South Downs Mercury

The monthly circular of South Downs Astronomical Society
Issue: 503 – January 2017 Editor: Roger Burgess

<u>We will be needing a new Society Secretary at the AGM in January members are invite to put their name forward before the AGM</u>

- Next meeting Friday 6th January Lecture room of the South Downs Planetarium, Chichester, at 7.30pm. Please support a raffle we are organizing this month

- AGM this the one meeting during the year when the Trustees of the South Downs AS run the first half of the meeting. In addition to appointing a new Secretary we have to appoint a new committee; anyone wishing to put their name forward can do so at the beginning of the meeting. If you know someone who might be able to serve on the committee, please ask them before nominating them. Being a committee member does not involve too much time or effort, the main thing is to be willing to take on some quite simple tasks, such as meet and greet at the main meetings, attend around six committee meetings each year

- Main Talk Marco Bruni " Gravity Waves"

  - Festive nebulae light up Milky Way Galaxy satellite

This glowing nebula, named NGC 248, is located within the Small Magellanic Cloud, a satellite galaxy of the Milky Way and about 200 000 light-years from Earth. The nebula was observed with Hubble's Advanced Camera for Surveys in Sept. 2015, as part of a survey called the Small Magellanic cloud Investigation of Dust and Gas Evolution (SMIDGE).
Credit: NASA, ESA, STScI, K. Sandstrom (University of California, San Diego), and the SMIDGE team

The sheer observing power of the NASA/ESA Hubble Space Telescope is rarely better illustrated than in an image such as this. This glowing pink nebula, named NGC 248, is located in the Small Magellanic Cloud, just under 200,000 light-years away and yet can still be seen in great detail. Our home galaxy, the Milky Way, is part of a collection of galaxies known as the Local Group. Along with the Andromeda Galaxy, the Milky Way is one of the Group's most massive members, around which many smaller satellite galaxies orbit. The Magellanic Clouds are famous examples, which can easily be seen with the naked eye from the southern hemisphere. Within the smaller of these satellite galaxies, the Small Magellanic Cloud, the NASA/ESA Hubble Space Telescope captured two festive-looking emission nebulae, conjoined so they appear as one. Intense radiation from the brilliant central stars is causing hydrogen in the nebulae to glow pink. Together the nebulae are called NGC 248. They were discovered in 1834 by the astronomer Sir John Herschel. NGC 248 is about 60 light-years long and 20 light-years wide. It is among a number of glowing hydrogen nebulae in the Small Magellanic Cloud, which lies in the southern constellation of Tucana (The Toucan), about 200,000 light-years away.

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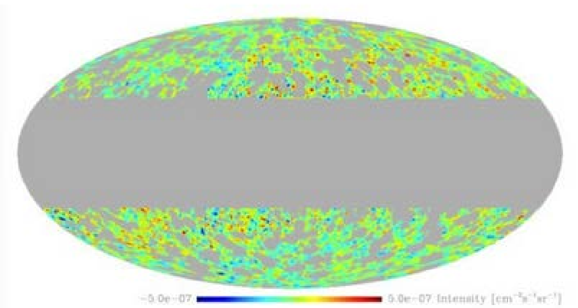
The nebula was observed as part of a Hubble survey, the Small Magellanic cloud Investigation of Dust and Gas Evolution (SMIDGE). In this survey astronomers are using Hubble to probe the Small Magellanic Cloud to understand how its dust -- an important component of many galaxies and related to star formation -- is different from the dust in the Milky Way. Thanks to its relative proximity, the Small Magellanic Cloud is a valuable target. It also turns out to have only between a fifth and a tenth of the amount of heavy elements that the Milky Way has, making the dust similar to what we expect to see in galaxies in the earlier Universe. This allows astronomers to use it as a cosmic laboratory to study the history of the Universe in our cosmic backyard. These observations also help us to understand the history of our own galaxy as most of the star formation happened earlier in the Universe, at a time when the percentage of heavy elements in the Milky Way was much lower than it is now.
The data used in this image were taken with Hubble's Advanced Camera for Surveys in September 2015.

