, it is about 1.4-million light years away, on the fringes of the Milky Way's gravitational influence. "It may be a 'free-floating' Local Group dwarf, rather than a satellite of the Milky Way," notes team member Sergey Koposov, of the Max Planck Institute for Astronomy in Heidelberg. In addition to its greater distance, Leo T is distinct from the previous seven discoveries in that it has both populations of fairly old stars (greater than five billion years old) and comparatively young populations (less that one billion years old). It also appears to have neutral hydrogen gas – an indication that its star-forming days may not be over.

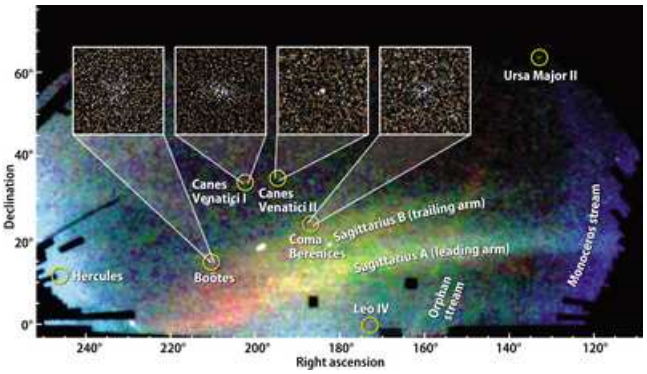

Figure 10: *Researchers from the Sloan Digital Sky Survey (SDSS-II) announced the discovery of eight new dwarf galaxies, seven of them satellites orbiting the Milky Way. They objects resemble systems cannibalized by the Milky Way billions of years ago to build up its stellar halo and thick disk, characterized as "crumbs from the galactic*

feast." *The systems discovered by the SDSS-II in the last three years are comparable in number to all the Milky Way satellites detected in the preceding 70 years. They help close the gap between the observed number of dwarf satellites and theoretical predictions.Credit: Vasily Belokurov, SDSS-II Collaboration.*

Leo T could be the bellwether of a large population of faint galaxies that reside in the Local Group but are not closely associated with either the Milky Way or the Andromeda galaxy. Because it is too distant to be strongly influenced by the tidal force of the Milky Way, Leo T's low luminosity (the equivalent of roughly 50,000 Suns) is likely intrinsic, not a consequence of the tidal stripping of loosely bound stars. "Leo T probably has always been very faint, retaining its gas and slowly forming stars in relative isolation," comments Mike Irwin, a discovery-team member and Cambridge University astronomer.

In addition, the large number of new dwarfs – in combination with previously discovered systems from the SDSS-II and other sky surveys – changes the complexion of the cold-dark-matter theory's "missing satellite" problem. "These discoveries bring the data and the theory closer together," comments Zucker, though there may still be a gap between them.

2.8 Black hole boldly goes where no black hole has gone before

Source: ESA Press Release, January 3rd, 2007 [10]

Astronomers have found a black hole where few thought they could ever exist, inside a globular star cluster. The finding has broad implications for the dynamics of stars clusters and also for the existence of a still-speculative new class of black holes called 'intermediate-mass' black holes. The discovery is reported in the current issue of Nature. Tom Maccarone of the University of Southampton in England leads an international team on the finding, made primarily with the European Space Agency's XMM-Newton satellite.

Globular clusters are dense bundles of thousands to millions of old stars, and many scientists have doubted that black holes could survive in such an exclusive environment. Computer simulations show that a newly formed black hole would first sink towards the centre of the cluster but quickly get gravitationally slingshot out entirely when interacting with the cluster's myriad stars. The new finding provides the first convincing evidence that some black hole might not only survive but grow and flourish in globular clusters. What has astonished astronomers is how quickly the black hole was found.

"We were preparing for a long, systematic search of thousands of globular clusters with the hope of finding just one black hole," said Maccarone. "But bingo, we found one as soon as we started the search. It was only the second globular cluster we looked at."

The search continues to find more, Maccarone said, yet only one black hole was needed to resolve the decades-old discussion about black holes and globular clusters.

Scientists say there are two main classes of black holes. Supermassive black holes containing the mass of millions to billions of suns are found in the core of most galaxies, including our own. A quasar is one kind of supermassive black hole. Stellar-size black holes contain the mass of about ten suns. These are created from the collapsed core of massive stars. Our galaxy likely contains millions of these black holes.

Black holes are, by definition, invisible. But the region around them can flare up periodically when the black hole feeds. As gas falls into a black hole, it will heat to high temperatures and radiate brightly, particularly in X-rays. Maccarone's team found one such stellar-mass black hole by chance feeding in a globular cluster in a galaxy named NGC 4472, about fifty million light-years away in the Virgo Cluster.

XMM-Newton is extremely sensitive to variable X-ray sources and can efficiently search across large patches of the sky. The team also used NASA's Chandra X-ray Observatory, which has superb angular resolution to pinpoint the X-ray source's location. This allowed them to match up the position of the X-ray source with optical images to prove that the black hole was indeed in a globular cluster.

Globular clusters are some of the oldest structures in the universe, containing stars over 12 thousand million years old. Black holes in a cluster would likely have formed many thousand millions of years ago, which is why astronomers have assumed they would have been kicked out a long time ago.

Details in the X-ray light detected by XMM-Newton leave little doubt that this is a black hole - the object is too bright, and varies by too much to be anything else. In fact, the source is 'extra bright', - an Ultraluminous X-ray object, or ULX. ULXs are brighter than the 'Eddington limit' for stellar mass black holes, the brightness level at which the outward force from X-rays is expected balance the powerful gravitational forces from the black hole. Thus it is often suggested that the ULXs might be intermediate mass black holes black holes of thousands of solar masses, heavier than the 10-solar-mass stellar black holes, and lighter

than the million to thousand million solar mass black holes in quasars. These black holes might then be the missing links between the black holes formed in the death throes of massive stars and the ones in the centres of galaxies.

It is perhaps possible for a stellar-mass black hole to gain enough mass through merging with other stellar-mass black holes or accreting star gas to stay locked in a cluster. About 100 solar masses would do. Once entrenched, the black hole has the opportunity to merge with other black holes or accrete gas from a local neighbourhood rife with star-stuff. In this way, they could grow into IMBHs.

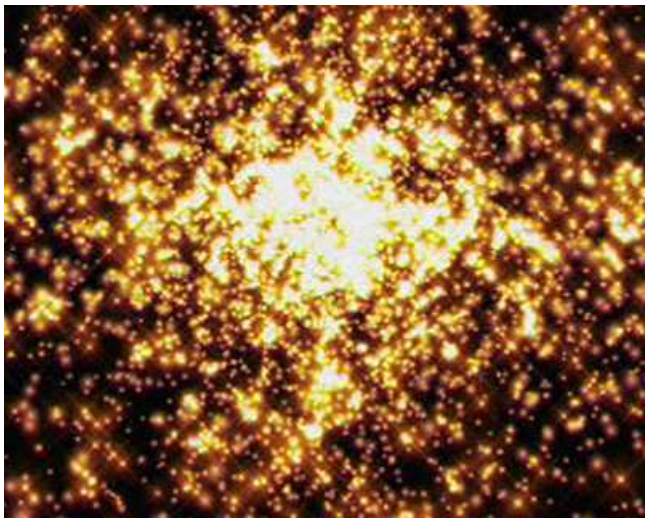

Figure 11: *Artist's impression of globular star cluster*

"If a black hole is massive enough, there's a good chance it can survive the pressures of living in a globular cluster, since it will be too heavy to be kicked out," said Arunav Kundu of Michigan State University, a co-author on the Nature report. "That's what is intriguing about this discovery. We may be seeing how a black hole can grow considerably, become more entrenched in the cluster, and then grow some more.

"On the other hand," continued Kundu, "there are a variety of ways to make ULXs without requiring intermediate mass black holes. In particular, if the light goes out in a different direction than the one from which the gas comes in, it doesn't put any force on the gas. Also, if the light can be 'focused' towards us by reflecting off the gas in the same way that light from a flashlight bulb bounces off the little mirror in the flashlight, making the object appear brighter than it really is."

