The Celestial Mechanic
The Official Newsletter of the Astronomy Associates of Lawrence

Volume 37 Number 11 November 2011

COMING EVENTS

SUPERMASSIVE BLACK HOLES
Dr. Greg Rudnick
Physics & Astronomy, KU
Friday, Dec. 9, 2011
7:30 PM
2001 Malott Hall

Public Observing
Sunday December 04
Prairie Park Nature Center
8:00 PM

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INSIDE THIS ISSUE

Report from the Officers:
The first big event, Webelo Scout Astronomy Night last Friday, went off without a hitch. A few hundred scouts and their parents occupied Wescoe Hall to take in some astronomical insight delivered by Rick Heschmeyer. The participants then stormed the beaches of Wescoe to get a better view of the sky through an extensive array of telescopes. Fortunately, the weather cooperated by remaining cloud-free until closing time a little after 9 PM. Amazingly, the weather on Sunday evening proved even better, though attendance at the public observing session was limited to club members.

As you already know, the lecture by Steve Hawley will occur later this week. Hope to see you all there. The semester will close out with two more

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Of Local Interest

UH Astronomer Finds Planet in the Process of Forming

The first direct image of a planet in the process of forming around its star has been captured by University of Hawaii astronomer Adam Kraus.
(***Adam graduated from KU with a BS in Astronomy in 2003.)***

What astronomers are calling LkCa 15 b, looks like a hot "protoplanet" surrounded by a swath of cooler dust and gas, which is falling into the still-forming planet. Images have revealed that the forming planet sits inside a wide gap between the young parent star and an outer disk of dust.

Kraus (UH Institute for Astronomy) and colleague Michael Ireland (Macquarie University and the Australian Astronomical Observatory) combined the power of the 10-meter Keck telescopes with a bit of optical sleight of hand. "LkCa 15 b is the youngest planet ever found, about 5 times younger than the previous record holder," said Kraus. "This young gas giant is being built out of the dust and gas. In the past, you couldn't measure this kind of phenomenon because it's happening so close to the star. But, for the first time, we've been able to directly measure the planet itself as well as the dusty matter around it."

Kraus will be presented the discovery at an Oct. 19 meeting at NASA's Goddard Space Flight Center. The meeting follows the acceptance of a research paper on the discovery by Kraus and Ireland by The Astrophysical Journal. The optical sleight of hand used by the astronomers is to combine the power of Keck's Adaptive Optics with a technique called aperture mask interferometry. The former is the use of a deformable mirror to rapidly correct for

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club events. On Sunday, Dec. 04 we will have our last public observing session of the year. If the exceptional dry weather holds up, it should be crisp but lovely.

The followup event is our annual holiday celebration on Friday, Dec. 09 in 2001 Malott Hall. Our guest speaker is Dr. Greg Rudnick, KU professor of Physics and Astronomy and a leading expert on observational studies of galaxies that reveal the fundamental nature of their origin and evolution. The event will include some holiday refreshments and a collection of door prizes.

From the Astronomical League: As a continuation of an article earlier this year, the League has added a new set of posters to its site “What are Outreach Downloads?” These include “How do you find celestial objects?” and an updated version of “How is your knowledge of astronomy and stargazing?”. All of the downloads are accessible at http://www.astroleague.org/outreach. ***Long-Term Planning***: ALCON 2012 has been scheduled for July 4-7, 2012 in Chicago!

Any suggestions for improving the club or newsletter are always welcome.

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atmospheric distortions of starlight. The latter involves placing a small mask with several holes in the path of the light collected and concentrated by a giant telescope. With that, the scientists can manipulate the light waves.

"It's like we have an array of small mirrors," said Kraus. "We can manipulate the light and cancel out distortions." The technique allows the astronomers to cancel out the bright light of stars. They can then resolve disks of dust around stars and see gaps in the dusty layers where protoplanets may be hiding.

