South Downs Mercury

The monthly circular of South Downs Astronomical Society
Issue: 553 – June 2021 Editor: Roger Burgess
THE MEETING IS CANCELLED DUE TO COVID-19

We have a virtual meeting Friday 4th June Zoom Meeting 19:30 William Joyce 'interacting and active galaxies'. Assuming some time this year we will be holding the delayed AGM, we are looking for a new secretary and committee members, it probably won't be until September so you have time to prepare.

- A revolutionary method to drastically reduce stray light on space telescopes

Date: May 19, 2021
Source: University of Liege

A team of researchers at the Centre Spatial de Liège (CSL) of the University of Liège has just developed a method to identify the contributors and origins of stray light on space telescopes. This is a major advance in the field of space engineering that will help in the acquisition of even finer space images and the development of increasingly efficient space instruments. This study has just been published in the journal *Scientific Reports*.
Space telescopes are becoming more and more powerful. Technological developments in recent years have made it possible, for example, to observe objects further and further into the universe or to measure the composition of the Earth's atmosphere with ever greater precision. However, there is still one factor limiting the performance of these telescopes: stray light. A phenomenon that has been known fora long time, stray light results in light reflections (ghost reflections between lenses, scattering, etc.) that damage the quality of images and often lead to blurred images. Until now, the methods for checking and characterizing this stray light during the development phase of the telescopes have been very limited, making it possible to "just" know whether or not the instrument was sensitive to the phenomenon, forcing engineers to revise all their calculations in positive cases, leading to considerable delays in the commissioning of these advanced tools.
Researchers at the Centre Spatial de Liège (CSL), in collaboration with the University of Strasbourg, have just developed a revolutionary method for solving this problem by using a femto-second pulsed laser to send light beams to illuminate the telescope. "Stray light rays take (in the telescope) different optical paths from the rays that form the image," explains Lionel Clermont, an expert in space optical systems and stray light at CSL. Thanks to this, and using an ultra-fast detector (of the order of 10-9 seconds of resolution, i.e. a thousandth of a millionth of a second), we are measuring the image and the different stray light effects at different times. In addition to this decomposition, we can identify each of the contributors using their arrival times, which are directly related to the optical path, and thus know the origin of the problem." The CSL engineers have now demonstrated the effectiveness of this method in a paper, just published in the journal *Scientific Reports*, in which they present the first film showing ghost reflections in a refractive telescope arriving at different times. "We have also been able to use these measurements to reverse engineer theoretical models," says Lionel Clermont, "which will make it possible, for example, to build better image processing models in the future." By correlating these measurements with numerical models, the scientists will now be able to determine precisely the origin of the stray light and thus act accordingly to improve the system, both by improving the hardware and with the development of correction algorithms.
More than just a scientific curiosity, this method developed at the CSL could well lead to a small revolution in the field of high-performance space instruments. "We have already received a great deal of interest from the ESA (European Space Agency) and from industrialists in the space sector," says Marc

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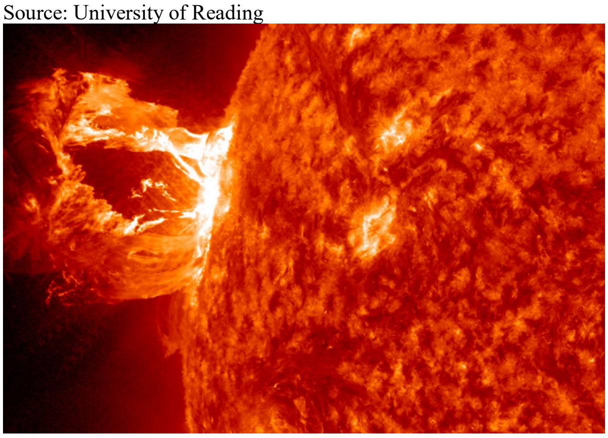
Georges, an expert in metrology and lasers at CSL and co-author of the study. This method responds to an urgent problem that has been unresolved until now." In the near future, CSL researchers intend to continue the development of this method, to increase its TRL (Technology Readiness Level) and bring it to an industrial level. An industrial application is already planned for the FLEX (Fluorescence Explorer) project, an earth observation telescope that is part of ESA's Living Planet Program. The researchers hope to be able to apply it to scientific instruments as well.

- Moon mission delays could increase risks from solar storms

Date: May 20, 2021
Source: University of Reading



Planned missions to return humans to the Moon need to hurry up to avoid hitting one of the busiest periods for extreme space weather, according to scientists conducting the most in-depth ever look at solar storm timing.
Scientists at the University of Reading studied 150 years of space weather data to investigate patterns in the timing of the most extreme events, which can be extremely dangerous to astronauts and satellites, and even disrupt power grids if they arrive at Earth.
The researchers found for the first time that extreme space weather events are more likely to occur early in even-numbered solar cycles, and late in odd-numbered cycles -- such as the one just starting. They are also more likely during busy periods of solar activity and in bigger cycles, mirroring the pattern for moderate space weather.
The findings could have implications for the NASA-led Artemis mission, which plans to return humans to the moon in 2024, but which could be delayed to the late 2020s.
Professor Mathew Owens, a space physicist at the University of Reading, said: "Until now, the most extreme space-weather events were thought to be random in their timing and thus little could be done to plan around them.
"However, this research suggests they are more predictable, generally following the same 'seasons' of activity as smaller space-weather events. But they also show some important differences during the most active season, which could help us avoid damaging space-weather effects.
"These new findings should allow us to make better space weather forecasts for the solar cycle that is just beginning and will run for the decade or so. It suggests any significant space missions in the years ahead -- including returning astronauts to the Moon and later, onto Mars -- will be less likely to encounter extreme space-weather events over the first half of the solar cycle than the second."
Extreme space weather is driven by huge eruptions of plasma from the Sun, called coronal mass ejections, arriving at Earth, causing a global geomagnetic disturbance.
Previous research has generally focused on how big extreme space weather events can be, based on observations of previous events. Predicting their timing is far more difficult because extreme events are rare, so there is relatively little historic data in which to identify patterns.
In the new study, the scientists used a new method applying statistical modelling to storm timing for the first time. They looked at data from the past 150 years -- the longest period of data available for this type of research -- recorded by ground-based instruments that measure magnetic fields in the Earth's atmosphere, located in the UK and Australia.
The Sun goes through regular 11-year cycles of its magnetic field, which is seen in the number of sunspots on its surface. During this cycle the Sun's magnetic north and south poles switch places. Each cycle includes a solar maximum period, where solar activity is at its greatest, and a quiet solar minimum phase.
Previous research has shown moderate space weather is more likely during the solar maximum than the period around the solar minimum, and more likely during cycles with a larger peak sunspot number. However, this is the first study that shows the same pattern is also true of extreme events.
The major finding, though, was that extreme space weather events are more likely to occur early in even-numbered solar cycles, and late in odd-numbered cycles, such as cycle 25, which began in December 2019.

The scientists believe this could be because of the orientation of the Sun's large-scale magnetic field, which flips at solar maximum so it is pointing opposite to Earth's magnetic field early in even cycles and late in odd cycles. This theory will need more investigation.
This new research on space weather timing allows predictions to be made for extreme space weather during solar cycle 25. It could therefore be used to plan the timing of activities that could be affected by extreme space weather, such as power grid maintenance on Earth, satellite operations, or major space missions.
The findings suggest that any major operations planned beyond the next five years will have to make allowances for the higher likelihood of severe space weather late in the current solar cycle between 2026 and 2030.
A major solar eruption in August 1972, between NASA's Apollo 16 and 17 missions, was strong enough that it could have caused major technical or health problems to astronauts had it occurred while they were en route or around the Moon.