- No trace of dark matter in gamma-ray background



The data that were analysed in the work described here. Fluctuations in the isotropic gamma-ray background, based on 81 months of data. Emission from our own Galaxy, the Milky Way, is masked in grey. *Credit: Mattia Fornasa, UvA/Grappa*

Researchers from the University of Amsterdam's (UvA) GRAPPA Centre of Excellence have just published the most precise analysis of the fluctuations in the gamma-ray background to date. By making use of more than six years of data gathered by the Fermi Large Area Telescope, the researchers found two different source classes contributing to the gamma-ray background. No traces of a contribution of dark matter particles were found in the analysis. The collaborative study was performed by an international group of researchers and is published in the latest edition of the journal *Physical Review D*. Gamma rays are particles of light, or photons, with the highest energy in the universe and are invisible to the human eye. The most common emitters of gamma rays are blazars: supermassive black holes at the centres of galaxies. In smaller numbers, gammy rays are also produced by a certain kind of stars called pulsars and in huge stellar explosions such as supernovae. In 2008 NASA launched the Fermi satellite to map the gamma-ray universe with extreme accuracy. The Large Area Telescope, mounted on the Fermi satellite, has been taking data ever since. It continuously scans the entire sky every three hours. The majority of the detected gamma rays is produced in our own Galaxy (the Milky Way), but the Fermi telescope also managed to detect more than 3000 extragalactic sources (according to the latest count performed in January 2016). However, these individual sources are not enough to explain the total amount of gamma-ray photons coming from outside our Galaxy. In fact, about 75% of them are unaccounted for.

Isotropic gamma-ray background

As far back as the late 1960s, orbiting observatories found a diffuse background of gamma rays streaming from all directions in the universe. If you had gamma-ray vision, and looked at the sky, there would be no place that would be dark. The source of this so-called isotropic gamma-ray background has hitherto remained unknown. This radiation could be produced by unresolved blazars, or other sources too faint to be detected with the Fermi telescope. Parts of the gamma-ray background might also hold the fingerprint of the illustrious dark matter particle, a so-far undetected particle held responsible for the missing 80% of the matter in our universe. If two dark matter particles collide, they can annihilate and produce a signature of gamma-ray photons.

Fluctuations

Together with colleagues, Dr Mattia Fornasa, an astroparticle physicist at the UvA and lead author of the paper, performed an extensive analysis of the gamma-ray background by using 81 months of data gathered by the Fermi Large Area Telescope - much more data and with a larger energy range than in previous studies. By studying the fluctuations in the intensity of the gamma-ray background, the researchers were able to distinguish two different contributions to the gamma-ray background. One class of gamma-ray sources is needed to explain the fluctuations at low energies (below 1 GeV) and another type to generate the fluctuations at higher energy - the signatures of these two contributions is markedly different. In their paper the researchers suggest that the gamma rays in the high-energy ranges - from a few GeV up - are likely originating from unresolved blazars. Further investigation into these potential sources is currently being carried out by Fornasa, fellow UvA researcher Shin'ichiro Ando and colleagues from the University of Torino, Italy. However, it seems much harder to pinpoint a source for the fluctuations with energies below 1 GeV. None of the known gamma-ray emitters have a behaviour that is consistent with the new data.

Constraints on dark matter

To date, the Fermi telescope has not detected any conclusive indication of gamma-ray emission originating from dark-matter particles. Also, this latest study showed no indication of a signal associated with dark matter. Using their data, Fornasa and colleagues were even able to rule out some models of dark matter that would have produced a detectable signal. 'Our measurement complements other search campaigns that used gamma rays to look for dark matter and it confirms that there is little room left for dark matter induced gamma-ray emission in the isotropic gamma-ray background', says Fornasa.

- ❖ Lunar sonic booms

Mini shock waves on the moon

The sonic boom created by an airplane comes from the craft's large, speeding body crashing into molecules in the air. But if you shrank the plane to the size of a molecule, would it still generate a shock wave?

Scientists such as University of Iowa physicist Jasper Halekas hope to answer that question by studying miniature shock waves on the moon. These sonic boomlets, physicists believe, are being generated by protons in the solar wind -- moving at supersonic speed -- colliding with pockets of magnetic fields that bubble up from the moon's crust. Halekas discussed new findings about the physics underlying the moon's mini shock waves at the American Geophysical Union fall meeting in San Francisco. Halekas's talk, "Kinetic Interactions Between the Solar Wind and Lunar Magnetic Fields," was presented on Dec. 14. "We basically don't understand how a magnetic field that small would generate something that we would notice," says Halekas, associate professor in physics and astronomy at the UI. "The general consensus was the solar wind would go right by it." The findings come from NASA's ARTEMIS mission, where two probes circling Earth's nearest celestial neighbour have been gathering high-fidelity measurements of the shock waves. Halekas is the deputy principal investigator on the mission. The moon's magnetic fields first were measured by astronauts beginning with the Apollo 12 mission in 1969. Their portable magnetometers recorded magnetic intensities that varied by location; yet, the highest recorded result was just 1 percent the magnetic field strength on Earth. Despite the fields' weakness and small size, spacecraft since then have documented the solar wind-magnetic field collisions, called "limb shocks," at the boundary between the moon's light side -- the side facing the sun -- and its dark side. Those collisions produce a reflected plume of sorts that radiates from the moon, similar to ripples on a pond. ARTEMIS has made 40 observations of the shock waves, Halekas says. Scientists want to better understand how these mini shock waves are created, as they may occur elsewhere in the solar system. For example, localized shock waves may occur as the solar wind blows by asteroids, Halekas says. It would be important to know about how it all works before trying to land astronauts on a zooming block of rock, as NASA has said it wants to do. The moon is a good place to study the phenomenon. "They may represent the smallest shock waves in our solar system," Halekas says, "and perhaps even the smallest shock waves that can be formed." In a related talk, UI graduate student Stephanie Howard will discuss the ripples that radiate from where the solar wind collides with the lunar magnetic fields. It's the first presentation at a major scientific meeting for Howard, who is in her third year of doctoral studies. "It was a big surprise to me when I found out I would be giving a talk instead of just presenting a poster," she says. "But I think it'll be a great opportunity to meet and present my own research to others who work in the same field."