"Interferometry has actually been around since the 1800s, but through the use of adaptive optics has only been able to reach nearby young suns for about the last 7 years." said Dr. Ireland. "Since then we've been trying to push the technique to its limits using the biggest telescopes in the world, especially Keck." The discovery of LkCa 15 b began as a survey of 150 young dusty stars in star-forming regions. That led to the more concentrated study of a dozen stars.

"LkCa 15 was only our second target, and we immediately knew we were seeing something new," said Kraus. "We could see a faint point source near the star, so thinking it might be a Jupiter-like planet we went back a year later to get more data." In further investigations at varying wavelengths, the astronomers were intrigued to discover that the phenomenon was more complex than a single companion object.

"We realized we had uncovered a super Jupiter-sized gas planet, but that we could also measure the dust and gas surrounding it. We'd found a planet at its very beginning" said Kraus. Drs. Kraus and Ireland plan to continue their observations of LkCa 15 and other nearby young stars in their efforts to construct a clearer picture of how planets and solar systems form.

About the Astronomy Associates of Lawrence

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the second Friday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. Approximately the last Sunday of each month we have an open house at the Prairie Park Nature Center. Periodic star parties are scheduled as well. For more information, please contact the club officers:our president, Rick Heschmeyer at rcjbm@sbcglobal.net, our webmaster, Gary Webber, at gwebber@ku.edu, or our faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Fridays and Sundays when events are scheduled. The information about AAL can be found at

http://www.ku.edu/~aal.

Copies of the *Celestial Mechanic* can also be found on the web at

http://www.ku.edu/~aal/celestialmechanic

How the Milky Way Killed Off Nearby Galaxies

Two researchers from Observatoire Astronomique de Strasbourg have revealed for the first time the existence of a new signature of the birth of the first stars in our galaxy, the Milky Way. More than 12 billion years ago, the intense ultraviolet light from these stars dispersed the gas of our Galaxy's nearest companions, virtually putting a halt to their ability to form stars and consigning them to a dim future. Now Pierre Ocvirk and Dominique Aubert, members of the Light in the Dark Ages of the Universe (LIDAU) collaboration, have explained why some galaxies were killed off, while stars continued to form in more distant objects.

The first stars of the Universe appeared about 150 million years after the Big Bang. Back then, the hydrogen and helium gas filling the universe was cold enough for its atoms to be electrically neutral. As the ultraviolet (UV) light of the first stars propagated through this gas, it broke apart the proton-electron pairs that make up hydrogen atoms, returning them to the so-called plasma state they experienced in the first moments of the Universe. This process, known as reionisation, also resulted in significant heating, which had dramatic consequences: the gas became so hot that it escaped the weak gravity of the lowest mass galaxies, thereby depriving them of the material needed to form stars.

It is now widely accepted that this process can explain the small number and large ages of the stars seen in the faintest dwarf galaxy satellites of the Milky Way. It also helps scientists understand why galaxies like the Milky Way have so few satellites around them -- the 'missing satellites' problem. The stripping out of gas from these galaxies makes them sensitive probes of the UV radiation in the reionisation epoch.

The satellite galaxies are also relatively close, from 30000 to 900000 light-years away, which allows us to study them in great detail, something that will be enhanced by the coming generation of larger telescopes. Comparing the population of their stars in each galaxy with its position could give us a unique insight into the structure of the UV radiation emitted from the earliest stars in the Milky Way.

Until now, models for this process assumed that the radiation leading to the removal of gas from galaxy satellites was produced collectively by all the large galaxies nearby, resulting in a uniform background of UV light. The new model put together by the two French researchers proves this assumption wrong.

Ocvirk and Aubert looked at the way the invisible 'dark matter' that makes up about 23% of the Universe structured itself with the stars in our Galaxy and its environs from shortly after the Big Bang to the present day. They used the high resolution numerical simulation Via Lactea II to model the formation of stars in gas trapped in the dark matter haloes that envelop galaxies, and then to describe how this gas reacted to UV radiation.