- Icy clouds could have kept early Mars warm enough for rivers and lakes

Date: April 26, 2021
Source: University of Chicago

Mars (stock image; elements furnished by NASA).
Credit: © Artsiom P / stock.adobe.com

One of the great mysteries of modern space science is neatly summed up by the view from NASA's Perseverance, which just landed on Mars: Today it's a desert planet, and yet the rover is sitting right next to an ancient river delta.
The apparent contradiction has puzzled scientists for decades, especially because at the same time that Mars had flowing rivers, it was getting less than a third as much sunshine as we enjoy today on Earth.
But a new study led by University of Chicago planetary scientist Edwin Kite, an assistant professor of geophysical sciences and an expert on climates of other worlds, uses a computer model to put forth a promising explanation: Mars could have had a thin layer of icy, high-altitude clouds that caused a greenhouse effect.
"There's been an embarrassing disconnect between our evidence, and our ability to explain it in terms of physics and chemistry," said Kite. "This hypothesis goes a long way toward closing that gap."
Of the multiple explanation’s scientists had previously put forward, none have ever quite worked. For example, some suggested that a collision from a huge asteroid could have released enough kinetic energy to warm the planet. But other calculations showed this effect would only last for a year or two -- and the tracks of ancient rivers and lakes show that the warming likely persisted for at least hundreds of years.
Kite and his colleagues wanted to revisit an alternate explanation: High-altitude clouds, like cirrus on Earth. Even a small amount of clouds in the atmosphere can significantly raise a planet's temperature, a greenhouse effect similar to carbon dioxide in the atmosphere.
The idea had first been proposed in 2013, but it had largely been set aside because, Kite said, "It was argued that it would only work if the clouds had implausible properties." For example, the models suggested that water would have to linger for a long time in the atmosphere -- much longer than it typically does on Earth -- so the whole prospect seemed unlikely.
Using a 3D model of the entire planet's atmosphere, Kite and his team went to work. The missing piece, they found, was the amount of ice on the ground. If there was ice covering large portions of Mars, that would create surface humidity that favours low-altitude clouds, which aren't thought to warm planets very much (or can even cool them, because clouds reflect sunlight away from the planet.)
But if there are only patches of ice, such as at the poles and at the tops of mountains, the air on the ground becomes much drier. Those conditions favour a high layer of clouds -- clouds that tend to warm planets more easily.
The model results showed that scientists may have to discard some crucial assumptions based on our own particular planet.

"In the model, these clouds behave in a very un-Earth-like way," said Kite. "Building models on Earth-based intuition just won't work, because this is not at all similar to Earth's water cycle, which moves water quickly between the atmosphere and the surface."

Here on Earth, where water covers almost three-quarters of the surface, water moves quickly and unevenly between ocean and atmosphere and land -- moving in swirls and eddies that mean some places are mostly dry (the Sahara) and others are drenched (the Amazon). In contrast, even at the peak of its habitability, Mars had much less water on its surface. When water vapor winds up in the atmosphere, in Kite's model, it lingers.

"Our model suggests that once water moved into the early Martian atmosphere, it would stay there for quite a long time -- closer to a year -- and that creates the conditions for long-lived high-altitude clouds," said Kite.

NASA's newly landed Perseverance rover should be able to test this idea in multiple ways, too, such as by analysing pebbles to reconstruct past atmospheric pressure on Mars.

Understanding the full story of how Mars gained and lost its warmth and atmosphere can help inform the search for other habitable worlds, the scientists said.

"Mars is important because it's the only planet we know of that had the ability to support life -- and then lost it," Kite said. "Earth's long-term climate stability is remarkable. We want to understand all the ways in which a planet's long-term climate stability can break down -- and all of the ways (not just Earth's way) that it can be maintained. This quest defines the new field of comparative planetary habitability."

The co-authors on the paper were former UChicago postdoctoral researcher Liam Steele, now with the Jet Propulsion Laboratory; Michael Mischna of the Jet Propulsion Laboratory, and Mark Richardson of Aeolis Research. Parts of the analysis were performed at the University of Chicago Research Computing Centre.

- New evidence of how and when the Milky Way came together

Aging individual stars helped date an early merger event

Date: May 17, 2021
Source: Ohio State University

Spiral galaxy illustration (stock image).
Credit: © Alexandr Mitiuc / stock.adobe.com

New research provides the best evidence to date into the timing of how our early Milky Way came together, including the merger with a key satellite galaxy.

Using relatively new methods in astronomy, the researchers were able to identify the most precise ages currently possible for a sample of about a hundred red giant stars in the galaxy. With this and other data, the researchers were able to show what was happening when the Milky Way merged with an orbiting satellite galaxy, known as Gaia-Enceladus, about 10 billion years ago.

Their results were published today (May 17, 2021) in the journal *Nature Astronomy*.

"Our evidence suggests that when the merger occurred, the Milky Way had already formed a large population of its own stars," said Fiorenzo Vincenzo, co-author of the study and a fellow in The Ohio State University's Centre for Cosmology and Astroparticle Physics.

Many of those "homemade" stars ended up in the thick disc in the middle of the galaxy, while most that were captured from Gaia-Enceladus are in the outer halo of the galaxy.

"The merging event with Gaia-Enceladus is thought to be one of the most important in the Milky Way's history, shaping how we observe it today," said Josefina Montalban, with the School of Physics and Astronomy at the University of Birmingham in the U.K., who led the project.

By calculating the age of the stars, the researchers were able to determine, for the first time, that the stars captured from Gaia-Enceladus have similar or slightly younger ages compared to the majority of stars that were born inside the Milky Way.

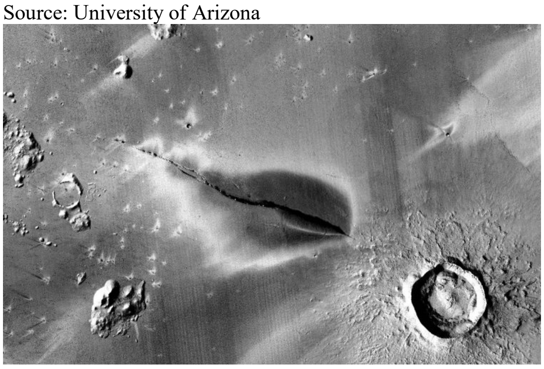
A violent merger between two galaxies can't help but shake things up, Vincenzo said. Results showed that the merger changed the orbits of the stars already in the galaxy, making them more eccentric.

Vincenzo compared the stars' movements to a dance, where the stars from the former Gaia-Enceladus move differently than those born

within the Milky Way. The stars even "dress" differently, Vincenzo said, with stars from outside showing different chemical compositions from those born inside the Milky Way.
The researchers used several different approaches and data sources to conduct their study.
One way the researchers were able to get such precise ages of the stars was through the use of asteroseismology, a relatively new field that probes the internal structure of stars.
Aster seismologists study oscillations in stars, which are sound waves that ripple through their interiors, said Mathieu Vrard, a postdoctoral research associate in Ohio State's Department of Astronomy.
"That allows us to get very precise ages for the stars, which are important in determining the chronology of when events happened in the early Milky Way," Vrard said.
The study also used a spectroscopic survey, called APOGEE, which provides the chemical composition of stars -- another aid in determining their ages.
"We have shown the great potential of asteroseismology, in combination with spectroscopy, to age-date individual stars," Montalban said.
This study is just the first step, according to the researchers.
"We now intend to apply this approach to larger samples of stars, and to include even more subtle features of the frequency spectra," Vincenzo said.
"This will eventually lead to a much sharper view of the Milky Way's assembly history and evolution, creating a timeline of how our galaxy developed."
The work is the result of the collaborative Aster chronometry project, funded by the European Research Council.