- Feeding the ravenous black hole at the centre of our galaxy

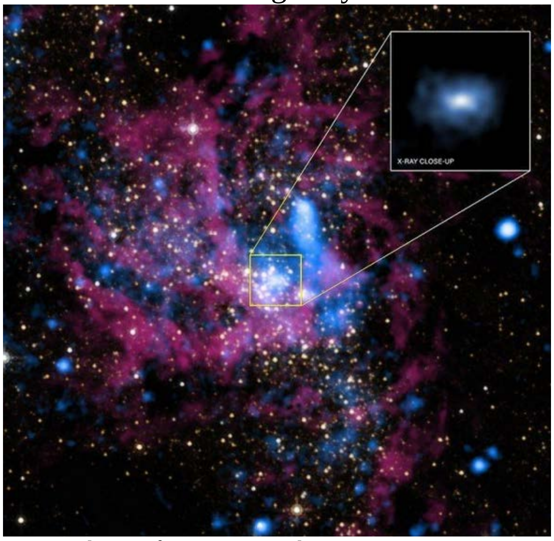


Image and inset of region surrounding Sagittarius A*.
Credit: NASA/UMass/D.Wang et al. Inset: NASA/STSc

Scientists at Princeton University and the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) have developed a rigorous new method for modelling the accretion disk that feeds the supermassive black hole at the centre of our Milky Way galaxy. The paper, published online in December in the journal *Physical Review Letters*, provides a much-needed foundation for simulation of the extraordinary processes involved. Accretion disks are clouds of plasma that orbit and gradually swirl into massive bodies such as black holes -- intense gravitational fields produced by stars that collapse to a tiny fraction of their original size. These collapsed stars are bounded by an "event horizon," from which not even light can escape. As accretion disks flow toward event horizons, the power some of the brightest and most energetic sources of electromagnetic radiation in the universe.

Four million times the mass of the sun

The colossal black hole at the centre of the Milky Way -- called "Sagittarius A*" because it is found in the constellation Sagittarius -- has a gravitational mass that is four million times greater than our own sun. Yet the accretion disk plasma that spirals into this mass is "radiatively inefficient," meaning that it emits much less radiation than one would expect. "So the question is, why is this disk so quiescent?" asks Matthew Kunz, lead author of the paper, assistant professor of astrophysical sciences at Princeton University and a physicist at PPPL. Co-authors include James Stone, Princeton professor of astrophysical sciences, and Eliot Quataert, director of theoretical astrophysics at the University of California, Berkeley. To develop a method for finding the answer, the researchers considered the nature of the superhot Sagittarius A* accretion disk. Its plasma is so hot and dilute that it is collision less, meaning that the trajectories of protons and electrons inside the plasma rarely intersect. This lack of collisionality distinguishes the Sagittarius A* accretion disk from brighter and more radiative disks that orbit other black holes. The brighter disks are collisional and can be modelled by formulas dating from the 1990s, which treat the plasma as an electrically conducting fluid. But "such models are inappropriate for accretion onto our supermassive black hole," Kunz said, since they cannot describe the process that causes the collision less Sagittarius A* disk to grow unstable and spiral down.