An image of the dwarf galaxy Bootes II, one of 21 known companions to the Milky Way. (Credit: V. Belokurov and Sloan Digital Sky Survey collaboration)

Pierre Ocvirk comments, "This is the first time that a model accounts for the effect of the radiation emitted by the first stars formed at the centre of the Milky Way on its satellite galaxies.

'In contrast to previous models, the radiation field produced is not uniform, but decreases in intensity as one moves away from the centre of the Milky Way.

'The satellite galaxies close to the galactic centre see their gas evaporate very quickly. They form so few stars that they can be undetectable with current telescopes. At the same time, the more remote satellite galaxies experience on average a weaker irradiation. Therefore they manage to keep their gas longer, and form more stars. As a consequence they are easier to detect and appear more numerous."

The new model appears to be a close match to observations of our Galaxy and its neighborhood and suggests that the first stars of our galaxy played a major role in the photo-evaporation of the satellite galaxies' gas, adds Dr Ocvirk. "It is not large nearby galaxies but our own that caused the demise of its tiny neighbors, asphyxiating them through its intense radiation."

NASA's Space Place

The Gray Cubicle You Want to Work In

By Dr. Tony Phillips

Some of the employees of NASA's Science Mission Directorate may work in gray cubicles, but their jobs are anything but dull. They get to study Earth, the Sun, the Solar System, and the Universe!

It's another day at the office.

You're sitting in a gray cubicle, tap-tap-taping away on your keyboard, when suddenly your neighbor lets out a whoop of delight.

Over the top of the carpeted divider you see a star exploding on the computer screen. An unauthorized video game? No, this explosion is real. A massive star just went supernova in the Whirlpool Galaxy, and the first images from Hubble are popping up on your office-mate's screen.

It's another day at the office ... *at NASA*.

Just down the hall, another office-mate is analyzing global temperature trends. On the floor below, a team of engineers gathers to decode signals from a spaceship that entered "safe mode" when it was hit by a solar flare. And three floors above, a financial analyst snaps her pencil-tip as she tries to figure out how to afford *just one more* sensor for a new robotic spacecraft.