- ❖ Volcanoes on Mars could be active, raising possibility Mars was recently habitable

Date: May 10, 2021
Source: University of Arizona



Evidence of recent volcanic activity on Mars shows that eruptions could have taken place in the past 50,000 years, according to new study by researchers at the University of Arizona's Lunar and Planetary Laboratory and the Planetary Science Institute.
Most volcanism on the Red Planet occurred between 3 and 4 billion years ago, with smaller eruptions in isolated locations continuing perhaps as recently as 3 million years ago. But, until now, there was no evidence to indicate Mars could still be volcanically active.
Using data from satellites orbiting Mars, researchers discovered a previously unknown volcanic deposit. They detail their findings in the paper "Evidence for geologically recent explosive volcanism in Elysium Planitia, Mars," published in the journal *Icarus*.
"This may be the youngest volcanic deposit yet documented on Mars," said lead study author David Horvath, who did the research as a postdoctoral researcher at UArizona and is now a research scientist at the Planetary Science Institute. "If we were to compress Mars' geologic history into a single day, this would have occurred in the very last second."
The volcanic eruption produced an 8-mile-wide, smooth, dark deposit surrounding a 20-mile-long volcanic fissure.
"When we first noticed this deposit, we knew it was something special," said study co-author Jeff Andrews-Hanna, an associate professor at the UArizona Lunar and Planetary Laboratory and the senior author on the study. "The deposit was unlike anything else found in the region, or indeed on all of Mars, and more closely resembled features created by older volcanic eruptions on the Moon and Mercury."
Further investigation showed that the properties, composition and distribution of material match what would be expected for a pyroclastic eruption -- an explosive eruption of magma driven by expanding gasses, not unlike the opening of a shaken can of soda.
The majority of volcanism in the Elysium Planitia region and elsewhere on Mars consists of lava flowing across the surface, similar to recent eruptions in Iceland being studied by co-author Christopher Hamilton, a UArizona associate professor of lunar and planetary sciences. Although there are numerous examples of explosive volcanism on Mars, they occurred long ago. However, this deposit appears to be different.

"This feature overlies the surrounding lava flows and appears to be a relatively fresh and thin deposit of ash and rock, representing a different style of eruption than previously identified pyroclastic features," Horvath said. "This eruption could have spewed ash as high as 6 miles into Mars' atmosphere. It is possible that these sorts of deposits were more common but have been eroded or buried."
The site of the recent eruption is about 1,000 miles (1,600 kilometres) from NASA's InSight lander, which has been studying seismic activity on Mars since 2018. Two Mars quakes, the Martian equivalent of earthquakes, were found to originate in the region around the Cerberus Fossae, and recent work has suggested the possibility that these could be due to the movement of magma deep underground.
"The young age of this deposit absolutely raises the possibility that there could still be volcanic activity on Mars, and it is intriguing that recent Mars quakes detected by the InSight mission are sourced from the Cerberus Fossae," Horvath said. In fact, the team of researchers predicted this to be a likely location for Mars quakes several months before NASA's InSight lander touched down on Mars.
A volcanic deposit such as this one also raises the possibility for habitable conditions below the surface of Mars in recent history, Horvath said.
"The interaction of ascending magma and the icy substrate of this region could have provided favourable conditions for microbial life fairly recently and raises the possibility of extant life in this region," he said.
Similar volcanic fissures in this region were the source of enormous floods, perhaps as recently as 20 million years ago, as groundwater erupted out onto the surface.
Andrews-Hanna's research group continues to investigate the causes of the eruption.
Pranabendu Moitra, a research scientist in the UArizona Department of Geosciences, has been probing the mechanism behind the eruption.
An expert in similar explosive eruptions on Earth, Moitra developed models to look at the possible cause of the Martian eruption. In a forthcoming paper in the journal Earth and Planetary Science Letters, he suggests that the explosion either could have been a result of gases already present in the Martian magma, or it could have happened when the magma came into contact with Martian permafrost.
"The ice melts to water, mixes with the magma and vaporizes, forcing a violent explosion of the mixture," Moitra said. "When water mixes with magma, it's like pouring gasoline on a fire."
He also points out that the youngest volcanic eruption on Mars happened only 6 miles (10 kilometres) from the youngest large-impact crater on the planet -- a 6-mile-wide crater named Zunil.
"The ages of the eruption and the impact are indistinguishable, which raises the possibility, however speculative, that the impact actually triggered the volcanic eruption," Moitra said.
Several studies have found evidence that large quakes on Earth can cause magma stored beneath the surface to erupt. The impact that formed the Zunil crater on Mars would have shaken the Red Planet just like an earthquake, Moitra explained.
While the more dramatic giant volcanoes elsewhere on Mars -- such as Olympus Mons, the tallest mountain in the solar system -- tell a story of the planet's ancient dynamics, the current hotspot of Martian activity seems to be in the relatively featureless plains of the planet's Elysium region.
Andrews-Hanna said it's remarkable that one region hosts the epicentres of present-day earthquakes, the most recent floods of water, the most recent lava flows, and now an even more recent explosive volcanic eruption.
"This may be the most recent volcanic eruption on Mars," he said, "but I think we can rest assured that it won't be the last."
The volcanic deposit described in this study, along with ongoing seismic rumbling in the planet's interior detected by InSight and possible evidence for releases of methane plumes into the atmosphere detected by NASA's MAVEN orbiter, suggest that Mars is far from a cold, inactive world, Andrews-Hanna said.
"All these data seem to be telling the same story," he said. "Mars isn't dead."

- Alien radioactive element prompts creation rethink

Date: May 18, 2021
Source: Australian National University

The first-ever discovery of an extra-terrestrial radioactive isotope on Earth has scientists rethinking the origins of the elements on our planet.

The tiny traces of plutonium-244 were found in ocean crust alongside radioactive iron-60. The two isotopes are evidence of violent cosmic events in the vicinity of Earth millions of years ago.
Star explosions, or supernovae create many of the heavy elements in the periodic table, including those vital for human life, such as iron, potassium and iodine.
To form even heavier elements, such as gold, uranium and plutonium it was thought that a more violent event may be needed, such as two neutron stars merging.
However, a study led by Professor Anton Wallner from The Australian National University (ANU) suggests a more complex picture.
"The story is complicated -- possibly this plutonium-244 was produced in supernova explosions or it could be left over from a much older, but even more spectacular event such as a neutron star detonation," lead author of the study, Professor Wallner said.
Any plutonium-244 and iron-60 that existed when the Earth formed from interstellar gas and dust over four billion years ago has long since decayed, so current traces of them must have originated from recent cosmic events in space.
The dating of the sample confirms two or more supernova explosions occurred near Earth.
"Our data could be the first evidence that supernovae do indeed produce plutonium-244," Professor Wallner said
"Or perhaps it was already in the interstellar medium before the supernova went off, and it was pushed across the solar system together with the supernova ejecta."
Professor Wallner also holds joint positions at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and Technical University Dresden in Germany, and conducted this work with researchers from Australia, Israel, Japan, Switzerland and Germany.
The VEGA accelerator at Australian Nuclear Science and Technology Organisation, (ANSTO) in Sydney was used to identify the tiny traces of the plutonium-244.