Ongoing work will help to determine whether this object is a stellar-mass black hole showing an unusual manner of sucking in gas, allowing it to be extra bright, or an IMBH. The team, which also includes Steve Zepf from Michigan State University, and Katherine Rhode from Wesleyan University, has data for thousands of other globular clusters, which they are now analyzing in an effort to determine just how common this phenomenon is.

2.9 Astronomers detect black hole in tiny 'dwarf' galaxy

Source: University of Washington Press Release, January 7th, 2007 [11]

Astronomers have found evidence of a supermassive black hole at the heart of a dwarf elliptical galaxy about 54 million light years away from the Milky Way Galaxy where Earth resides.

It is only the second time a supermassive black hole has been discerned in a dwarf galaxy, and only the third time that astronomers have observed a double nucleus at the heart of a galaxy, said Victor P. Debattista, a postdoctoral researcher in astronomy at the University of Washington.

The galaxy, called VCC128, lies in the Virgo Cluster and is about 1 percent the size of the Milky Way. All of its stars combined would equal 100 million to 1 billion of our suns, Debattista said.

"It's a very small galaxy, on the outskirts of the cluster," he said. "It is effectively the smallest galaxy in which there is a supermassive black hole."

Black holes lie at the center of many galaxies, and have gravitational fields so powerful that nothing – not even light – can escape. A supermassive black hole is so large that its mass equals anywhere between 100,000 and 10 billion of our suns.

Debattista is the lead author of a poster detailing the discovery being presented today at the American Astronomical Society national meeting in Seattle. Co-authors are Ignacio Ferreras of Kings College in London, Anna Pasquali of the Max-Planck-Institut fr Astronomie in Germany, Anil Seth at the Harvard-Smithsonian Center for Astrophysics in Boston, Sven De Rijcke of the Universiteit Gent in Belgium, and Lorenzo Morelli of Pontificia Universidad Catlica in Chile. The work was funded by a grant from the National Science Foundation, a Brooks Prize Fellowship at the UW and the Fund for Scientific Research in Belgium.

The scientists were sifting through archived data from the Hubble Space Telescope when they found the supermassive black hole. They were studying the nuclei of dwarf galaxies,

which are thought to develop from globular clusters, tightly packed spherical collections of stars that orbit a galaxy. As they examined the properties of the nuclei, they discovered one galaxy, VCC128, that had a double nucleus. Ultimately they determined the double nucleus is made up of two points of light from stars collected at opposite edges of a ring surrounding a black hole. Using the 3.5-meter telescope at the Apache Point Observatory in New Mexico, they measured properties of light from the nucleus and found that the nucleus is a ring of stars at least 1 billion years old, meaning the system probably is very stable.

”The fact that we found a black hole is impressive because it’s been thought that a galaxy this small should not be able to host a black hole,” Debattista said. ”It had been speculated that dwarf galaxies like this could not make black holes.”

The researchers believe the black hole has a mass at least equal to the ring of stars surrounding it, ranging from 1 million to 50 million times the mass of our sun.

”The question remains whether other dwarf galaxies with bright nuclei are indeed similar systems. We may not see more of these stellar rings because they are so small,” said Ferreras.

The finding helps in understanding the processes occurring in low-mass dwarf galaxies as they travel through space and merge with other dwarfs to form larger galaxies. As that happens, their black holes also become more massive.

”The dwarf galaxies that escaped from this merging process offer us the opportunity to study the properties of the building blocks of today’s massive galaxies and the supermassive black holes they host,” said De Rijcke.

2.10 Integral sees the Galactic centre playing hide and seek

Source: ESA Press Release, January 18th, 2007 [12]

ESA’s gamma ray observatory Integral has caught the centre of our galaxy in a moment of rare quiet. A handful of the most energetic high-energy sources surrounding the black hole at the centre of the Galaxy had all faded into a temporary silence when Integral looked. This unusual event is allowing astronomers to probe for even fainter objects and may give them a glimpse of matter disappearing into the massive black hole at the centre of our galaxy.

The Galactic centre is one of the most dynamic places in our Galaxy. It is thought to be home to a gigantic black hole, called Sagittarius A* (pronounced ’A star’). Since the beginning of the Integral mission, ESA’s gamma ray observatory has allowed astronomers to keep watch on this ever-changing environment.

Integral has discovered many new sources of high-energy radiation near the galactic centre. From February 2005, Integral began to regularly monitor the centre of the Galaxy, and its immediate environment, known as the Galactic bulge.

Erik Kuulkers of ESA’s Integral Science Operations Centre, ESAC, Spain, leads the Galactic bulge monitoring programme. Integral now keeps its high-tech eyes on about 80 high-energy sources in the galactic bulge. ”Most of these are X-ray binaries,” says Kuulkers.

X-ray binaries are made up of two stars in orbit around one another. One star is a relatively normal star; the other is a collapsed star, such as a white dwarf, neutron star or even a black hole. If the stars are close enough together, the strong gravity of the collapsed star can pull off gaseous material from the normal star. As this gas spirals down around the collapsed star, it is heated to over a million degrees centigrade and this causes it to emit high energy X-rays and gamma rays. The amount of gas falling from one star to the other determines the brightness of the X-ray and gamma-ray emission.

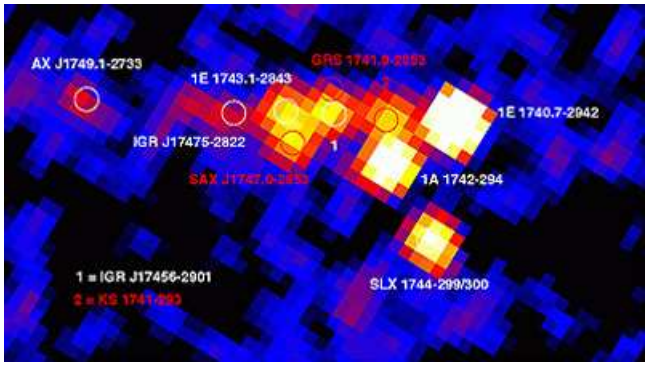

Figure 12: *Integral’s average view of the Galactic Centre*

According to the Integral observations in April 2006, the high-energy rays from about ten sources closest to the galactic centre all faded temporarily. Kuulkers excludes the possibility that a mysterious external force is acting on all the objects to drive them into quiescence. ”All the sources are variable and it was just by accident or sheer luck that they had turned off during that observation,” he says with a smile.

The fortuitous dimming allows astronomers to set new limits on how faint these X-ray binaries can become. It also allows a number of new investigations to be undertaken with the data.

"When these normally bright sources are faint, we can look for even fainter sources," says Kuulkers. These could be other X-ray binaries or the high-energy radiation from giant molecular clouds interacting with past supernovae. There is also the possibility of detecting the faint high-energy radiation from the massive black hole in our Galaxy's centre.

Integral's Galactic bulge monitoring programme will continue throughout this year. The data is made available, within a day or two of being collected, to the scientific community via the Internet from a dedicated webpage at the Integral Science Data Centre (IDSC), Geneva, Switzerland. This way, anyone interested in specific sources can watch for interesting changes and trigger follow up observations with other telescopes in good time.

2.11 Light Echo at Galactic Center: Chandra Discovers Light Echo from the Milky Way's Black Hole

Source: Chandra Press Release, January 10th, 2007 [13]

This set of Chandra images shows evidence for a light echo generated by the Milky Way's supermassive black hole, a.k.a. Sagittarius A* (pronounced "A-star"). Astronomers believe a mass equivalent to the planet Mercury was devoured by the black hole about 50 years earlier, causing an X-ray outburst which then reflected off gas clouds near Sagittarius A*.

The large image shows a Chandra view of the middle of the Milky Way, with Sagittarius A* labeled. The smaller images show close-ups of the region marked with ellipses. Clear changes in the shapes and brightness of the gas clouds are seen between the 3 different observations in 2002, 2004 and 2005. This behavior agrees with theoretical predictions for a light echo produced by Sagittarius A* and helps rule out other interpretations.