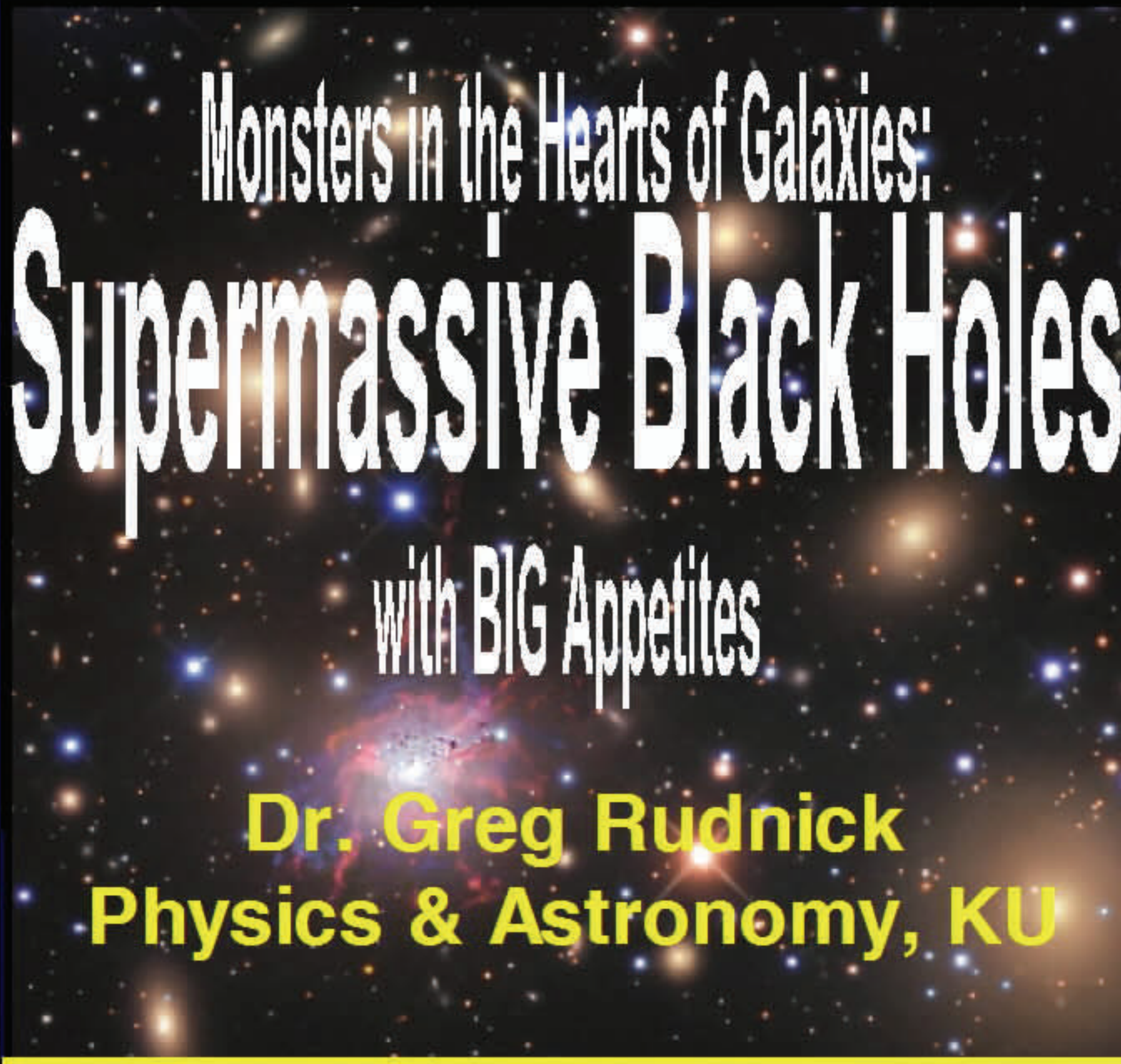
These are just a few of the things going on every day at NASA headquarters in Washington DC and more than a dozen other NASA centers scattered around the country. The variety of NASA research and, moreover, the variety of NASA people required to carry it out often comes as a surprise. Consider the following:

NASA's Science Mission Directorate (SMD) supports research in four main areas: Earth Science, Heliophysics, Astrophysics, and Planetary Science. Read that list one more time. It includes everything in the cosmos from the ground beneath our feet to the Sun in the sky to the most distant galaxies at the edge of the Universe. Walking among the cubicles in NASA's science offices, you are likely to meet people working on climate change, extraterrestrial life, Earth-threatening asteroids, black holes or a hundred other things guaranteed to give a curious-minded person goose bumps. Truly, no other government agency has a bigger job description.

And it's not just scientists doing the work. NASA needs engineers to design its observatories and build its spacecraft, mathematicians to analyze orbits and decipher signals, and financial wizards to manage the accounts and figure out how to pay for everything NASA dreamers want to do. Even writers and artists have a place in the NASA scheme of things. Someone has to explain it all to the general public.

Clearly, some cubicles are more interesting than others. For more information about the Science Mission Directorate, visit science.nasa.gov. And for another way to reach the Space Place, go to http://science.nasa.gov/kids.

The Astronomy Associates of Lawrence



Monsters in the Hearts of Galaxies:

Supermassive Black Holes

with BIG Appetites

Dr. Greg Rudnick
Physics & Astronomy, KU

FRIDAY December 09, 2011

7:30 PM

2001 Malott Hall

University of Kansas

FREE AND
OPEN TO THE PUBLIC

Faraway Eris Is Pluto's Twin

In November 2010, the distant dwarf planet Eris passed in front of a faint background star, an event called an occultation. These occurrences are very rare and difficult to observe as the dwarf planet is very distant and small. The next such event involving Eris will not happen until 2013. Occultations provide the most accurate, and often the only, way to measure the shape and size of a distant Solar System body.