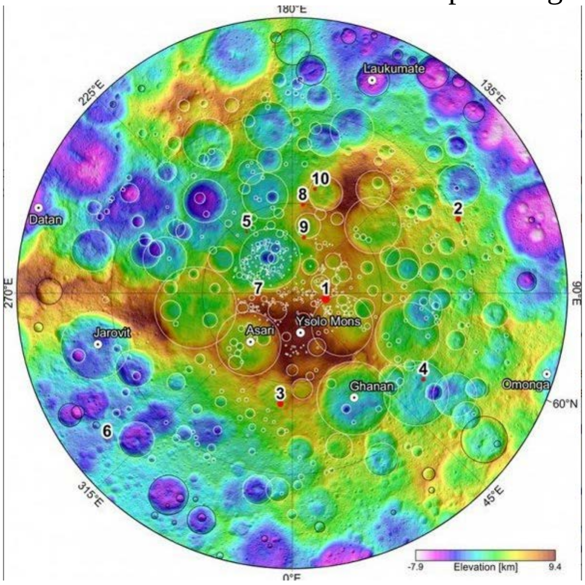
Tracing collision less particles

To model the process for the Sagittarius A* disk, the paper replaces the formulas that treat the motion of collisional plasmas as a macroscopic fluid. Instead, the authors use a method that physicists call "kinetic" to systematically trace the paths of individual collision less particles. This complex approach, conducted using the Pegasus computer code developed at Princeton by Kunz, Stone and Xuening Bai, now a lecturer at Harvard University, produced a set of equations better able to model behaviour of the disk that orbits the supermassive black hole.

This kinetic approach could help astrophysicists understand what causes the accretion disk region around the Sagittarius A* hole to radiate so little light. Results could also improve understanding of other key issues, such as how magnetized plasmas behave in extreme environments and how magnetic fields can be amplified.

The goal of the new method, said Kunz, "will be to produce more predictive models of the emission from black-hole accretion at the galactic centre for comparison with astrophysical observations." Such observations come from instruments such as the Chandra X-ray observatory, an Earth-orbiting satellite that NASA launched in 1999, and the upcoming Event Horizon Telescope, an array of nine Earth-based radio telescopes located in countries around the world.

- Ceres: Water ice in eternal polar night

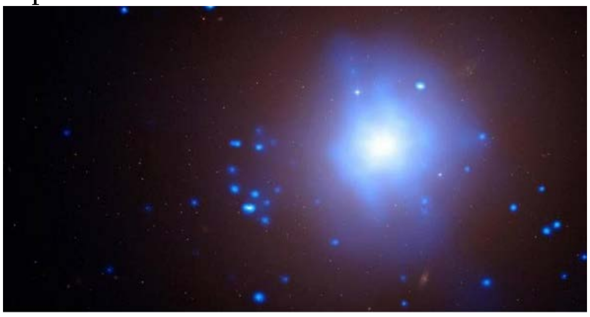


View of the North Pole: The colours show the varying height of Ceres' landscape. The numbers refer to ten craters where the Framing Cameras built in Göttingen at the Max Planck Institute for Solar System Research have discovered water ice.
Credit: © Nature Astronomy

The American Dawn space probe has been orbiting the asteroid Ceres between Mars and Jupiter since March 2015. Thanks to the two identical on board cameras from the Max Planck Institute for Solar System Research (MPS), the Framing Cameras, the dwarf planet has been almost completely mapped. In a current study, a team headed by scientists from the MPS reports on Ceres' most northerly regions, where the Göttingen cameras have performed a very special feat: they have succeeded in taking photos of water ice deposits in places ruled by almost eternal darkness. Thomas Platz is the lead author of the study now published in *Nature Astronomy*, a new specialist journal. "Using our cameras, we looked at the craters in the region near the north pole between 65 and 90 degrees north. Some of these craters are at least partially in eternal darkness which means they are never reached by sunlight. The reason for this is that Ceres' rotational axis has an angle of inclination of only 4.028 degrees," explains the member of the Framing Camera team at the MPS. The small axial inclination means the Sun never rises far above the horizon in the sky above Ceres' Polar Regions. This in turn means that obstacles such as crater walls cast long shadows; considerable areas of the polar region are even shrouded in eternal night. Although sunlight never falls directly onto these locations, tiny amounts of scattered light do reach them, reflected from directly illuminated crater walls in the vicinity, for example. The camera can use this weak light and explore the darkness. This is how it came across several bright deposits -- water ice. Hunting for ice deposits is hard work: of the 634 identified craters with permanent dark areas, ten craters with conspicuously bright spots in their interior were found in the images of the Framing Cameras. A comparatively young crater, still unnamed but provisionally called Number 2, plays a special role here; it lies 69.9 degrees north and has a diameter of 3.8 kilometres. The bright deposits there extend beyond the permanent darkness right into the area which is sometimes illuminated by direct sunlight. "This offers the opportunity to analyse the light reflected from there with Dawn's VIR (Visible and IR Spectrometer) on board instrument, which was supplied by the Italian space agency," explains Andreas Nathues, who heads the Framing Camera experiment at the MPS. "We can clearly see the spectral signature of water ice, but were unable to find other frozen gases." The scientists assume that the other bright deposits are also made mainly of water ice. Scientists have long thought that Ceres' interior contains large amounts of ice because its density is so low -- 2.1621 grams per cubic centimetre. This is now the second time that water has been found directly on the surface. The current results join measurements from the Herschel telescope operated by the European Space Agency ESA, which measured water vapour close to Ceres in 2014. In December 2015, moreover, Max Planck researchers in Göttingen used the Framing Cameras to record patches of mist over two craters close to the equator, likewise an indication of water in vapour form. Deposits of ice on parts of Ceres' surface which experience direct sunlight are found to be unstable over long, geological periods of time. The dwarf plant has no atmosphere and thus the ice sublimates in a relatively short period of time once it reaches the surface. This means it passes directly from ice to the gaseous state. At places which are permanently in darkness, and thus extremely cold, where the temperatures fall below minus 163 degrees Celsius, ice can survive for a very long time. "We know ice deposits exist in the polar regions of our Moon and the planet Mercury, both of which have no atmosphere either. These ice deposits can be explained as the result of external events such as the impacts of comets," says Nathues. "The craters near Ceres' poles, however, contain ice which is probably indigenous to Ceres, i.e. it originates mainly from Ceres itself," explains Platz. As the co-authors of the study of the Free University of Berlin have been able to show in a simulation, the impact which originally created the Oxo crater, for example, could have blasted away icy rock which exists below the surface and hurled it as far as the Polar Regions. Dawn's mission to Vesta and Ceres is managed by the Jet Propulsion Laboratory for NASA's Science Mission Directorate in Washington. Dawn is a project of the directorate's Discovery Program, managed by NASA's Marshall Space Flight Centre in Huntsville, Alabama. UCLA is responsible for overall Dawn mission science. Orbital ATK, Inc., of Dulles, Virginia, designed and built the spacecraft. JPL is managed for NASA by the California Institute of Technology in Pasadena. The framing cameras were provided by the Max Planck Institute for Solar System Research, Gottingen, Germany, with significant contributions by the German Aerospace Centre (DLR) Institute of Planetary Research, Berlin, and in coordination with the Institute of Computer and Communication Network Engineering, Braunschweig. The framing camera project is funded by the Max Planck Society, DLR, and NASA.