While the primary X-rays from the outburst would have reached Earth about 50 years ago, before X-ray observatories were in place to see it, the reflected X-rays took a longer path and arrived in time to be recorded by Chandra.

The clouds of gas featured in the image are glowing by a process called fluorescence. Iron in these clouds has been bombarded either by X-rays from a source that had an outburst in the past or by very energetic electrons. The electrons or photons hit the iron atoms, knocking out electrons close to the nucleus, causing electrons further out to fill the hole, emitting X-rays in the process.

The detection of variability in these fluorescing gas clouds rules out the possibility that they were bombarded by energetic electrons. It also helps rule out other explanations for the X-ray emission, including the possibility that the gas clouds are the remnants of exploded stars or that the light echo came not from Sagittarius A* but from a neutron star or black hole pulling matter away from a binary companion.

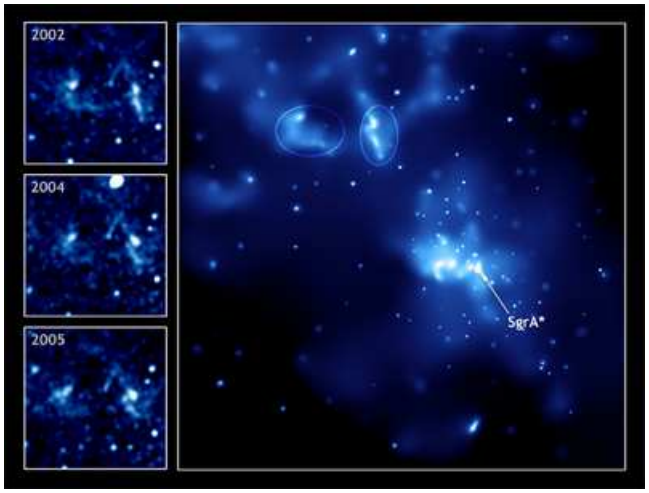

Figure 13:

Studying this light echo gives a crucial history of activity from Sagittarius A*, and it also illuminates and probes the poorly understood gas clouds near the center of the galaxy.

2.12 Hubble Maps the Cosmic Web of "Clumpy" Dark Matter in 3-D

Source: Hubble News, January 7th, 2007 [14]

An international team of astronomers using NASA's Hubble Space Telescope has created a three-dimensional map that provides the first direct look at the large-scale distribution of dark matter in the universe.

Dark matter is an invisible form of matter that accounts for most of the universe's mass.

The map provides the best evidence yet that normal matter, largely in the form of galaxies, accumulates along the densest concentrations of dark matter. The map reveals a loose network of filaments that grew over time and intersect in massive structures at the locations of clusters of galaxies.

The map stretches halfway back to the beginning of the universe and shows how dark matter has grown increasingly "clumpy" as it collapses under gravity.

This milestone takes astronomers from inference to direct observation of dark matter's influence in the universe. Previous studies of dark matter are based largely on numerical

simulations of the expected evolution of large-scale structure. This evolution is driven by the gravitational attraction of dark matter.

Mapping dark matter's distribution in space and time is fundamental to understanding how galaxies grew and clustered over billions of years. Tracing the growth of clustering in the dark matter may eventually also shed light on dark energy, a repulsive form of gravity that influences how dark matter clumps.

The new maps of dark matter and galaxies will provide critical observational underpinnings to future theories for how structure formed in the evolving universe under the relentless pull of gravity. Theories suggest the universe transitioned from a smooth distribution of matter into a sponge-like structure of long filaments.

The research results appeared online today in the journal Nature and were presented at the 209th meeting of the American Astronomical Society in Seattle, Wash., by Richard Massey for the dark matter and Nick Scoville for the galaxies. Both researchers are from the California Institute of Technology, Pasadena, Calif.

"It's reassuring how well our map confirms the standard theories for structure formation." said Massey. He calls dark matter the "scaffolding" inside of which stars and galaxies have been assembled over billions of years.

Researchers created the map using Hubble's largest survey of the universe, the Cosmic Evolution Survey ("COSMOS") with an international team of 70 astronomers led by Scoville. The COSMOS survey covers a sufficiently wide area of sky nine times the area of the Earth's Moon. This allows for the large-scale filamentary structure of dark matter to be evident. To add 3-D distance information, the Hubble observations were combined with multicolor data from powerful ground-based telescopes. "The 3-D information is vital to studying the evolution of the structures over cosmic time," said Jason Rhodes, a collaborator in the study at the Jet Propulsion Laboratory in Pasadena, Calif.

The dark matter map was constructed by measuring the shapes of half a million faraway galaxies. To reach us, the galaxies' light has traveled through intervening dark matter. The dark matter deflected the light slightly as it traveled through space. Researchers used the observed, subtle distortion of the galaxies' shapes to reconstruct the distribution of intervening mass along Hubble's line of sight a method called weak gravitational lensing. This effect is analogous to deducing the rippling pattern in a glass shower door by measuring how light from behind it is distorted as it passes through the glass.

"Although this technique has been employed previously, the depth of the COSMOS image and its superior resolution enables a more precise and detailed map, covering a large enough area to see the extended filamentary structures," said co-investigator Richard Ellis of the California Institute of Technology.

For astronomers, the challenge of mapping the universe has been similar to mapping a city from nighttime aerial snapshots showing only streetlights. Dark matter is invisible, so only the luminous galaxies can be seen directly. The new images are equivalent to seeing a city, its suburbs and country roads in daylight, for the first time. Major arteries and intersections become evident, and a variety of neighborhoods are revealed.

A separate COSMOS team led by Scoville presented images of the large scale galactic structures in the same area with the dark matter. Galaxies appear in visible light seen with Hubble and in ground-based Subaru telescope images by Yoshiaku Taniguchi and colleagues. The hot gas in the densest galaxy clusters was imaged in X-rays by Gunther Hasinger and colleagues using the European Space Agency's XMM-Newton telescope.

Galaxy structures inside the dark matter scaffolding show clusters of galaxies in the process of assembly. These structures can be traced over more than 80 million light-years in the COSMOS survey approximately five times the extent of the nearby Virgo galaxy cluster. In the densest early universe structures, many galaxies already have old stellar populations, implying that these galaxies formed first and accumulated the greatest masses in a bottom-up assembly process where smaller galaxies merge to make bigger galaxies like tributaries converging to form a large river.

The COSMOS survey shows that galaxies with on-going star formation, even to the present epoch, dwell in less populated voids and dark matter filaments. "It is remarkable how the environment on the enormous cosmic scales seen in the dark matter structures can influence the properties of individual stars and galaxies both the maturity of the stellar populations and the progressive 'downsizing' of star formation to smaller galaxies is clearly dependent on the dark matter environment," said Scoville.

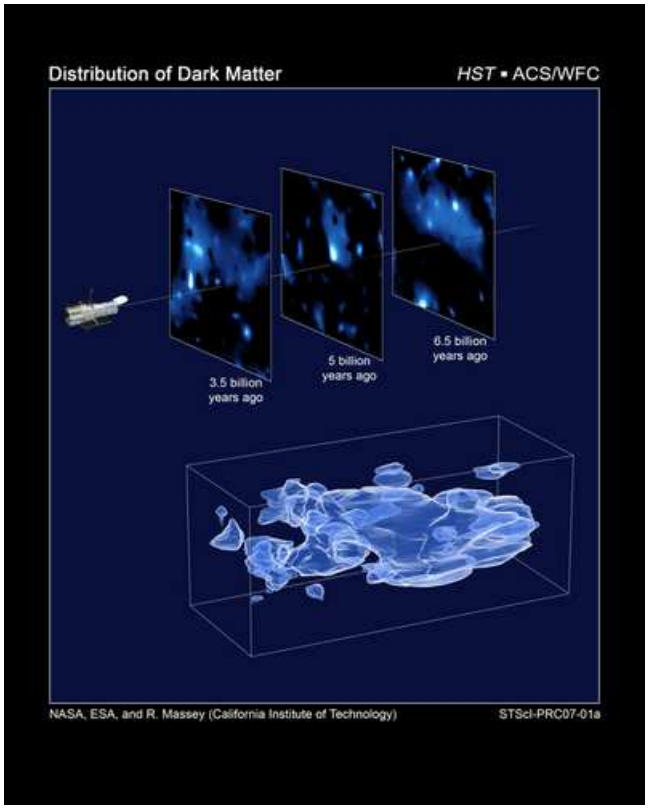

Figure 14: *This three-dimensional map offers a first look at the web-like large-scale distribution of dark matter, an invisible form of matter that accounts for most of the universe's mass. This milestone takes astronomers from inference to direct observation of dark matter's influence in the universe. Because of the finite speed of light, regions furthest away are also seen as they existed a long time ago. The map stretches halfway back in time to the beginning of the universe.*

"The comparison is of fundamental importance," said Massey. "Almost all current scientific knowledge concerns only baryonic matter. Now that we have begun to map out where dark matter is, the next challenge is to determine what it is, and specifically its relationship to normal matter."