The candidate star for the occultation was identified by studying pictures from the MPG/ESO 2.2-metre telescope at ESO's La Silla Observatory. The observations were carefully planned and carried out by a team of astronomers from a number of (mainly French, Belgian, Spanish and Brazilian) universities using -- among others -- the TRAPPIST [1] (TRAnsiting Planets and PlanetesImals Small Telescope, eso1023) telescope, also at La Silla.

This artist's impression shows the distant dwarf planet Eris. New observations have shown that Eris is smaller than previously thought and almost exactly the same size as Pluto. Eris is extremely reflective and its surface is probably covered in frost formed from the frozen remains of its atmosphere.

"Observing occultations by the tiny bodies beyond Neptune in the Solar System requires great precision and very careful planning. This is the best way to measure Eris's size, short of actually going there," explains Bruno Sicardy, the lead author.

Observations of the occultation were attempted from 26 locations around the globe on the predicted path of the dwarf planet's shadow -- including several telescopes at amateur observatories, but only two sites were able to observe the event directly, both of them located in Chile. One was at ESO's La Silla Observatory using the TRAPPIST telescope, and the other was located in San Pedro de Atacama and used two telescopes [2]. All three telescopes recorded a sudden drop in brightness as Eris blocked the light of the distant star.

The combined observations from the two Chilean sites indicate that Eris is close to spherical. These measurements should accurately measure its shape and size as long as they are not distorted by the presence of large mountains. Such features are, however, unlikely on such a large icy body.

Eris was identified as a large object in the outer Solar System in 2005. Its discovery was one of the factors that led to the creation of a new class of objects called dwarf planets and the reclassification of Pluto from planet to dwarf planet in 2006. Eris is currently three times further from the Sun than Pluto.

While earlier observations using other methods suggested that Eris was probably about 25% larger than Pluto with an estimated diameter of 3000 kilometres, the new study proves that the two objects are essentially the same size. Eris's newly determined diameter stands at 2326 kilometres, with an accuracy of 12 kilometres. This makes its size better known than that of its closer counterpart Pluto, which has a diameter estimated to be between 2300 and 2400 kilometres. Pluto's diameter is harder to measure because the presence of an atmosphere makes its edge impossible to detect directly by occultations. The motion of Eris's satellite Dysnomia [3] was used to estimate the mass of Eris. It was found to be 27% heavier than Pluto [4]. Combined with its diameter, this provided Eris's density, estimated at 2.52 grams per cm^3 [5].

"This density means that Eris is probably a large rocky body covered in a relatively thin mantle of ice," comments Emmanuel Jehin, who contributed to the study [6].

The surface of Eris was found to be extremely reflective, reflecting 96% of the light that falls on it (a visible albedo of 0.96 [7]). This is even brighter than fresh snow on Earth, making Eris one of the most reflective objects in the Solar System, along with Saturn's icy moon Enceladus. The bright surface of Eris is most likely composed of a nitrogen-rich ice mixed with frozen methane -- as indicated by the object's spectrum -- coating the dwarf planet's surface in a thin and very reflective icy layer less than one millimetre thick.

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NASA Telescopes Help Solve Ancient Supernova Mystery

A mystery that began nearly 2,000 years ago, when Chinese astronomers witnessed what would turn out to be an exploding star in the sky, has been solved. New infrared observations from NASA's Spitzer Space Telescope and Wide-field Infrared Survey Explorer, or WISE, reveal how the first supernova ever recorded occurred and

This image combines data from four different space telescopes to create a multi-wavelength view of all that remains of the oldest documented example of a supernova, called RCW 86. The Chinese witnessed the event in 185 A.D., documenting a mysterious "guest star" that remained in the sky for eight months. X-ray images from the European Space Agency's XMM-Newton Observatory and NASA's Chandra X-ray Observatory are combined to form the blue and green colors in the image. The X-rays show the interstellar gas that has been heated to millions of degrees by the passage of the shock wave from the supernova.