- A super flash from a star and a supermassive black hole

The brightest flash of light in the cosmos could be a rare event involving a star and a supermassive black hole



In just the right conditions, the destruction of a star in a black hole's gravitational tide should produce an unusual flash of light.
Credit: Chandra/Harvard

When astronomers and astrophysicists observe flashes of light in the dark sky, they assume they have seen a supernova. Possibly a star has burnt up its supply of nuclear fuel and collapsed, throwing off its outer layers into space; or maybe a dense white dwarf siphoned off material from a companion star until it exploded from excess weight. But a flash of light observed on June 14, 2015 did not fit any of the usual models. For one thing, the intensity of the light was double that of the brightest supernova recorded up to that point. So astrophysicists were already asking what process could have caused it. And there were other anomalies, as well: Rather than gradually cooling, which is what happens in the average supernova, the temperature of the material emitting radiation went down -- and then up again, remaining at the higher level for quite a while. And the site of the flash was a puzzle, as well: Supernovae tend to occur in young, "blue" galaxies, but this one took place in an old "red" galaxy, in which the stars were not really candidates for exploding. Postdoctoral fellow Giorgos Leloudas and Prof. Avishay Gal-Yam of the Particle Physics and Astrophysics Department of the Weizmann Institute of Science investigated. Together with colleagues at the Institute, Drs. Paul Vreeswijk, Ofer Yaron and Steve Schulze, Joel Johannson, and Ira Bar, as well as researchers around the world, they closely observed, measured and recorded the event. This led them to the discovery that the spectrum of the light had changed several times, and the hypothesis they formed based on this finding was that they had observed an extremely rare event: the destruction of a star by the gravitational tides of a black hole at the centre of its galaxy. The flash had, in fact, come from the middle of that distant galaxy, and further analysis suggested that the observations fit what is known about stars being caught in a black hole's gravitational tide. The reason such an event, producing such a bright flash, is so rare is that two conditions must be met for it to occur: The star must stray close enough to the black hole to cross its "event horizon" -- the point at which it cannot escape the pull of the giant mass -- but the light produced in its destruction must somehow escape the black hole's all-consuming gravity. And for these conditions to occur, the galaxy's central black hole, which is immense even by black-hole standards, must be rotating at a relativistic speed -- close to the speed of light. Observing the light over several months, the team came to the conclusion that the best explanation for the unusual flash of light was, indeed, the destruction of a star caught in the gravitational tides of an exceptionally massive black hole rotating extremely rapidly.