In making the COSMOS survey, Hubble photographed 575 slightly overlapping views of the universe using the Advanced Camera for Surveys' (ACS) Wide Field Camera onboard Hubble. It took nearly 1,000 hours of observations. Thousands of galaxies' spectra were obtained by using the European Southern Observatory's Very Large Telescope in Chile, and the Subaru telescope in Hawaii. The distances to the galaxies were accurately determined through their spectral redshifts. The distribution of the normal matter was partly determined with the European Space Agency's XMM-Newton telescope.

2.13 First Triple Quasar Discovered at W. M. Keck Observatory

Source: W.M. Keck Observatory Press Release, January 8th, 2007 [15]

Astronomers using the W. M. Keck Observatory have discovered a triple quasar.

Quasars are powerful sources of electromagnetic energy, which includes radio waves and light. They are believed to be powered by supermassive black holes in the centers of galaxies.

While roughly 100,000 quasars and dozens of double quasars have been observed in recent years, the discovery by scientists at the California Institute of Technology and Ecole Polytechnique Federale de Lausanne (EPFL) in Switzerland is the first involving quasars from three relatively close galaxies.

It also shows how large telescopes like the twin instruments operated by the Keck Observatory atop Mauna Kea are furthering humankind's understanding of the universe.

"As more binary and triple quasar systems are discovered, science will have a new tool with which to understand how galaxies and supermassive black holes in the distant universe may have developed and changed over time," said Dr. Taft Armandroff, director of the W. M. Keck Observatory. "This is an area of research for which large telescopes like Keck I are well-suited."

S. George Djorgovski, a Caltech professor and the leader of the team which made the discovery, said quasars are thought to be powered by gas falling into the black holes, a process believed to be enhanced when galaxies collide. The triple quasar is located about 10.5 billion light years away a time when galaxy interactions were at their peak, Djorgovski said.

Such a mingling of galaxies would explain the increasing number of double or binary quasars discovered in recent years as well as the presence of the triple quasar, according to Ashish Mahabal, another Caltech scientist involved in the discovery.

Although quasars are extremely bright, capable of producing more light than an entire galaxy of a hundred billion stars, their massive energy comes from an area smaller than our solar system.

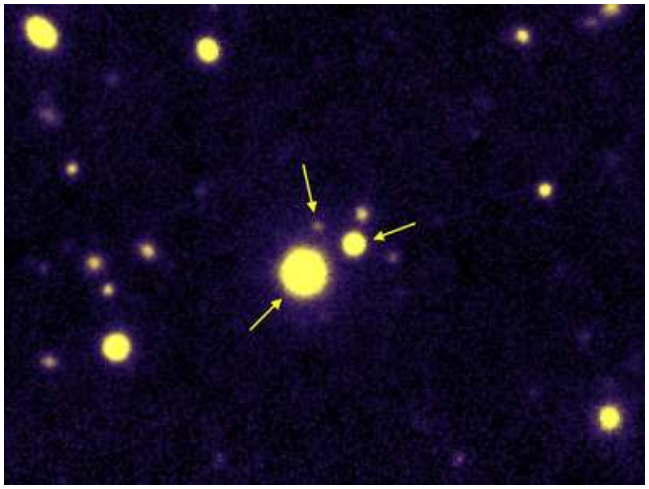

Figure 15:

The latest discovery began modestly in 1989 with the finding of a distant quasar named LBQS 1429-008 by astronomers at Cambridge in England. The astronomers, led by Dr. Paul Hewett of Cambridge's Institute of Astronomy, also found a fainter quasar in the same area.

However, Hewett and his colleagues at first believed the second quasar to be a case of gravitational lensing. That concept, proffered by Albert Einstein in his theory of relativity, involves a large mass such as a cluster of galaxies which can cause a light image to split, in essence creating a double image. But research over the past several years has prompted astronomers to propose that the find was actually a pair of close quasars.

And then a third, even fainter quasar was found using observations from one of Keck's twin 10-meter telescopes combined with measurements from the European Southern Observatory's 8.2-meter Very Large Telescope located in Chile.

Extensive computer modeling carried out by Djorgovski's research team appears to rule out the possibility that the triple quasar could be the product of gravitational lensing. They also were unable to find any galaxy which could be producing such a lensing phenomenon. In addition, the team was able to document small but significant differences in the properties of the three quasars, lending further credence to the belief they are separate entities.

Additional information is posted to Dr. George Djorgovski's Web site at: [16]

2.14 Superstrings could add gravitational cacophony to universe's chorus

Source: University of Washington Press Release, January 8th, 2007 [17]

Albert Einstein theorized long ago that moving matter would warp the fabric of four-dimensional space-time, sending out ripples of gravity called gravitational waves. No one has observed such a phenomenon so far, but University of Washington researchers believe it is possible to detect such waves coming from strange wispy structures called cosmic superstrings.

Many physicists consider a complex and sometimes-controversial premise called string theory to be a leading candidate to unify their understanding of the four basic forces of nature – gravity, electromagnetic, weak and strong. String theory is sometimes criticized for being untestable or even unscientific, but some versions now predict an exotic behavior with observable effects: the formation of cosmic superstrings, narrow tubes of energy left from the beginning of the universe that have been stretched to enormous lengths by the expansion of the universe, said UW cosmologist Craig Hogan.

If the theories are correct, there are countless cosmic superstrings stretched like a galactic-sized rubber band. They resemble ultra-thin tubes with some of the vacuum of the early universe preserved inside, Hogan said. The strings can form into loops that "flop around" and emit gravitational waves as they decay and eventually disappear.

"They're so light that they can't have any effect on cosmic structure, but they create this bath of gravitational waves just by decaying," he said.

Theory holds that every time something moves it emits a gravitational wave. Colliding black holes send out more waves than anything else, typically a million times more power than is produced by all the galaxies in the universe. While some gravitational waves could occur at frequencies high enough that a human theoretically could hear them, many more of the sources have very low frequencies, 10 to 20 octaves below the range of human hearing, Hogan said.

"Big masses tend to take a long time to move about, so there are more sources at lower frequencies," he said. "Sensing these vibrations would add the soundtrack to the beautiful imagery of astronomy that we are used to seeing. All this time, we have been watching a silent movie."

A proposed orbiting observatory called the Laser Interferometer Space Antenna, being developed by the National Aeronautics and Space Administration, could provide the first measurements of very low frequency gravitational waves, perhaps the first such measurements at any

frequency, Hogan said. In addition to the expected wave sources, such as binary stars and black holes, these signals also might include the first direct evidence of cosmic superstrings.

”If we see some of this background, we will have real physical evidence that these strings exist,” he said.

Calculations for gravitational waves generated by cosmic strings, as well as the larger rationale for the space antenna mission, are being presented today at the American Astronomical Society national meeting in Seattle in a poster by Hogan and Matt DePies, a UW physics doctoral student and visiting physics lecturer.

An Earth-based project called the Laser Interferometer Gravitational-Wave Observatory also is attempting to observe gravitational waves, but it is searching in higher frequencies where Hogan believes waves from superstrings would be much harder to detect. That’s because the background noise would make it difficult to identify the waves emitted by strings.

”The strings, if they exist, are part of that noise, but we want to listen in at lower frequencies and try to detect them,” he said.