Infrared data from NASA's Spitzer Space Telescope, as well as NASA's Wide-Field Infrared Survey Explorer (WISE) are shown in yellow and red, and reveal dust radiating at a temperature of several hundred degrees below zero, warm by comparison to normal dust in our Milky Way galaxy. This is the first time that this type of cavity has been seen around a white dwarf system prior to explosion. Scientists say the results may have significant implications for theories of white-dwarf binary systems and Type Ia supernovae. RCW 86 is approximately 8,000 light-years away. At about 85 light-years in diameter, it occupies a region of the sky in the southern constellation of Circinus that is slightly larger than the full moon.

how its shattered remains ultimately spread out to great distances. The findings show that the stellar explosion took place in a hollowed-out cavity, allowing material expelled by the star to travel much faster and farther than it would have otherwise.

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"This supernova remnant got really big, really fast," said Brian J. Williams, an astronomer at North Carolina State University in Raleigh. Williams is lead author of a new study detailing the findings online in the Astrophysical Journal. "It's two to three times bigger than we would expect for a supernova that was witnessed exploding nearly 2,000 years ago. Now, we've been able to finally pinpoint the cause."

In 185 A.D., Chinese astronomers noted a "guest star" that mysteriously appeared in the sky and stayed for about 8 months. By the 1960s, scientists had determined that the mysterious object was the first documented supernova. Later, they pinpointed RCW 86 as a supernova remnant located about 8,000 light-years away. But a puzzle persisted. The star's spherical remains are larger than expected. If they could be seen in the sky today in infrared light, they'd take up more space than our full moon.

The solution arrived through new infrared observations made with Spitzer and WISE, and previous data from NASA's Chandra X-ray Observatory and the European Space Agency's XMM-Newton Observatory.

The findings reveal that the event is a "Type Ia" supernova, created by the relatively peaceful death of a star like our sun, which then shrank into a dense star called a white dwarf. The white dwarf is thought to have later blown up in a supernova after siphoning matter, or fuel, from a nearby star.

"A white dwarf is like a smoking cinder from a burnt-out fire," Williams said. "If you pour gasoline on it, it will explode."

The observations also show for the first time that a white dwarf can create a cavity around it before blowing up in a Type Ia event. A cavity would explain why the remains of RCW 86 are so big. When the explosion occurred, the ejected material would have traveled unimpeded by gas and dust and spread out quickly.

Spitzer and WISE allowed the team to measure the temperature of the dust making up the RCW 86 remnant at about minus 325 degrees Fahrenheit, or minus 200 degrees Celsius. They then calculated how much gas must be present within the remnant to heat the dust to those temperatures. The results point to a low-density environment for much of the life of the remnant, essentially a cavity.

Scientists initially suspected that RCW 86 was the result of a core-collapse supernova, the most powerful type of stellar blast. They had seen hints of a cavity around the remnant, and, at that time, such cavities were only associated with core-collapse supernovae. In those events, massive stars blow material away from them before they blow up, carving out holes around them.

But other evidence argued against a core-collapse supernova. X-ray data from Chandra and XMM-Newton indicated that the object consisted of high amounts of iron, a telltale sign of a Type Ia blast. Together with the infrared observations, a picture of a Type Ia explosion into a cavity emerged.

"Modern astronomers unveiled one secret of a two-millennia-old cosmic mystery only to reveal another," said Bill Danchi, Spitzer and WISE program scientist at NASA Headquarters in Washington. "Now, with multiple observatories extending our senses in space, we can fully appreciate the remarkable physics behind this star's death throes, yet still be as in awe of the cosmos as the ancient astronomers."

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"This layer of ice could result from the dwarf planet's nitrogen or methane atmosphere condensing as frost onto its surface as it moves away from the Sun in its elongated orbit and into an increasingly cold environment," Jehin adds. The ice could then turn back to gas as Eris approaches its closest point to the Sun, at a distance of about 5.7 billion kilometres. The new results also allow the team to make a new measurement for the surface temperature of the dwarf planet. The estimates suggest a temperature for the surface facing the Sun of -238 Celsius at most, and an even lower value for the night side of Eris.