- ❖ Microlensing study suggests most common outer planets likely Neptune-mass

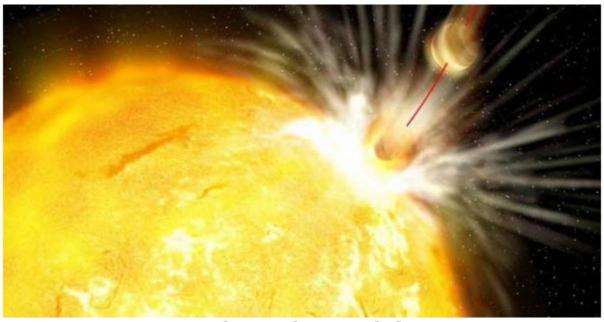
Neptune-mass exoplanets like the one shown in this artist's rendering may be the most common in the icy regions of planetary systems. Beyond a certain distance from a young star, water and other substances remain frozen, leading to an abundant population of icy objects that can collide and form the cores of new planets. In the foreground, an icy body left over from this period drifts past the planet.
Credit: NASA/Goddard/Francis Reddy

A new statistical study of planets found by a technique called gravitational microlensing suggests that Neptune-mass worlds are likely the most common type of planet to form in the icy outer realms of planetary systems. The study provides the first indication of the types of planets waiting to be found far from a host star, where scientists suspect planets form most efficiently. "We've found the apparent sweet spot in the sizes of cold planets. Contrary to some theoretical predictions, we infer from current detections that the most numerous have masses similar to Neptune, and there doesn't seem to be the expected increase in number at lower masses," said lead scientist Daisuke Suzuki, a post-doctoral researcher at NASA's Goddard Space Flight Centre in Greenbelt, Maryland, and the University of Maryland Baltimore County. "We conclude that Neptune-mass planets in these outer orbits are about 10 times more common than Jupiter-mass planets in Jupiter-like orbits." Gravitational microlensing takes advantage of the light-bending effects of massive objects predicted by Einstein's general theory of relativity. It occurs when a foreground star, the lens, randomly aligns with a distant background star, the source, as seen from Earth. As the lensing star drifts along in its orbit around the galaxy, the alignment shifts over days to weeks, changing the apparent brightness of the source. The precise pattern of these changes provides astronomers with clues about the nature of the lensing star, including any planets it may host. "We mainly determine the mass ratio of the planet to the host star and their separation," said team member David Bennett, an astrophysicist at Goddard. "For about 40 percent of microlensing planets, we can determine the mass of the host star and therefore the mass of the planet." More than 50 exoplanets have been discovered using microlensing compared to thousands detected by other techniques, such as detecting the motion or dimming of a host star caused by the presence of planets. Because the necessary alignments between stars are rare and occur randomly, astronomers must monitor millions of stars for the tell-tale brightness changes that signal a microlensing event. However, microlensing holds great potential. It can detect planets hundreds of times more distant than most other methods, allowing astronomers to investigate a broad swath of our Milky Way galaxy. The technique can locate exoplanets at smaller masses and greater distances from their host stars, and it's sensitive enough to find planets floating through the galaxy on their own, unbound to stars. NASA's Kepler and K2 missions have been extraordinarily successful in finding planets that dim their host stars, with more than 2,500 confirmed discoveries to date. This technique is sensitive to close-in planets but not more distant ones. Microlensing surveys are complementary, best probing the outer parts of planetary systems with less sensitivity to planets closer to their stars. "Combining microlensing with other techniques provides us with a clearer overall picture of the planetary content of our galaxy," said team member Takahiro Sumi at Osaka University in Japan. From 2007 to 2012, the Microlensing Observations in Astrophysics (MOA) group, a collaboration between researchers in Japan and New Zealand, issued 3,300 alerts informing the astronomical community about ongoing microlensing events. Suzuki's team identified 1,474 well-observed microlensing events, with 22 displaying clear planetary signals. This includes four planets that were never previously reported. To study these events in greater detail, the team included data from the other major microlensing project operating over the same period, the Optical Gravitational Lensing Experiment (OGLE), as well as additional observations from other projects designed to follow up on MOA and OGLE alerts. From this information, the researchers determined the frequency of planets compared to the mass ratio of the planet and star as well as the distances