- Stunning simulation of stars being born is most realistic ever

First high-resolution model to simulate an entire gas cloud where stars are born

Date: May 18, 2021
Source: Northwestern University

A team including Northwestern University astrophysicists has developed the most realistic, highest-resolution 3D simulation of star formation to date. The result is a visually stunning, mathematically-driven marvel that allows viewers to float around a colourful gas cloud in 3D space while watching twinkling stars emerge.
Called STARFORGE (Star Formation in Gaseous Environments), the computational framework is the first to simulate an entire gas cloud -- 100 times more massive than previously possible and full of vibrant colours -- where stars are born.
It also is the first simulation to simultaneously model star formation, evolution and dynamics while accounting for stellar feedback, including jets, radiation, wind and nearby supernovae activity. While other simulations have incorporated individual types of stellar feedback, STARFORGE puts them altogether to simulate how these various processes interact to affect star formation.
Using this beautiful virtual laboratory, the researchers aim to explore longstanding questions, including why star formation is slow and inefficient, what determines a star's mass and why stars tend to form in clusters.
The researchers have already used STARFORGE to discover that protostellar jets -- high-speed streams of gas that accompany star formation -- play a vital role in determining a star's mass. By calculating a star's exact mass, researchers can then determine its brightness and internal mechanisms as well as make better predictions about its death.
Newly accepted by the *Monthly Notices of the Royal Astronomical Society*, an advanced copy of the manuscript, detailing the research behind the new model, appeared online today. An accompanying paper, describing how jets influence star formation, was published in the same journal in February 2021.

"People have been simulating star formation for a couple decades now, but STARFORGE is a quantum leap in technology," said Northwestern's Michael Grudi?, who co-led the work. "Other models have only been able to simulate a tiny patch of the cloud where stars form -- not the entire cloud in high resolution. Without seeing the big picture, we miss a lot of factors that might influence the star's outcome."

"How stars form is very much a central question in astrophysics," said Northwestern's Claude-André Faucher-Giguère, a senior author on the study. "It's been a very challenging question to explore because of the range of physical processes involved. This new simulation will help us directly address fundamental questions we could not definitively answer before."

Grudi? is a postdoctoral fellow at Northwestern's Centre for Interdisciplinary Exploration and Research in Astrophysics (CIERA). Faucher-Giguère is an associate professor of physics and astronomy at Northwestern's Weinberg College of Arts and Sciences and member of CIERA. Grudi? co-led the work with Dávid Guszejnov, a postdoctoral fellow at the University of Texas at Austin.

From start to finish, star formation takes tens of millions of years. So even as astronomers observe the night sky to catch a glimpse of the process, they can only view a brief snapshot.

"When we observe stars forming in any given region, all we see are star formation sites frozen in time," Grudi? said. "Stars also form in clouds of dust, so they are mostly hidden."

For astrophysicists to view the full, dynamic process of star formation, they must rely on simulations. To develop STARFORGE, the team incorporated computational code for multiple phenomena in physics, including gas dynamics, magnetic fields, gravity, heating and cooling and stellar feedback processes.

Sometimes taking a full three months to run one simulation, the model requires one of the largest supercomputers in the world, a facility supported by the National Science Foundation and operated by the Texas Advanced Computing Centre.

The resulting simulation shows a mass of gas -- tens to millions of times the mass of the sun -- floating in the galaxy. As the gas cloud evolves, it forms structures that collapse and break into pieces, which eventually form individual stars. Once the stars form, they launch jets of gas outward from both poles, piercing through the surrounding cloud. The process ends when there is no gas left to form anymore stars.

Already, STARFORGE has helped the team discover a crucial new insight into star formation. When the researchers ran the simulation without accounting for jets, the stars ended up much too large -- 10 times the mass of the sun. After adding jets to the simulation, the stars' masses became much more realistic -- less than half the mass of the sun.

"Jets disrupt the inflow of gas toward the star," Grudi? said. "They essentially blow away gas that would have ended up in the star and increased its mass. People have suspected this might be happening, but, by simulating the entire system, we have a robust understanding of how it works."

Beyond understanding more about stars, Grudi? and Faucher-Giguère believe STARFORGE can help us learn more about the universe and even ourselves.

"Understanding galaxy formation hinges on assumptions about star formation," Grudi? said. "If we can understand star formation, then we can understand galaxy formation. And by understanding galaxy formation, we can understand more about what the universe is made of. Understanding where we come from and how we're situated in the universe ultimately hinges on understanding the origins of stars."

"Knowing the mass of a star tells us its brightness as well as what kinds of nuclear reactions are happening inside it," Faucher-Giguère said. "With that, we can learn more about the elements that are synthesized in stars, like carbon and oxygen -- elements that we are also made of."

Video:
https://www.youtube.com/watch?v=Aehqb-vDV_w

- New evidence of how and when the Milky Way came together

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Spiral galaxy illustration (stock image).
Credit: © Alexandr Mitiuc / stock.adobe.com

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Many of those "homemade" stars ended up in the thick disc in the middle of the galaxy, while most that were captured from Gaia-Enceladus are in the outer halo of the galaxy.
"The merging event with Gaia-Enceladus is thought to be one of the most important in the Milky Way's history, shaping how we observe it today," said Josefina Montalban, with the School of Physics and Astronomy at the University of Birmingham in the U.K., who led the project.
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- Supermassive black holes devour gas just like their petite counterparts

Regardless of size, all black holes experience similar accretion cycles, a new study finds
Date: May 17, 2021
Source: Massachusetts Institute of Technology

On Sept. 9, 2018, astronomers spotted a flash from a galaxy 860 million light years away. The source was a supermassive black hole about 50 million times the mass of the sun. Normally quiet, the gravitational giant suddenly awoke to devour a passing star in a rare instance known as a tidal disruption event. As the stellar debris fell toward the black hole, it released an enormous amount of energy in the form of light.

Researchers at MIT, the European Southern Observatory, and elsewhere used multiple telescopes to keep watch on the event, labelled AT2018fyk. To their surprise, they observed that as the supermassive black hole consumed the star, it exhibited properties that were similar to that of much smaller, stellar-mass black holes.

The results, published today in the *Astrophysical Journal,* suggest that accretion, or the way black holes evolve as they consume material, is independent of their size.

"We've demonstrated that, if you've seen one black hole, you've seen them all, in a sense," says study author Dheeraj "DJ" Pasham, a research scientist in MIT's Kavli Institute for Astrophysics and Space Research. "When you throw a ball of gas at them, they all seem to do more or less the same thing. They're the same beast in terms of their accretion."

Pasham's co-authors include principal research scientist Ronald Remillard and former graduate student Anirudh Chiti at MIT, along with researchers at the European Southern Observatory, Cambridge University, Leiden University, New York University, the University of Maryland, Curtin University, the University of Amsterdam, and the NASA Goddard Space Flight Centre.

A stellar wake-up

When small stellar-mass black holes with a mass about 10 times our sun emit a burst of light, it's often in response to an influx of material from a companion star. This outburst of radiation sets off a specific evolution of the region around the black hole. From quiescence, a black hole transitions into a "soft" phase dominated by an accretion disk as stellar material is pulled into the black hole. As the amount of material influx drops, it transitions again to a "hard" phase where a white-hot corona takes over. The black hole eventually settles back into a steady quiescence, and this entire accretion cycle can last a few weeks to months.

Physicists have observed this characteristic accretion cycle in multiple stellar-mass black holes for several decades. But for supermassive black holes, it was thought that this process would take too long to capture entirely, as these goliaths are normally grazers, feeding slowly on gas in the central regions of a galaxy.