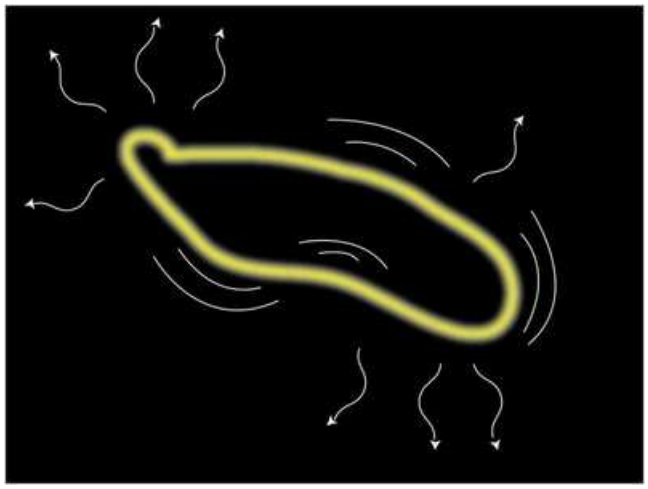

Figure 16: *Cosmic superstring loops wiggle and oscillate, producing gravitational waves, then slowly shrink as they lose energy until they disappear. Credit: Matt DePies/UW*

3 Space missions

3.1 Total Loss of Boeing-built NSS-8 Satellite

Source: Boeing news release, January 31st, 2007 [18]

A Sea Launch Zenit-3SL vehicle, carrying the Boeing-built NSS-8 satellite, experienced an anomaly Tuesday during launch. There were no injuries involved in the launch failure, but the NSS-8 satellite was declared a total loss. There are three other Boeing satellite launches on Sea Launch scheduled in 2007: Thuraya D3, Spaceway F3 and DIRECTV 11. Boeing is working closely with Sea Launch and the NSS-8 customer, SES New Skies, as well as other customers impacted by this event.

Figure 17: *Sea Launch before the explosion. Image credit: Boeing*

3.2 Engineers Investigate Issue on One of Hubble's Science Instruments

Source: NASA News, January 29th, 2007 [19]

NASA engineers are examining a problem related to the Advanced Camera for Surveys (ACS) aboard the agency's Hubble Space Telescope.

On Jan. 27, the observatory entered a protective "safemode" condition at 7:34 a.m. EST. An initial investigation indicates the camera has stopped functioning, and the input power feed to its Side B electronics package has failed.

The instrument had been operating on its redundant electronics since June 30, 2006, when NASA engineers transitioned from the primary, Side A, electronics package due to a malfunction. Engineers currently are assessing the option to return ACS science operations to the primary electronics so that observations could resume in a reduced mode.

Hubble was recovered from safemode around 2 a.m. EST on Jan. 28, and science observations will resume this week using the remaining Hubble instruments: Wide Field Planetary Camera 2, Near Infrared Camera Multi-Object Spectrograph, and the Fine Guidance Sensors.

In November 2006, the Space Telescope Science Institute in Baltimore selected a set of backup non-ACS science programs for use in case of a future ACS anomaly. These programs now will be inserted into the science schedule to maintain a highly productive observing program.

An Anomaly Review Board was appointed on Jan. 29, to investigate the ACS anomaly. The board will perform a thorough investigation and assessment to decide the best course of action. The board is scheduled to present their findings and recommendations by March 2.

"It is too early to know what influences the ACS anomaly may have on Hubble Space Telescope Servicing Mission-4 planning" said Preston Burch, associate director/program manager for the Hubble Space Telescope. "It is important that the review board conduct a thorough investigation that will allow us to determine if there are any changes needed in the new instruments that will be installed on the upcoming servicing mission so that we can be sure of maximizing the telescope's scientific output. We are continuing to make excellent progress in our preparations for the servicing mission, which is presently targeted to fly in September 2008."

The Advanced Camera for Surveys is a third-generation instrument consisting of three electronic cameras, filters and dispersers that detect light from the ultraviolet to the near infrared. The instrument was installed during a March 2002, servicing mission. It was developed jointly by NASA's Goddard Space Flight Center, Greenbelt, Md., Johns Hopkins University, Baltimore; Ball Aerospace, Boulder, Colo.; and the Space Telescope Science Institute.

3.3 NASA Creates Microscopic Technology for Webb Space Telescope

Source: NASA News, January 24th, 2007 [20]

NASA engineers and scientists building the James Webb Space Telescope have created a new telescope technology called "microshutters." Microshutters are tiny doorways the width of a few hairs that will allow the telescope to view the most distant stars and galaxies humans have ever seen.

The microshutters will enable scientists to mask unwanted light from foreground objects so the telescope can focus on the faint light of the first stars and galaxies that formed in the universe. Only the Webb Telescope has this technology. The Webb Telescope will launch in the next decade.

In December 2006, the microshutters passed crucial environmental testing to demonstrate that they can withstand the rigors of launching and placement in deep space. NASA's Goddard Space Flight Center, Greenbelt, Md., designed, tested and built the instrument technology. The microshutters will work in conjunction with the telescope's Near Infrared Spectrograph that is being built by the European Space Agency.

"To build a telescope that can peer farther than the Hubble Space Telescope can, we needed brand new technology," said Murzy Jhabvala, chief engineer of Goddard's Instrument Technology and Systems Division. "We've worked on this design for more than six years, opening and closing the tiny shutters tens of thousands of times to perfect the technology."

Each of the 62,000 shutters measures 100 by 200 microns, or roughly the width of three to six human hairs. The shutters are arranged in four identical grids that have a layout of 171 rows by 365 columns. These shutter grids are in front of an eight million-pixel infrared detector that records the light passing through the open shutters. The detector itself represents a technology breakthrough.

Astronomers using ground-based telescopes first take a picture of the sky and map all the objects in which they are interested. They then create a mask resembling a sieve to place on the telescope so that only the light from areas of interest can reach the telescope's detectors.

In space, the Webb Telescope will have a wide field of view, and its deep, long observation of the sky will contain mil-

lions of light sources. Microshutters allow scientists to remotely and systematically block out light that they do not want, allowing the large-format detector to measure infrared spectra optimally. Previously, masks of space telescopes only covered large regions of a field of view at any one time.

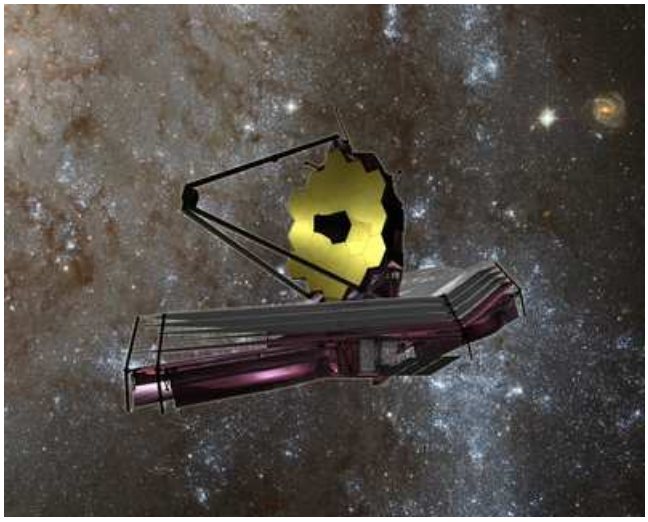

Figure 18: *Artist impression of the James Webb Telescope. Image credit: NASA*

”The microshutters provide a conduit for faint light to reach the telescope detectors with very little loss,” said Harvey Moseley, the Microshutter Principal Investigator at Goddard. ”The shutters allow us to perform spectroscopy on up to 100 targets simultaneously. We will be able to see deeper in less time.”

Each shutter grid array is etched from a single piece of silicon, leaving a sculpture of cavities and doorframes with microscopic hinges and moving doors. The tiny shutters are laced with magnetic cobalt-iron strips.