between them. For a typical planet-hosting star with about 60 percent the sun's mass, the typical microlensing planet is a world between 10 and 40 times Earth's mass. For comparison, Neptune in our own solar system has the equivalent mass of 17 Earths.
The results imply that cold Neptune-mass worlds are likely to be the most common types of planets beyond the so-called snow line, the point where water remained frozen during planetary formation. In the solar system, the snow line is thought to have been located at about 2.7 times Earth's mean distance from the sun, placing it in the middle of the main asteroid belt today. A paper detailing the findings was published in *The Astrophysical Journal* on Dec. 13. "Beyond the snow line, materials that were gaseous closer to the star condense into solid bodies, increasing the amount of material available to start the planet-building process," said Suzuki. "This is where we think planetary formation was most efficient, and it's also the region where microlensing is most sensitive."
NASA's Wide Field Infrared Survey Telescope (WFIRST), slated to launch in the mid-2020s, will conduct an extensive microlensing survey. Astronomers expect it will deliver mass and distance determinations of thousands of planets, completing the work begun by Kepler and providing the first galactic census of planetary properties.
NASA's Ames Research Centre manages the Kepler and K2 missions for NASA's Science Mission Directorate. The Jet Propulsion Laboratory (JPL) in Pasadena, California, managed Kepler mission development. Ball Aerospace & Technologies Corporation operates the flight system with support from the Laboratory for Atmospheric and Space Physics at the University of Colorado in Boulder. WFIRST is managed at Goddard, with participation by JPL, the Space Telescope Science Institute in Baltimore, the Infrared Processing and Analysis Centre, also in Pasadena, and a science team comprising members from U.S. research institutions across the country. For more information on how NASA's Kepler is working with ground-based efforts, including the MOA and OGLE groups, to search for planets using microlensing, please visit:
https://www.nasa.gov/feature/ames/kepler/searching-for-far-out-and-wandering-worlds/
Related video:
https://youtu.be/qzlR3kBCLYM

- Astronomers discover dark past of planet-eating 'Death Star'

Solar twin could hold clues to planetary formation



HIP68468, a twin star to the sun about 300 light-years away, may have swallowed one or more of its planets, based on lithium and refractory elements recently discovered near its surface.
Credit: Illustration by Gabi Perez / Instituto de Astrofísica de Canarias

An international team of scientists, including researchers from the University of Chicago, has made the rare discovery of a planetary system with a host star similar to Earth's sun. Especially intriguing is the star's unusual composition, which indicates it ingested some of its planets. "It doesn't mean that the sun will 'eat' the Earth any time soon," said Jacob Bean, assistant professor of astronomy and astrophysics at UChicago and co-author of an *Astronomy & Astrophysics* article on the research. "But our discovery provides an indication that violent histories may be common for planetary systems, including our own." Unlike the artificial planet-destroying Death Star in the movie "Star Wars," this natural version could provide clues about how planetary systems evolve over time.
Astronomers discovered the first planet orbiting a star other than the sun in 1995. Since then, more than two thousand exoplanets have been identified. Rare among them are planets that orbit a star similar to Earth's sun. Due to their extreme similarity to the sun, these so-called solar twins are ideal targets for investigating the connections between stars and their planets. Bean and his colleagues studied star HIP68468, which is 300 light years away, as part of a multi-year project to discover planets that orbit solar twins. It's tricky to draw conclusions from a single system, cautioned Megan Bedell, an UChicago doctoral student who is co-author of the research and the lead planet finder for the collaboration. She said the team plans "to study more stars like this to see whether this is a common outcome of the planet formation process." Computer simulations show that billions of years from now, the accumulated

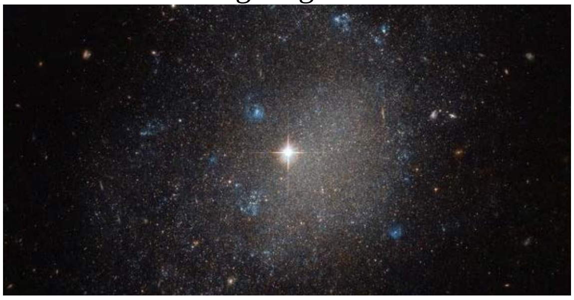
gravitational tugs and pulls between planets will eventually cause Mercury to fall into the sun, said Debra Fischer, a professor of astronomy at Yale University who was not involved in the research. "This study of HIP68468 is a post-mortem of this process happening around another star similar to our sun. The discovery deepens our understanding of the evolution of planetary systems."

Two planets discovered

Using the 3.6-meter telescope at La Silla Observatory in Chile, the research team of scientists from several continents discovered its first exoplanet in 2015. The more recent discovery needs to be confirmed, but includes two planet candidates -- a super Neptune and a super Earth. Their orbits are surprisingly close to their host star, with one 50 percent more massive than Neptune and located at a Venus-like distance from its star. The other, the first super Earth around a solar twin, is three times the Earth's mass and so close to its star that its orbit takes just three days. "These two planets most likely didn't form where we see them today," Bedell said. Instead, they probably migrated inward from the outer parts of the planetary system. Other planets could have been ejected from the system -- or ingested by their host star. HIP68468's composition points to a history of ingesting planets. It contains four times more lithium than would be expected for a star that is 6 billion years old, as well as a surplus of refractory elements -- metals resistant to heat and that are abundant in rocky planets.