"This process normally happens on timescales of thousands of years in supermassive black holes," Pasham says. "Humans cannot wait that long to capture something like this."

But this entire process speeds up when a black hole experiences a sudden, huge influx of material, such as during a tidal disruption event, when a star comes close enough that a black hole can tidally rip it to shreds.

"In a tidal disruption event, everything is abrupt," Pasham says. "You have a sudden chunk of gas being thrown at you, and the black hole is suddenly woken up, and it's like, 'whoa, there's so much food -- let me just eat, eat, eat until it's gone.' So, it experiences everything in a short time span. That allows us to probe all these different accretion stages that people have known in stellar-mass black holes."

A supermassive cycle

In September 2018, the All-Sky Automated Survey for Supernovae (ASASSN) picked up signals of a sudden flare. Scientists subsequently determined that the flare was the result of a tidal disruption event involving a supermassive black hole, which they labelled TDE AT2018fyk. Wevers, Pasham, and their colleagues jumped at the alert and were able to steer multiple telescopes, each trained to map different bands of the ultraviolet and X-ray spectrum, toward the system.

The team collected data over two years, using X-ray space telescopes XMM-Newton and the Chandra X-Ray Observatory, as well as NICER, the X-ray-monitoring instrument aboard the International Space Station, and the Swift Observatory, along with radio telescopes in Australia.

"We caught the black hole in the soft state with an accretion disk forming, and most of the emission in ultraviolet, with very few in the X-ray," Pasham says. "Then the disk collapses, the corona gets stronger, and now it's very bright in X-rays. Eventually there's not much gas to feed on, and the overall luminosity drops and goes back to undetectable levels."

The researchers estimate that the black hole tidally disrupted a star about the size of our sun. In the process, it generated an enormous accretion disk, about 12 billion kilometres wide, and emitted gas that they estimated to be about 40,000 Kelvin, or more than 70,000 degrees Fahrenheit. As the disk became weaker and less bright, a corona of compact, high-energy X-rays took over as the dominant phase around the black hole before eventually fading away.
"People have known this cycle to happen in stellar-mass black holes, which are only about 10 solar masses. Now we are seeing this in something 5 million times bigger," Pasham says.
"The most exciting prospect for the future is that such tidal disruption events provide a window into the formation of complex structures very close to the supermassive black hole such as the accretion disk and the corona," says lead author Thomas Wevers, a fellow at the European Southern Observatory. "Studying how these structures form and interact in the extreme environment following the destruction of a star, we can hopefully start to better understand the fundamental physical laws that govern their existence."
In addition to showing that black holes experience accretion in the same way, regardless of their size, the results represent only the second time that scientists have captured the formation of a corona from beginning to end.
"A corona is a very mysterious entity, and in the case of supermassive black holes, people have studied established coronas but don't know when or how they formed," Pasham says. "We've demonstrated you can use tidal disruption events to capture corona formation. I'm excited about using these events in the future to figure out what exactly is the corona."
This research was partially supported by the Australian Government through the Australian Research Council's Discovery Projects funding scheme.

- Charting the expansion history of the universe with supernovae

Date: May 14, 2021
Source: National Institutes of Natural Sciences

An international research team analysed a database of more than 1000 supernova explosions and found that models for the expansion of the Universe best match the data when a new time dependent variation is introduced. If proven correct with future, higher-quality data from the Subaru Telescope and other observatories, these results could indicate still unknown physics working on the cosmic scale.
Edwin Hubble's observations over 90 years ago showing the expansion of the Universe remain a cornerstone of modern astrophysics. But when you get into the details of calculating how fast the Universe was expanding at different times in its history, scientists have difficulty getting theoretical models to match observations.
To solve this problem, a team led by Maria Dainotti (Assistant Professor at the National Astronomical Observatory of Japan and the Graduate University for Advanced Studies, SOKENDAI in Japan and an affiliated scientist at the Space Science Institute in the U.S.A.) analysed a catalogue of 1048 supernovae which exploded at different times in the history of the Universe. The team found that the theoretical models can be made to match the observations if one of the constants used in the equations, appropriately called the Hubble constant, is allowed to vary with time.
There are several possible explanations for this apparent change in the Hubble constant. A likely but boring possibility is that observational biases exist in the data sample. To help correct for potential biases, astronomers are using Hyper Suprime-Cam on the Subaru Telescope to observe fainter supernovae over a wide area. Data from this instrument will increase the sample of observed supernovae in the early Universe and reduce the uncertainty in the data.
But if the current results hold-up under further investigation, if the Hubble constant is in fact changing, that opens the question of what is driving the change. Answering that question could require a new, or at least modified, version of astrophysics.

- Hubble tracks down fast radio bursts to galaxies' spiral arms

Date: May 20, 2021
Source: NASA/Goddard Space Flight Centre

Astronomers using NASA's Hubble Space Telescope have traced the locations of five brief, powerful radio blasts to the spiral arms of five distant galaxies.
Called fast radio bursts (FRBs), these extraordinary events generate as much energy in a thousandth of a second as the Sun does in a year. Because these transient radio pulses disappear in much less than the blink of an eye, researchers have had a hard time tracking down where they come from, much less determining what kind of object or objects is causing them. Therefore, most of the time, astronomers don't know exactly where to look.
Locating where these blasts are coming from, and in particular, what galaxies they originate from, is important in determining what kinds of astronomical events trigger such intense flashes of energy. The new Hubble survey of eight FRBs helps researchers narrow the list of possible FRB sources.

Flash in the Night

The first FRB was discovered in archived data recorded by the Parkes radio observatory on July 24, 2001. Since then astronomers have uncovered up to 1,000 FRBs, but they have only been able to associate roughly 15 of them to particular galaxies.
"Our results are new and exciting. This is the first high-resolution view of a population of FRBs, and Hubble reveals that five of them are localized near or on a galaxy's spiral arms," said Alexandra Mannings of the University of California, Santa Cruz, the study's lead author. "Most of the galaxies are massive, relatively young, and still forming stars. The imaging allows us to get a better idea of the overall host-galaxy properties, such as its mass and star-formation rate, as well as probe what's happening right at the FRB position because Hubble has such great resolution."
In the Hubble study, astronomers not only pinned all of them to host galaxies, but they also identified the kinds of locations they originated from. Hubble observed one of the FRB locations in 2017 and the other seven in 2019 and 2020.
"We don't know what causes FRBs, so it's really important to use context when we have it," said team member Wen-fai Fong of Northwestern University in Evanston, Illinois. "This technique has worked very well for identifying the progenitors of other types of transients, such as supernovae and gamma-ray bursts. Hubble played a big role in those studies, too."
The galaxies in the Hubble study existed billions of years ago. Astronomers, therefore, are seeing the galaxies as they appeared when the universe was about half its current age. Many of them are as massive as our Milky Way. The observations were made in ultraviolet and near-infrared light with Hubble's Wide Field Camera 3.
Ultraviolet light traces the glow of young stars strung along a spiral galaxy's winding arms. The researchers used the near-infrared images to calculate the galaxies' mass and find where older populations of stars reside.

Location, Location, Location

The images display a diversity of spiral-arm structure, from tightly wound to more diffuse, revealing how the stars are distributed along these prominent features. A galaxy's spiral arms trace the distribution of young, massive stars. However, the Hubble images reveal that the FRBs found near the spiral arms do not come from the very brightest regions, which blaze with the light from hefty stars. The images help support a picture that the FRBs likely do not originate from the youngest, most massive stars.
These clues helped the researchers rule out some of the possible triggers of types of these brilliant flares, including the explosive deaths of the youngest, most massive stars, which generate gamma-ray bursts and some types of supernovae. Another unlikely source is the merger of neutron stars, the crushed cores of stars that end their lives in supernova explosions. These mergers take billions of years to occur and are usually found far from the spiral arms of older galaxies that are no longer forming stars.