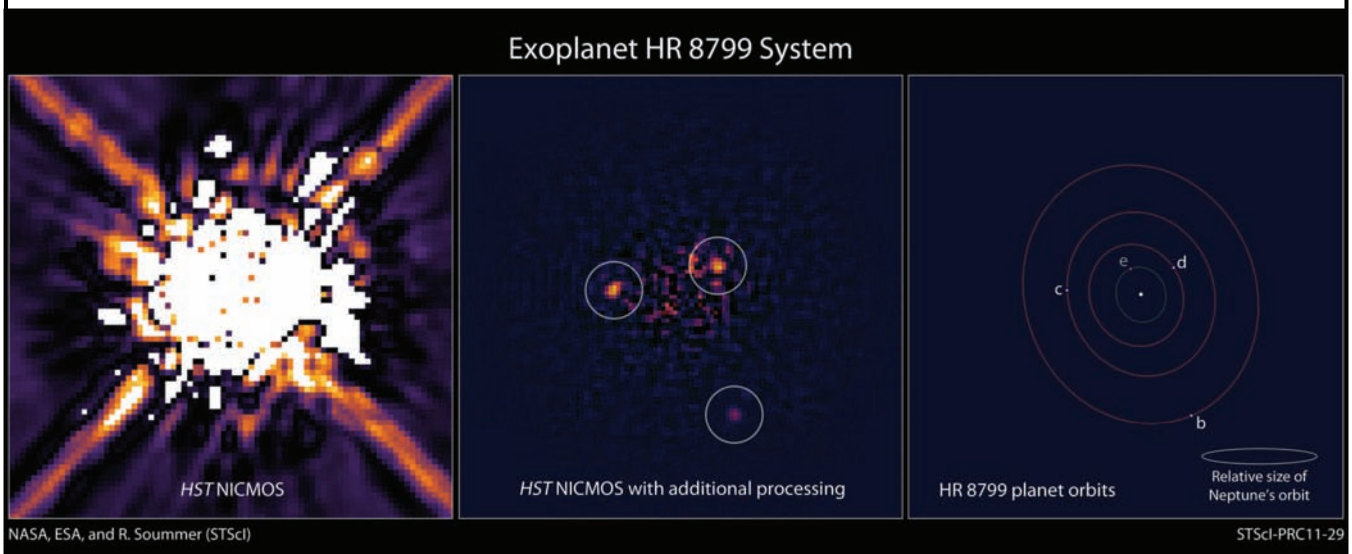
"It is extraordinary how much we can find out about a small and distant object such as Eris by watching it pass in front of a faint star, using relatively small telescopes. Five years after the creation of the new class of dwarf planets, we are finally really getting to know one of its founding members," concludes Bruno Sicardy.

Astronomers Find Elusive Planets in Decade-Old Hubble Data

In a painstaking re-analysis of Hubble Space Telescope images from 1998, astronomers have found visual evidence for two extrasolar planets that went undetected back then. Finding these hidden gems in the Hubble archive gives astronomers an invaluable time machine for comparing much earlier planet orbital motion data to more recent observations. It also demonstrates a novel approach for planet hunting in archival Hubble data.

Four giant planets are known to orbit the young, massive star HR 8799, which is 130 light-years away. In 2007 and 2008 the first three planets were discovered in near-infrared ground-based images taken with the W.M. Keck Observatory and the Gemini North telescope by Christian Marois of the National Research Council in Canada and his team. Marois and his colleagues then uncovered the fourth and innermost planet in 2010. This is the only multiple-exoplanet system for which astronomers have obtained direct snapshots. In 2009 David Lafreniere of the University of Montreal recovered hidden exoplanet data in Hubble images of HR 8799 taken in 1998 with the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). He identified the position of the outermost planet known to orbit the star. This first demonstrated the power of a new data-processing technique for retrieving faint planets buried in the glow of the central star.