In the hot interior of stars like HIP68468 and the sun, lithium is consumed over time. Planets, on the other hand, preserve lithium because their inner temperatures are not high enough to destroy the element. As a result, when a star engulfs a planet, the lithium that the planet deposits in the stellar atmosphere stands out. Taken together, the lithium and the engulfed rocky planet material in the atmosphere of HIP68468 is equivalent to the mass of six Earths. "It can be very hard to know the history of a particular star, but once in a while we get lucky and find stars with chemical compositions that likely came from in-falling planets," Fischer said. "That's the case with HD68468. The chemical remains of one or more planets are smeared in its atmosphere. "It's as if we saw a cat sitting next to a bird cage," she added. "If there are yellow feathers sticking out of the cat's mouth, it's a good bet that the cat swallowed a canary." The team continues to monitor more than 60 solar twins, looking for more exoplanets. Beyond that, the Giant Magellan Telescope under construction in Chile, for which UChicago is a founding partner, will be capable of detecting more Earth-like exoplanets around solar twins. "In addition to finding Earth-like planets, the Giant Magellan Telescope will enable astronomers to study the atmospheric composition of stars at even greater detail than we can today," Bean said. "That will further reveal the histories of planetary systems that are subtly imprinted on their host stars."

- Hubble chases a small stellar galaxy in the Hunting Dog



On a clear evening in April of 1789, the renowned astronomer William Herschel continued his unrelenting survey of the night sky, hunting for new cosmic objects -- and found cause to celebrate! He spotted this bright spiral galaxy, named NGC 4707, lurking in the constellation of Canes Venatici or The Hunting Dog. NGC 4707 lies roughly 22 million light-years from Earth.
Credit: ESA/Hubble & NASA

NGC stands for "New General Catalogue of Nebulae and Clusters of Stars." Over two centuries later, the NASA/ESA Hubble Space Telescope is able to "chase down" and view the same galaxy in far greater detail than Herschel could, allowing us to appreciate the intricacies and characteristics of NGC 4707 as never before. This striking image comprises observations from Hubble's Advanced Camera for Surveys (ACS), one of a handful of high-resolution instruments currently aboard the space telescope. Herschel himself reportedly described NGC 4707 as a "small, stellar" galaxy; while it is classified as a spiral (type Sm), its overall shape, centre, and spiral arms are very loose and undefined, and its central bulge is either very small or non-existent. It instead appears as a rough sprinkling of stars and bright flashes of blue on a dark canvas. The blue smudges seen across the frame highlight regions of recent or ongoing star formation, with new born stars glowing in bright, intense shades of cyan and turquoise.

- Number of known black holes expected to double in two years with new detection method

Researchers from the University of Waterloo have developed a method that will detect roughly 10 black holes per year, doubling the number currently known within two years, and it will likely unlock the history of black holes in a little more than a decade. Avery Broderick, a professor in the Department of Physics and Astronomy at the University of Waterloo, and Mansour Karami, a PhD student also from the Faculty of Science, worked with colleagues in the United States and Iran to come up with the method that has implications for the emerging field of gravitational wave astronomy and the way in which we search for black holes and other dark objects in space. It was published this week in *The Astrophysical Journal*.

"Within the next 10 years, there will be sufficient accumulated data on enough black holes that researchers can statistically analyse their properties as a population," said Broderick, also an associate faculty member at the Perimeter Institute for Theoretical Physics. "This information will allow us to study stellar mass black holes at various stages that often extend billions of years." Black holes absorb all light and matter and emit zero radiation, making them impossible to image, let alone detect against the black background of space. Although very little is known about the inner workings of black holes, we do know they play an integral part in the lifecycle of stars and regulate the growth of galaxies. The first direct proof of their existence was announced earlier this year by the Laser Interferometer Gravitational-Wave Observatory (LIGO) when it detected gravitational waves from the collision of two black holes merging into one.

"We don't yet know how rare these events are and how many black holes are generally distributed across the galaxy," said Broderick. "For the first time we'll be placing all the amazing dynamical physics that LIGO sees into a larger astronomical context." Broderick and his colleagues propose a bolder approach to detecting and studying black holes, not as single entities, but in large numbers as a system by combining two standard astrophysical tools in use today: microlensing and radio wave interferometry. Gravitational microlensing occurs when a dark object such as a black hole passes between us and another light source, such as a star. The star's light bends around the object's gravitational field to reach Earth, making the background star appear much brighter, not darker as in an eclipse. Even the largest telescopes that observe microlensing events in visible light have a limited resolution, telling astronomers very little about the object that passed by. Instead of using visible light, Broderick and his team propose using radio waves to take multiple snapshots of the microlensing event in real time. "When you look at the same event using a radio telescope -- interferometry -- you can actually resolve more than one image. That's what gives us the power to extract all kinds of parameters, like the object's mass, distance and velocity," said Karami, a doctoral student in astrophysics at Waterloo. Taking a series of radio images over time and turning them into a movie of the event will allow them to extract another level of information about the black hole itself.

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