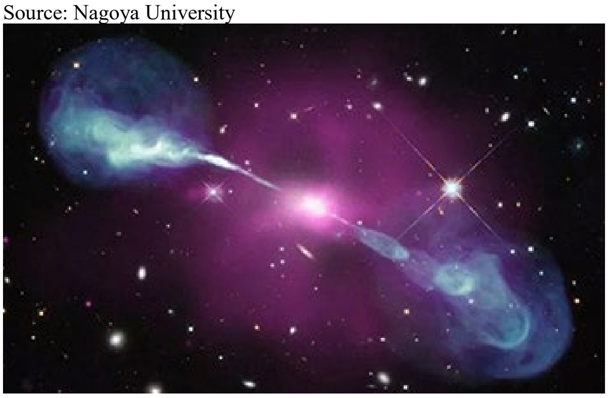
Magnetic Monsters

The team's Hubble results, however, are consistent with the leading model that FRBs originate from young magnetar outbursts. Magnetars are a type of neutron star with powerful magnetic fields. They're called the strongest magnets in the universe, possessing a magnetic field that is 10 trillion times more powerful than a refrigerator door magnet. Astronomers last year linked observations of an FRB spotted in our Milky Way galaxy with a region where a known magnetar resides.
"Owing to their strong magnetic fields, magnetars are quite unpredictable," Fong explained. "In this case, the FRBs are thought to come from flares from a young magnetar.

Massive stars go through stellar evolution and becomes neutron stars, some of which can be strongly magnetized, leading to flares and magnetic processes on their surfaces, which can emit radio light. Our study fits in with that picture and rules out either very young or very old progenitors for FRBs."
The observations also helped the researchers strengthen the association of FRBs with massive, star-forming galaxies. Previous ground-based observations of some possible FRB host galaxies did not as clearly detect underlying structure, such as spiral arms, in many of them. Astronomers, therefore, could not rule out the possibility that FRBs originate from a dwarf galaxy hiding underneath a massive one. In the new Hubble study, careful image processing and analysis of the images allowed researchers to rule out underlying dwarf galaxies, according to co-author Sunil Simha of the University of California, Santa Cruz.
Although the Hubble results are exciting, the researchers say they need more observations to develop a more definitive picture of these enigmatic flashes and better pinpoint their source. "This is such a new and exciting field," Fong said. "Finding these localized events is a major piece to the puzzle, and a very unique puzzle piece compared to what's been done before. This is a unique contribution of Hubble."
Video:
https://www.youtube.com/watch?v=Fj44JQvE4E0&t=2s

- Plasma jets reveal magnetic fields far, far away

Radio telescope images enable a new way to study magnetic fields in galaxy clusters millions of light years away
Date: May 24, 2021
Source: Nagoya University

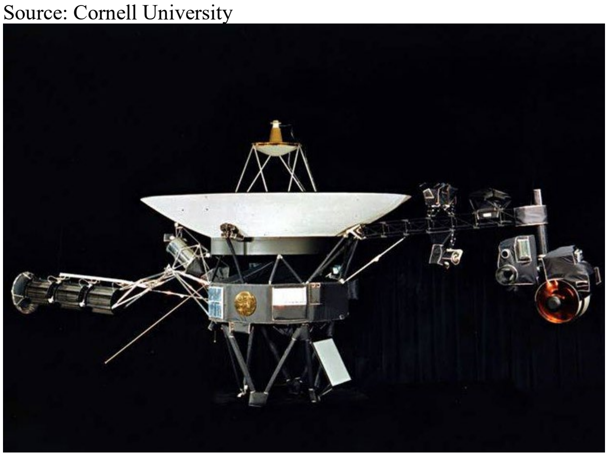


For the first time, researchers have observed plasma jets interacting with magnetic fields in a massive galaxy cluster 600 million light years away, thanks to the help of radio telescopes and supercomputer simulations. The findings, published in the journal *Nature*, can help clarify how such galaxy clusters evolve.
Galaxy clusters can contain up to thousands of galaxies bound together by gravity. Abell 3376 is a huge cluster forming as a result of a violent collision between two sub-clusters of galaxies. Very little is known about the magnetic fields that exist within this and similar galaxy clusters.
"It is generally difficult to directly examine the structure of intracluster magnetic fields," says Nagoya University astrophysicist Tsutomu Takeuchi, who was involved in the research. "Our results clearly demonstrate how long-wavelength radio observations can help explore this interaction."
An international team of scientists have been using the MeerKAT radio telescope in the Northern Cape of South Africa to learn more about Abell 3376's huge magnetic fields. One of the telescope's very high-resolution images revealed something unexpected: plasma jets emitted by a supermassive black hole in the cluster bend to form a unique T-shape as they extend outwards for distances as far as 326,156 light years away. The black hole is in galaxy MRC 0600-399, which is near the centre of Abell 3376.
The team combined their MeerKAT radio telescope data with X-ray data from the European Space Agency's space telescope XXM-Newton to find that the plasma jet bend occurs at the boundary of the sub cluster in which MRC 0600-399 exists.
"This told us that the plasma jets from MRC 0600-399 were interacting with something in the heated gas, called the intracluster medium, that exists between the galaxies within Abell 3376," explains Takeuchi.
To figure out what was happening, the team conducted 3D 'magnetohydrodynamic' simulations using the world's most powerful supercomputer in the field of astronomical calculations, ATERUI II, located at the National Astronomical Observatory of Japan. The simulations showed that the jet streams emitted by MRC 0600-399's black hole eventually reach and interact with magnetic fields at the border of the galaxy sub cluster. The jet stream compresses the magnetic field lines and moves along them, forming the characteristic T-shape.

"This is the first discovery of an interaction between cluster galaxy plasma jets and intracluster magnetic fields," says Takeuchi. An international team has just begun construction of what is planned to be the world's largest radio telescope, called the Square Kilometre Array (SKA).
"New facilities like the SKA are expected to reveal the roles and origins of cosmic magnetism and even to help us understand how the universe evolved," says Takeuchi. "Our study is a good example of the power of radio observation, one of the last frontiers in astronomy."

- In the emptiness of space, Voyager I detects plasma 'hum'

Date: May 10, 2021
Source: Cornell University



Voyager 1 -- one of two sibling NASA spacecraft launched 44 years ago and now the most distant human-made object in space -- still works and zooms toward infinity.

The craft has long since zipped past the edge of the solar system through the heliopause -- the solar system's border with interstellar space -- into the interstellar medium. Now, its instruments have detected the constant drone of interstellar gas (plasma waves), according to Cornell University-led research published in *Nature Astronomy*.

Examining data slowly sent back from more than 14 billion miles away, Stella Koch Ocker, a Cornell doctoral student in astronomy, has uncovered the emission. "It's very faint and monotone, because it is in a narrow frequency bandwidth," Ocker said. "We're detecting the faint, persistent hum of interstellar gas."

This work allows scientists to understand how the interstellar medium interacts with the solar wind, Ocker said, and how the protective bubble of the solar system's heliosphere is shaped and modified by the interstellar environment.

Launched in September 1977, the Voyager 1 spacecraft flew by Jupiter in 1979 and then Saturn in late 1980. Travelling at about 38,000 mph, Voyager 1 crossed the heliopause in August 2012.