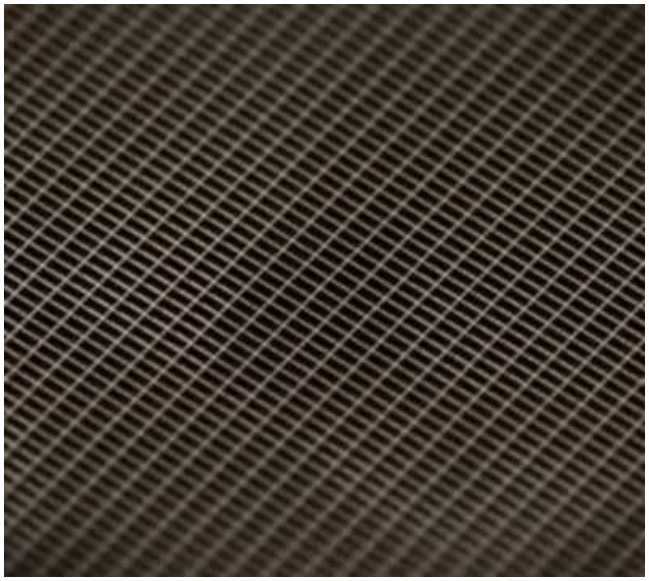

Figure 19: *Close-up of the Microshutters. Credit: NASA/Chris Gunn*

A passing magnet will open all the doors, pulling them down into the cavity. While the doors are opened, engineers can apply a combination of voltages to keep the selected microshutters open. The remainder close when the magnet moves away.

The microshutters must perform at a temperature of minus 388 degrees Fahrenheit (40 Kelvin, -233 degrees Celsius), which is the temperature of the Near Infrared Spectrograph.

The microshutters are needed for observing distant, faint sources. Hubble’s Ultra-Deep Field provides the deepest view of the universe, an image containing tens of thousands of light sources. Some of these light sources are relatively close and some are from an era just after galaxies and stars formed. To go deeper, scientists need to mask the brighter, closer sources and focus only on the most distant. The same microshutter technology also will efficiently reveal faint features in relatively nearby star fields, where scientists will analyze multiple sources at once.

”The microshutters are a remarkable engineering feat that will have applications both in space and on the ground, even outside the realm of astronomy in biotechnology, medicine and communications,” said Moseley.

3.4 Jupiter As Seen from Mars

Source: HiRISE Press Release, January 31st, 2007 [21]

The HiRISE camera is the most powerful telescope to have

left Earth orbit. As such, it is capable of some interesting astronomical observations.

This image of Jupiter and its major satellites (10 MB) was acquired to calibrate the pointing and color response of the camera. An oversight in planning this unusual observation put the focus mechanism in the wrong location, blurring the image. This does not detract from the calibration objectives, but makes the raw image less esthetic.

To compensate, the image has been ”sharpened” on the ground by Dennis Gallagher, the HiRISE chief optical designer. With this sharpening, and because Mars is closer to Jupiter than Earth is, this image has comparable resolution as the Hubble Space Telescope’s pictures of Jupiter.

Figure 20: *credit: Image NASA/JPL/University of Arizona*

The colors are not what is seen by the human eye because HiRISE is able to detect light with a slightly longer wavelength than we can (that is, the infrared).

While there is no standard observation geometry, this image was acquired on 11 January 2007, 2102 spacecraft event time to be precise.

3.5 Zooming to Pluto, New Horizons Closes in on Jupiter

Source: New Horizons Press Release, Januaru 18th, 2007 [22]

Just a year after it was dispatched on the first mission to Pluto and the Kuiper Belt, NASA’s New Horizons spacecraft is on the doorstep of the solar system’s largest planet about to swing past Jupiter and pick up even more speed on its voyage toward the unexplored regions of the planetary frontier.

The fastest spacecraft ever launched, New Horizons will make its closest pass to Jupiter on Feb. 28, threading its path through an ”aim point” 1.4 million miles (2.3 million kilometers) from the center of Jupiter. Jupiter’s gravity will accelerate New Horizons away from the Sun by an additional 9,000 miles per hour half the speed of a space shuttle in orbit pushing it past 52,000 mph and hurling it toward a pass through the Pluto system in July 2015.

At the same time, the New Horizons mission team is taking the spacecraft on the ultimate test drive using the flyby to put the probe’s systems and seven science instruments through the paces of a planetary encounter. More than 700 observations of Jupiter and its four largest moons are planned from January through June, including scans of Jupiter’s turbulent, stormy atmosphere and dynamic magnetic cocoon (called a magnetosphere); the most detailed survey yet of its gossamer ring system; maps of the composition and topography of the large moons Io, Europa, Ganymede and Callisto; and an unprecedented look at volcanic activity on Io.

The flight plan also calls for the first-ever trip down the long ”tail” of Jupiter’s magnetosphere, a wide stream of charged particles that extends tens of millions of miles beyond the planet, and the first close-up look at the ”Little Red Spot,” a nascent storm south of Jupiter’s famous Great Red Spot.

”Our highest priority is to get the spacecraft safely through the gravity assist and on its way to Pluto,” says New Horizons Principal Investigator Dr. Alan Stern, of the Southwest Research Institute, Boulder, Colo. ”But we also have an incredible opportunity to conduct a real-world-encounter stress test to wring out our procedures and techniques for Pluto, and to collect some valuable science data.”

The Jupiter test matches or exceeds the mission’s Pluto study in duration, data volume sent back to Earth, and operational intensity. Much of the data from the Jupiter flyby won’t be sent back to Earth until after closest approach, because the spacecraft’s main priority is to observe the planet and store data on its recorders before transmitting information home. ”We designed the Jupiter encounter to prove out our planning tools, our simulation capabilities, our spacecraft and our instrument sensors on a real planetary target, well before the Pluto encounter,” says Glen Fountain, New Horizons project manager at the Johns Hopkins University Applied Physics Laboratory (APL), Laurel, Md., which built and operates the spacecraft. ”If the team needs to adjust anything before Pluto, we’ll find out about it now.”

The mission team at APL, SwRI and other institutions has learned much in a hectic year since New Horizons lifted off from Cape Canaveral Air Force Station, Fla., last Jan.

19. The spacecraft has undergone a full range of system and instrument checkouts, instrument calibrations and commissioning, some flight software enhancements, and three small propulsive maneuvers to adjust its trajectory. Operational highlights of the past year included long-distance snapshots of both Jupiter and Pluto, and a flyby of asteroid 2002 JF56 (recently named "APL" by the International Astronomical Union).

With closest approach to Jupiter coming 13 months after launch, New Horizons will reach the planet faster than any of its seven previous visitors. Pioneers 10 and 11, Voyagers 1 and 2, Ulysses and Cassini all used Jupiter's gravity to reach other destinations; NASA's Galileo orbited the planet from 1995-2003.

New Horizons also provides the first close-up look at the Jovian system since Galileo, and the last until NASA's Juno mission arrives in 2016. "The Jupiter system is incredibly dynamic," says New Horizons Jupiter Encounter Science Team lead Dr. Jeff Moore, of NASA Ames Research Center, Moffett Field, Calif. "From constant changes in Jupiter's magnetosphere and atmosphere, to the evolving surfaces of moons such as Io, you get a new snapshot every time you go there."

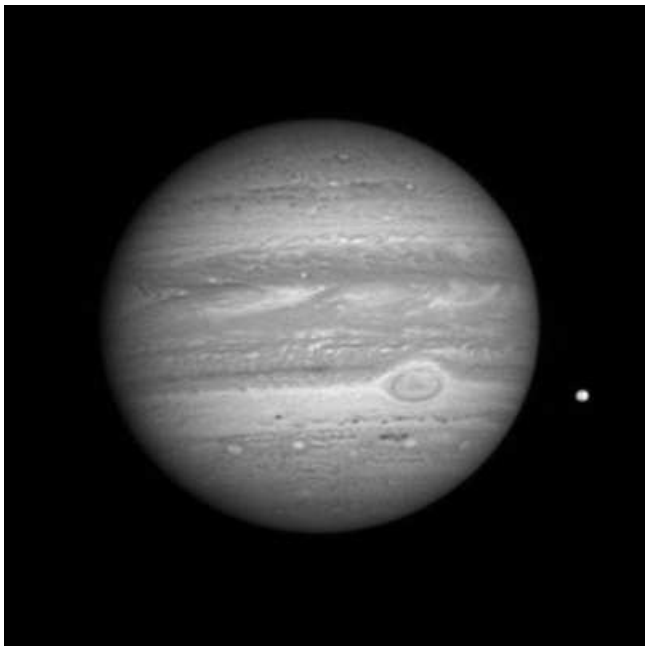

Figure 21:

After an eight-year cruise from Jupiter across the expanse of the solar system, New Horizons will conduct a five-month-long study of Pluto and its three moons in 2015, characterizing their global geology and geomorphology, mapping their surface compositions and temperatures, and examining Pluto's atmospheric composition and structure. Then, as part of a potential extended mission, New Horizons would conduct similar studies of one or more smaller worlds in the Kuiper Belt, the region of ancient, rocky and icy bodies far beyond Neptune's orbit.