A new analysis of the same archival NICMOS data by Remi Soummer of the Space Telescope Science Institute in Baltimore has recovered all three of the outer planets. The fourth, innermost planet is 1.5 billion miles from the star and cannot be



Left: This is an image of the star HR 8799 taken by Hubble's Near Infrared Camera and Multi-Object Spectrometer (NICMOS) in 1998. A mask within the camera (coronagraph) blocks most of the light from the star. In addition, software has been used to digitally subtract more starlight. Nevertheless, scattered light from HR 8799 dominates the image, obscuring the faint planets. **Center:** Recent, sophisticated software processing of the NICMOS data removes most of the scattered starlight to reveal three planets orbiting HR 8799. Astronomers used this decade-old image to calculate the orbits of the planets. **Right:** This is an illustration of the HR 8799 exoplanet system based on the reanalysis of Hubble NICMOS data and ground-based observations. The positions of the star and the orbits of the four known planets are shown schematically. The sizes of the dots are not to scale with the planet's true sizes. The three outermost planets, b, c, and d, are detected in both the NICMOS and ground-based data. A fourth, inner planet, e, was detected in ground-based observations. The orbits appear elongated because of a slight tilt of the plane of the orbits relative to our line of sight. The size of the HR 8799 planetary system is comparable to our solar system, as indicated by the orbit of Neptune, shown to scale.

seen because it is on the edge of the NICMOS coronagraphic spot that blocks the light from the central star.

By finding the planets in multiple images spaced over years of time, the orbits of the planets can be tracked. Knowing the orbits is critical to understanding the behavior of multiple-planet systems because massive planets can perturb each other's orbits. "From the Hubble images we can determine the shape of their orbits, which brings insight into the system stability, planet masses and eccentricities, and also the inclination of the system," says Soummer.

The three outer gas-giant planets have approximately 100-, 200-, and 400-year orbits. This means that astronomers need to wait a very long time to see how the planets move along their paths. The added time span from the Hubble data helps enor-

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mously. "The archive got us 10 years of science right now," he says. "Without this data we would have had to wait another decade. It's 10 years of science for free."

Nevertheless, the slowest-moving, outermost planet has barely changed position in 10 years. "But if we go to the next inner planet we see a little bit of an orbit, and the third inner planet we actually see a lot of motion," says Soummer.

The planets weren't found in 1998 when the Hubble observations were first taken because the methods used to detect them were not available at that time. When astronomers subtracted the light from the central star to look for the residual glow of planets, the residual light scatter was still overwhelming the faint planets.

Lafreniere developed a way to improve this type of analysis by using a library of reference stars to more precisely remove the "fingerprint" glow of the central star. Soummer's team took Lafreniere's method a step further and used 466 images of reference stars taken from a library containing over 10 years of NICMOS observations assembled by Glenn Schneider of the University of Arizona.

Soummer's team further increased contrast and minimized residual starlight. They completely removed the diffraction spikes, which are artifacts common to telescope imaging systems. This allowed them to see two of the faint inner planets in the Hubble data. The planets recovered in the NICMOS data are about 1/100,000th the brightness of the parent star when viewed in near-infrared light. Soummer next plans to analyze approximately 400 other stars in the NICMOS archive with the same technique, improving image quality by a factor of 10 over the imaging methods used when the data were obtained.

Soummer's work demonstrates the power of the Hubble Space Telescope data archive, which harbors images and spectral information from over 20 years of Hubble observations. Astronomers tap into this library to complement new observations with a wealth of invaluable data already gathered, yielding much more discovery potential than new observations alone. From the NICMOS archive data Soummer's team will assemble a list of planetary candidates to be confirmed by ground-based telescopes. If new planets are discovered they will once again have several years' worth of orbital motion to measure.

AAL

Astronomy Associates of Lawrence

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