After entering interstellar space, the spacecraft's Plasma Wave System detected perturbations in the gas. But, in between those eruptions -- caused by our own roiling sun -- researchers have uncovered a steady, persistent signature produced by the tenuous near-vacuum of space.

"The interstellar medium is like a quiet or gentle rain," said senior author James Cordes, the George Feldstein Professor of Astronomy. "In the case of a solar outburst, it's like detecting a lightning burst in a thunderstorm and then it's back to a gentle rain."

Ocker believes there is more low-level activity in the interstellar gas than scientists had previously thought, which allows researchers to track the spatial distribution of plasma -- that is, when it's not being perturbed by solar flares.

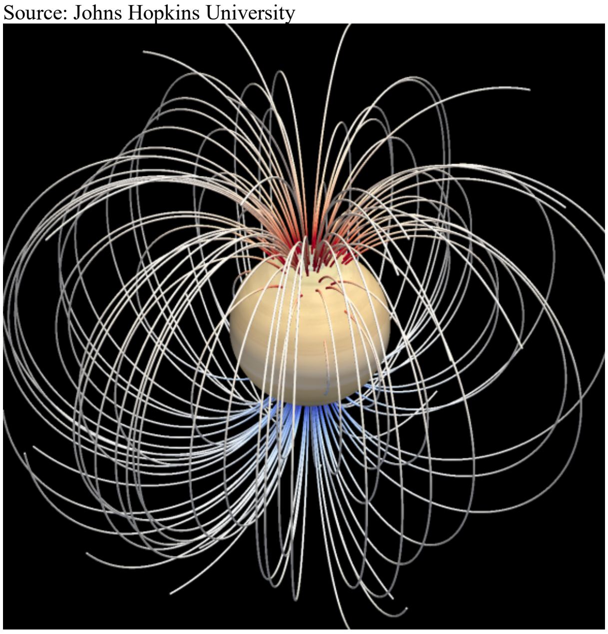
Cornell research scientist Shami Chatterjee explained how continuous tracking of the density of interstellar space is important. "We've never had a chance to evaluate it. Now we know we don't need a fortuitous event related to the sun to measure interstellar plasma," Chatterjee said. "Regardless of what the sun is doing, Voyager is sending back detail. The craft is saying, 'Here's the density I'm swimming through right now. And here it is now. And here it is now. And here it is now.' Voyager is quite distant and will be doing this continuously."

Voyager 1 left Earth carrying a Golden Record created by a committee chaired by the late Cornell professor Carl Sagan, as well as mid-1970s technology. To send a signal to Earth, it took 22 watts, according to NASA's Jet Propulsion Laboratory. The craft has almost 70 kilobytes of computer memory and -- at the beginning of the mission -- a data rate of 21 kilobits per second.

Due to the 14-billion-mile distance, the communication rate has since slowed to 160-bits-per-second, or about half a 300-baud rate.

- Scientists model Saturn's interior, explain planet's unique magnetic field

Date: May 5, 2021
Source: Johns Hopkins University



New Johns Hopkins University simulations offer an intriguing look into Saturn's interior, suggesting that a thick layer of helium rain influences the planet's magnetic field.
The models, published this week in *AGU Advances*, also indicate that Saturn's interior may feature higher temperatures at the equatorial region, with lower temperatures at the high latitudes at the top of the helium rain layer.
It is notoriously difficult to study the interior structures of large gaseous planets, and the findings advance the effort to map Saturn's hidden regions.
"By studying how Saturn formed and how it evolved over time, we can learn a lot about the formation of other planets similar to Saturn within our own solar system, as well as beyond it," said co-author Sabine Stanley, a Johns Hopkins planetary physicist.
Saturn stands out among the planets in our solar system because its magnetic field appears to be almost perfectly symmetrical around the rotation axis. Detailed measurements of the magnetic field gleaned from the last orbits of NASA's Cassini mission provide an opportunity to better understand the planet's deep interior, where the magnetic field is generated, said lead author Chi Yan, a Johns Hopkins PhD candidate.
By feeding data gathered by the Cassini mission into powerful computer simulations similar to those used to study weather and climate, Yan and Stanley explored what ingredients are necessary to produce the dynamo -- the electromagnetic conversion mechanism -- that could account for Saturn's magnetic field.
"One thing we discovered was how sensitive the model was to very specific things like temperature," said Stanley, who is also a Bloomberg Distinguished Professor at Johns Hopkins in the Department of Earth & Planetary Sciences and the Space Exploration Sector of the Applied Physics Lab. "And that means we have a really interesting probe of Saturn's deep interior as far as 20,000 kilometres down. It's a kind of X-ray vision."
Strikingly, Yan and Stanley's simulations suggest that a slight degree of non-axisymmetry could actually exist near Saturn's north and south poles.
"Even though the observations we have from Saturn look perfectly symmetrical, in our computer simulations we can fully interrogate the field," said Stanley.
Direct observation at the poles would be necessary to confirm it, but the finding could have implications for understanding another problem that has vexed scientists for decades: how to measure the rate at which Saturn rotates, or, in other words, the length of a day on the planet.
This project was conducted using computational resources at the Maryland Advanced Research Computing Centre (MARCC).

- A new window to see hidden side of magnetized universe

Date: May 5, 2021
Source: National Institutes of Natural Sciences

New observations and simulations show that jets of high-energy particles emitted from the central massive black hole in the brightest galaxy in galaxy clusters can be used to map the structure of invisible inter-cluster magnetic fields. These findings provide astronomers with a new tool for investigating previously unexplored aspects of clusters of galaxies.
As clusters of galaxies grow through collisions with surrounding matter, they create bow shocks and wakes in their dilute plasma. The plasma motion induced by these activities can drape intra-cluster magnetic layers, forming virtual walls of magnetic force. These magnetic layers, however, can only be observed indirectly when something interacts with them. Because it is simply difficult to

identify such interactions, the nature of intra-cluster magnetic fields remains poorly understood. A new approach to map/characterize magnetic layers is highly desired.
An international team of astronomers including Haruka Sakemi, a graduate student at Kyushu University (now a research fellow at the National Astronomical Observatory of Japan -- NAOJ), used the MeerKAT radio telescope located in the Northern Karoo desert of South Africa to observe a bright galaxy in the merging galaxy cluster Abell 3376 known as MRC 0600-399. Located more than 600 million light-years away in the direction of the constellation Columba, MRC 0600-399 is known to have unusual jet structures bent to 90-degree angles. Previous X-ray observations revealed that MRC 0600-399 is the core of a sub-cluster penetrating the main cluster of galaxies, indicating the presence of strong magnetic layers at the boundary between the main and sub-clusters. These features make MRC 0600-399 an ideal laboratory to investigate interactions between jets and strong magnetic layers.
The MeerKAT observations revealed unprecedented details of the jets, most strikingly, faint "double-scythe" structure extending in the opposite direction from the bend points and creating a "T" shape. These new details show that, like a stream of water hitting a pane of glass, this is a very chaotic collision. Dedicated computer simulations are required to explain the observed jet morphology and possible magnetic field configurations.
Takumi Ohmura, a graduate student at Kyushu University (now a research fellow at the University of Tokyo's Institute for Cosmic-Ray Research -- ICRR), from the team performed simulations on NAOJ's supercomputer ATERUI II, the most powerful computer in the world dedicated to astronomical calculations. The simulations assumed an arch-like strong magnetic field, neglecting messy details like turbulence and the motion of the galaxy. This simple model provides a good match to the observations, indicating that the magnetic pattern used in the simulation reflects the actual magnetic field intensity and structure around MRC 0600-399. More importantly, it demonstrates that the simulations can successfully represent the underlying physics so that they can be used on other objects to characterize more complex magnetic field structures in clusters of galaxies. This provides astronomers with a new way to understand the magnetized Universe and a tool to analyse the higher-quality data from future radio observatories like the SKA (the Square Kilometre Array).
Video: https://www.youtube.com/watch?v=-l9nMMDUncE