The New Horizons science payload includes imaging infrared and ultraviolet spectrometers, a multi-color camera, a long-range telescopic camera, two particle spectrometers, a space-dust detector and a radio science experiment. The compact, 1,050-pound spacecraft, drawing electricity from a single radioisotope thermoelectric generator, currently operates on slightly more power than a pair of 100 -watt light bulbs.

3.6 STEREO Sends Back First Solar Images

Source: NASA News, December 20th, 2006 [23]

NASA's twin Solar Terrestrial Relations Observatories (STEREO) sent back their first images of the sun this week and with them a view into the sun's mounting activity.

One image shows the first coronal mass ejection (CME) observed by STEREO's Ahead spacecraft, taken Dec. 9.

The other images show the sun's super-hot atmosphere. They were taken on Dec. 4, the first day of imaging observations for the Ahead spacecraft. The false color images show a number of bright magnetic active regions, including one on the far left edge of the sun which later produced a series of high energy flares and CMEs.

"We're absolutely thrilled. We've been looking forward to STEREO's unique vantage point for over 10 years now and the community couldn't be happier with these first views," said Michael Kaiser, STEREO project scientist at NASA Goddard Space Flight Center, Greenbelt, Md.

"Now we're holding our breath to see what the next big CME looks like in 3-D, so we can really start to answer some interesting questions."

After a successful launch on Oct. 25 from Cape Canaveral Air Force Station, Fla., STEREO spent the first few minutes separating from its stacked configuration aboard the single Delta II rocket. Shortly afterwards, mission operations personnel at The Johns Hopkins University Applied Physics Laboratory, (APL) Laurel, Md., monitored the two observatories as they traveled in an elliptical orbit from a point close to Earth to one extending just beyond the moon.

"STEREO is the first mission using the moon's gravity to redirect multiple spacecraft, launched aboard a single

rocket, to their respective orbits," said Ron Denissen, APL STEREO project manager. On Dec. 15, 2006, mission operations personnel at the laboratory used lunar gravitational swingbys to alter the spacecraft orbits, redirecting the "A" observatory to its orbit "ahead" of Earth. The "B" observatory will swing past the moon a second time on Jan. 21, redirecting it to an orbit "behind" Earth. The two will orbit the sun from this perspective, separating from each other by about 45 degrees per year. Scientists expect the two to be in position to produce 3-D images by April 2007.

"Our ultimate goal is seeing solar flares and coronal mass ejections in 3-D to better understand their origin, evolution and determine whether or not they're a threat to Earth," said Russell Howard, principal investigator for SECCHI, the imaging instrument suite aboard both observatories. Howard and his staff are a part of the Naval Research Laboratory (NRL) in Washington, DC.

Coronal mass ejections, - giant clouds of plasma shot out into space by the sun and X-ray emitting solar flares are the largest explosions in the solar system and can pack the force of a billion megaton nuclear bombs. They are caused by the buildup and sudden release of magnetic stress in the solar atmosphere above the turbulent active regions we see as sunspots.

When directed at Earth, CMEs can produce spectacular aurora and disrupt satellites, radio communications and power systems. Energetic particles associated with these solar eruptions permeate the entire solar system and may be hazardous to spacecraft and astronauts.

Figure 22: *A close up of loops in a magnetic active region. These loops, observed by STEREO's SECCHI/EUVI telescope, are at a million degrees C. This powerful active region, AR903, observed here on Dec. 4, produced a series of intense flares over the next few days. Credit: NASA*

Each STEREO observatory has 16 instruments. The PLAsma and SupraThermal Ion and Composition (PLASTIC) team, housed at the University of New Hampshire, Durham, N.H., started receiving data from its two instruments in early December. Researchers at the University of California, Berkeley, saw solar wind measurements from some of its In-situ Measurements of PArticles and CME Transients (IMPACT) instrument suite Nov.1. SWAVES the radio astronomy experiment, STEREO/WAVES, led by the Meudon Observatory in Paris, France obtained measurements just two days after launch on Oct 27.

"An integral part of exploration, heliophysics is the system science that unites all of the linked phenomena in the region of the cosmos influenced by a magnetically variable star like our sun," said Madhulika Guhathakurta, NASA STEREO program scientist at NASA Headquarters, Washington. The STEREO mission represents the most significant upgrade and expansion to this system science as it will not only provide a rich package of upgraded sensors, but it will travel to new vantage points."

Goddard manages the STEREO mission and APL designed and built the spacecraft. APL will maintain command and control of the observatories throughout the mission, while NASA tracks and receives the data, determines the orbit of the satellites, and coordinates the science results. STEREO is the third mission selected for NASA's Solar-Terrestrial Probe Program.

3.7 Eavesdropping on the Universe

Source: Harvard-Smithsonian Center for Astrophysics Press Release, January 8th, 2007 [24]

Astronomers have proposed an improved method of searching for intelligent extraterrestrial life using instruments like one now under construction in Australia. The Low Frequency Demonstrator (LFD) of the Mileura Wide-Field Array (MWA), a facility for radio astronomy, theoretically could detect Earth-like civilizations around any of the 1,000 nearest stars.

"Soon, we may be eavesdropping on signals from Galactic civilizations," says theorist Avi Loeb of the Harvard-Smithsonian Center for Astrophysics (CfA). "This is the first time in history that humans will be capable of finding a civilization like ours among the stars."

Loeb will present his findings on Wednesday, January 10, in a press conference at the American Astronomical Society

meeting in Seattle, Wash.

Previous SETI programs would not have detected an Earth-like civilization. The searches often looked for beacon-like signals deliberately beamed across space. Such beacons may not exist. Also, most radio SETI projects examined frequencies higher than 1 Gigahertz in order to avoid interference from both Earth-based and natural cosmic sources.

Instead of looking for deliberate broadcasts, Loeb and his co-author Matias Zaldarriaga (CfA) suggest looking for accidental leakage from an alien civilization. They point out that the new MWA-LFD, which is designed to study frequencies of 80-300 Megahertz, will pick up the same frequencies used by Earth technologies. On Earth, military radars are the most powerful broadcast sources, followed by television and FM radio. If similar broadcast sources exist on other planets, facilities like MWA-LFD might detect them.

”The MWA-LFD is a science instrument intended to study the distant, young universe,” explained Zaldarriaga. ”But by piggybacking onto its normal observations, SETI researchers could use it to look for E.T. civilizations.”

A SETI program at the MWA-LFD would complement other SETI projects. It will observe a larger area of the sky over a longer period of time and in a different frequency range.

Loeb and Zaldarriaga calculate that by staring at the sky for a month, the MWA-LFD could detect Earth-like radio signals from a distance of up to 30 light-years, which would encompass approximately 1,000 stars. More powerful broadcasts could be detected to even greater distances. Future observatories like the Square Kilometer Array could detect Earth-like broadcasts from 10 times farther away, which would encompass 100 million stars.

Figure 23: *A single antenna tile from the Mileura Wide-Field Array. The final telescope will use dozens of these tiles spread over an area of many square meters. Credit: Frank Briggs (Mt. Stromlo Observatory)*

If alien broadcasts were detected, additional observations could measure characteristics of the source planet, such as how fast it rotates or how long its year is. By combining that information with knowledge of the parent star, astronomers could estimate the temperature on the planet’s surface to assess whether it may have liquid water and life as we know it.

The MWA-LFD is a radio telescope designed to detect and characterize highly redshifted 21-centimeter emission from hydrogen molecules in the early universe. Its key scientific goal is to create a three-dimensional map of ionized ”bubbles” that formed as the first quasars and galaxies flooded space with ultraviolet light billions of years ago.

3.8 NASA Mars Team Teaches Old Rovers New Tricks to Kick Off Year Four

Source: JPL/NASA Press Release, December 28th, 2007 [25]

NASA’s twin Mars rovers, nearing the third anniversary of their landings, are getting smarter as they get older.

The unexpected longevity of Spirit and Opportunity is giving the space agency a chance to field-test on Mars some new capabilities useful both to these missions and future rovers. Spirit will begin its fourth year on Mars on Jan. 3 (PST); Opportunity on Jan. 24. In addition to their continuing scientific observations, they are now testing four new skills included in revised flight software uploaded to their onboard computers.

One of the new capabilities enables spacecraft to examine images and recognize certain types of features. It is based on software developed for NASA's Space Technology 6 "thinking spacecraft."

Spirit has photographed dozens of dusty whirlwinds in action, and both rovers have photographed clouds. Until now, however, scientists on Earth have had to sift through many transmitted images from Mars to find those few. With the new intelligence boost, the rovers can recognize dust devils or clouds and select only the relevant parts of those images to send back to Earth. This increased efficiency will free up more communication time for additional scientific investigations.

To recognize dust devils, the new software looks for changes from one image to the next, taken a few seconds apart, of the same field of view. To find clouds, it looks for non-uniform features in the portion of an image it recognizes as the sky.

Another new feature, called "visual target tracking," enables a rover to keep recognizing a designated landscape feature as the rover moves. Khaled Ali of NASA's Jet Propulsion Laboratory, Pasadena, Calif., flight software team leader for Spirit and Opportunity, said, "The rover keeps updating its template of what the feature looks like. It may be a rock that looks bigger as the rover approaches it, or maybe the shape looks different from a different angle, but the rover still knows it's the same rock."

Visual target tracking can be combined with a third new feature – autonomy in calculating where it is safe to reach out with the contact tools on the rover's robotic arm. The combination gives Spirit and Opportunity a capability called "go and touch," which is yet to be tested on Mars. So far in the mission, whenever a rover has driven to a new location, the crew on Earth has had to evaluate images of the new location to decide where the rover could place its contact instruments on a subsequent day. After the new software has been tested and validated, the crew will have the option of letting a rover choose an arm target for itself the same day it drives to a new location.

The new software also improves the autonomy of each rover for navigating away from hazards by building better maps of their surroundings than they have done previously. This new capability was developed by Carnegie Mellon University, Pittsburgh, and JPL.

"Before this, the rovers could only think one step ahead about getting around an obstacle," said JPL's Dr. John Callas, project manager for the Mars Exploration Rovers. "If they encountered an obstacle or hazard, they'd back off one step and try a different direction, and if that direction didn't work they'd try another, then another. And sometimes the rover could not find a solution. With this new capability, the rover will be smarter about navigating in complex terrain, thinking several steps ahead. It could back out of a dead-end cul-de-sac. It could even find its way through a maze."

This is the most comprehensive of four revisions to the rovers' flight software since launch. One new version was uplinked during the cruise to Mars, and the rovers have switched to upgraded versions twice since their January 2004 landings.

Callas said, "These rovers are a great resource for testing software that could be useful to future Mars missions without sacrificing our own continuing mission of exploration. This new software will be a baseline for development of flight software for Mars Science Laboratory, but it's also helpful in operating Spirit and Opportunity." NASA's Mars Science Laboratory is a next-generation Mars rover in development for planned launch in 2009.

Spirit and Opportunity have worked on Mars for nearly 12 times as long as their originally planned prime missions of 90 Martian days. Spirit has driven about 6.9 kilometers (4.3 miles); Opportunity has driven about 9.8 kilometers (6.1 miles). Spirit has returned more than 88,500 images, Opportunity more than 80,700. All the raw images are available online at [26] .

Currently, Spirit is investigating rocks and soils near a ridge where it kept its solar panels tilted toward the sun during the Martian winter. Opportunity is exploring "Victoria Crater," where cliffs in the crater wall expose rock layers with clues about a larger span of Mars history than the rover has previously examined.

Opportunity's key discovery since landing has been mineral and rock-texture evidence that water drenched and flowed over the surface in at least one region of Mars long ago. Spirit has found evidence that water in some form has altered mineral composition of some soils and rocks in older hills above the plain where the rover landed.

Among the rovers' many other accomplishments:

– Opportunity has analyzed a series of exposed rock layers recording changing environmental conditions from the times when the layers were deposited and later modified. Wind-blown dunes came and went. The water table fluctuated.

– Spirit has recorded dust devils forming and moving, events which were made into movie clips. These provide new insight into the interaction of Mars' atmosphere and surface.

– Both rovers have found metallic meteorites on Mars. Opportunity found one rock with a composition similar to a meteorite that reached Earth from Mars.

NASA's Mars Technology Program and New Millennium Program sponsored development of the new capabilities included in the new flight software.

3.9 Blue Origin's Goddard rocket revealed

Source: Blue Origin, January 2nd, 2007 [27]

It's been a huge secret for several years. Amazon.com's founder Jeff Bezos has a rocket company on the side called Blue Origin. But that's pretty much all we knew.

Well, now we know more. The Blue Origin website has been updated with photos and videos of the new Goddard rocket, which blasted off on November 13, 2006 from the West Texas launch facility. For its maiden voyage, the rocket launched vertically, reached an altitude of 87 metres (285 feet), and then landed back down vertically on the launch pad.

Goddard looks like just the nose cone from a much larger rocket, and it will eventually carry paying passengers to the edge of space - an altitude of 100 km (62 miles).

Figure 24: *Blue Origin's Goddard rocket shortly before launch. Image credit: Blue Origin*

4 Internet websites

[1] http://www.gps.caltech.edu/ mbrown/2003EL61/
[2] http://sohowww.nascom.nasa.gov/hotshots/
[3] http://www.spitzer.caltech.edu/Media/releases/ssc2007-02/release.shtml
[4] http://www.spitzer.caltech.edu/Media/releases/ssc2007-01/release.shtml
[5] http://hubblesite.org/newscenter/archive/releases/2007/07/full/
[6] http://hubblesite.org/newscenter/archive/releases/2007/03/full/
[7] http://hubblesite.org/newscenter/archive/releases/2007/05/full/
[8] http://www.keckobservatory.org/article.php?id=99
[9] http://www.science.psu.edu/alert/Schneider1-2007.htm
[10] http://www.esa.int/esaCP/SEML0QZTIVE_index_0.html
[11] http://uwnews.washington.edu/ni/article.asp?articleID=29275
[12] http://www.esa.int/esaCP/SEMGOVRMTWE_index_0.html
[13] http://chandra.harvard.edu/photo/2007/gcle/
[14] http://hubblesite.org/newscenter/archive/releases/2007/01/full/
[15] http://www.keckobservatory.org/article.php?id=98
[16] http://www.astro.caltech.edu/ george/qqq/

[17] http://uwnews.washington.edu/ni/article.asp?articleID=29374
[18] http://www.boeing.com/news/releases/2007/q1/070131d_nr.html
[19] http://www.nasa.gov/home/hqnews/2007/jan/HQ_0715_Hubble_ACS.html
[20] http://www.nasa.gov/home/hqnews/2007/jan/HQ_07014_Webb_microshutters.html
[21] http://hiroc.lpl.arizona.edu/images/PSP/diafotizo.php?ID=PSP_002162_9030
[22] http://pluto.jhuapl.edu/news_center/news/011807.htm
[23] http://www.nasa.gov/centers/goddard/news/topstory/2007/first_light.html
[24] http://www.cfa.harvard.edu/press/pr0701.html
[25] http://www.jpl.nasa.gov/news/news.cfm?release=2006-152
[26] http://marsrovers.jpl.nasa.gov/gallery/all/
[27] http://public.blueorigin.com/index.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.

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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/

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