- Hubble watches how a giant planet grows

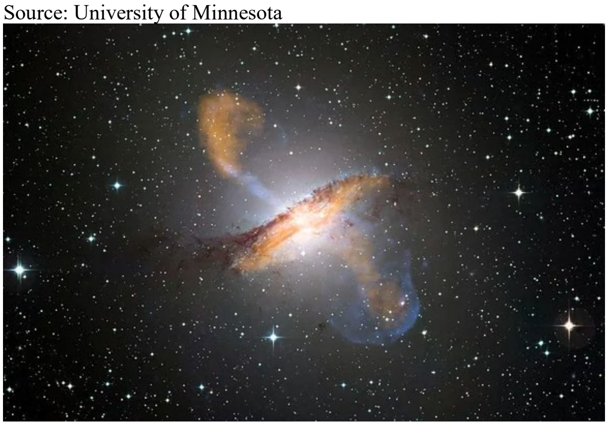
Date: April 29, 2021
Source: NASA/Goddard Space Flight Centre

NASA's Hubble Space Telescope is giving astronomers a rare look at a Jupiter-sized, still-forming planet that is feeding off material surrounding a young star.
"We just don't know very much about how giant planets grow," said Brendan Bowler of the University of Texas at Austin. "This planetary system gives us the first opportunity to witness material falling onto a planet. Our results open up a new area for this research."
Though over 4,000 exoplanets have been catalogued so far, only about 15 have been directly imaged to date by telescopes. And the planets are so far away and small, they are simply dots in the best photos. The team's fresh technique for using Hubble to directly image this planet paves a new route for further exoplanet research, especially during a planet's formative years.
This huge exoplanet, designated PDS 70b, orbits the orange dwarf star PDS 70, which is already known to have two actively forming planets inside a huge disk of dust and gas encircling the star. The system is located 370 light-years from Earth in the constellation Centaurus.
"This system is so exciting because we can witness the formation of a planet," said Yifan Zhou, also of the University of Texas at Austin. "This is the youngest bona fide planet Hubble has ever directly imaged." At a youthful five million years, the planet is still gathering material and building up mass.
Hubble's ultraviolet light (UV) sensitivity offers a unique look at radiation from extremely hot gas falling onto the planet.
"Hubble's observations allowed us to estimate how fast the planet is gaining mass," added Zhou.
The UV observations, which add to the body of research about this planet, allowed the team to directly measure the planet's mass growth rate for the first time. The remote world has already bulked up to five times the mass of

Jupiter over a period of about five million years. The present measured accretion rate has dwindled to the point where, if the rate remained steady for another million years, the planet would only increase by approximately an additional 1/100th of a Jupiter-mass.
Zhou and Bowler emphasize that these observations are a single snapshot in time -- more data are required to determine if the rate at which the planet is adding mass is increasing or decreasing. "Our measurements suggest that the planet is in the tail end of its formation process."
The youthful PDS 70 system is filled with a primordial gas-and-dust disk that provides fuel to feed the growth of planets throughout the entire system. The planet PDS 70b is encircled by its own gas-and-dust disk that's siphoning material from the vastly larger circumstellar disk. The researchers hypothesize that magnetic field lines extend from its circumplanetary disk down to the exoplanet's atmosphere and are funnelling material onto the planet's surface.
"If this material follows columns from the disk onto the planet, it would cause local hot spots," Zhou explained. "These hot spots could be at least 10 times hotter than the temperature of the planet." These hot patches were found to glow fiercely in UV light.
These observations offer insights into how gas giant planets formed around our Sun 4.6 billion years ago. Jupiter may have bulked up on a surrounding disk of infalling material. Its major moons would have also formed from leftovers in that disk.
A challenge to the team was overcoming the glare of the parent star. PDS 70b orbits at approximately the same distance as Uranus does from the Sun, but its star is more than 3,000 times brighter than the planet at UV wavelengths. As Zhou processed the images, he very carefully removed the star's glare to leave behind only light emitted by the planet. In doing so, he improved the limit of how close a planet can be to its star in Hubble observations by a factor of five.
"Thirty-one years after launch, we're still finding new ways to use Hubble," Bowler added. "Yifan's observing strategy and post-processing technique will open new windows into studying similar systems, or even the same system, repeatedly with Hubble. With future observations, we could potentially discover when the majority of the gas and dust falls onto their planets and if it does so at a constant rate."
The researchers' results were published in April 2021 in *The Astronomical Journal*.

- Small galaxies likely played important role in evolution of the Universe

Researchers find first-ever galaxy observed in a 'blow-away' state
Date: April 30, 2021
Source: University of Minnesota



A new study led by University of Minnesota astrophysicists shows that high-energy light from small galaxies may have played a key role in the early evolution of the Universe. The research gives insight into how the Universe became reionized, a problem that astronomers have been trying to solve for years.
The research is published in *The Astrophysical Journal*, a peer-reviewed scientific journal of astrophysics and astronomy.
After the Big Bang, when the Universe was formed billions of years ago, it was in an ionized state. This means that the electrons and protons floated freely throughout space. As the Universe expanded and started cooling down, it changed to a neutral state when the protons and electrons combined into atoms, akin to water vapor condensing into a cloud. Now however, scientists have observed that the Universe is back in an ionized state. A major endeavour in astronomy is figuring out how this happened. Astronomers have theorized that the energy for reionization must have come from galaxies themselves. But, it's incredibly hard for enough high energy light to escape a galaxy due to hydrogen clouds within it that absorb the light, much like clouds in the Earth's atmosphere absorb sunlight on an overcast day.
Astrophysicists from the Minnesota Institute for Astrophysics in the University of Minnesota's College of Science and Engineering may have found the answer to that problem. Using data from the Gemini telescope, the researchers have observed the

first ever galaxy in a "blow-away" state, meaning that the hydrogen clouds have been removed, allowing the high energy light to escape. The scientists suspect that the blow-away was caused by many supernovas, or dying stars, exploding in a short period of time.

"The star-formation can be thought of as blowing up the balloon," explained Nathan Eggen, the paper's lead author who recently received his master's degree in astrophysics from the University of Minnesota. "If, however, the star-formation was more intense, then there would be a rupture or hole made in the surface of the balloon to let out some of that energy. In the case of this galaxy, the star-formation was so powerful that the balloon was torn to pieces, completely blown-away."

The galaxy, named Pox 186, is so small that it could fit inside the Milky Way. The researchers suspect that its compact size, coupled with its large population of stars -- which amount to a hundred thousand times the mass of the sun -- made the blow-away possible.

The findings confirm that a blow-away is possible, furthering the idea that small galaxies were primarily responsible for the reionization of the Universe and giving more insight into how the Universe became what it is today.

"There are a lot of scenarios in science where you theorize that something should be the case, and you don't actually find it," Eggen said. "So, getting the observational confirmation that this sort of thing can happen is really important. If this one scenario is possible, then that means that there are other galaxies that also existed in blow-away states in the past. Understanding the consequences of this blow-away gives direct insight into the impacts similar blow-away would have had during the process of reionization."