`"The Southern Cross"

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HERMANUS ASTRONOMY CENTRE NEWSLETTER

JULY 2020

Monthly meeting There will be no meeting in July, due to the coronavirus pandemic. However, the committee is working towards offering Zoom presentations from August.

2020 meeting dates For your diaries. Remaining meeting dates are: 17 August, 21 September, 19 October and 16 November.

WHAT'S UP?

Celestial trio To the East, from 4 – 6 July, the Moon joins Jupiter and Saturn in a dance in and around Sagittarius. Jupiter is the third brightest object in the night sky after the Moon and Venus. It is also the largest of the planets, which a diameter of 143,000km. Although Saturn is not much smaller than Jupiter, with a diameter of 120,500km, it is much further away from Earth (1,277,127 v 628,514 million km) and appears much smaller. Both the planets are gas giants and both rotate very quickly: Jovian and Saturnian days last about 10 hours. With binoculars, it is possible to observe Jupiter's Galilean moons (up to 4, depending on their positions) and Saturn's largest moon, Titan. Titan is located much further away from its planet than the Galilean moons are from Jupiter. With a diameter of 5,150km, it is the second largest moon in the Solar System after Ganymede (one of the Galilean moons). Saturn's rings may make the planet appear elongated.

LAST MONTH'S ACTIVITIES

Monthly centre meeting No meeting took place in June, due to the coronavirus pandemic.

Interest groups

Cosmology No meeting took place in June, due to the coronavirus pandemic.

Astro-photography No meeting took place in June, due to the coronavirus pandemic.

Other activities

Educational outreach

Analemmatic sundials at schools When possible, work will continue on these at several Overstrand schools.

THIS MONTH'S ACTIVITIES

Monthly centre meeting The presentation scheduled for 20 July has been cancelled, due to the coronavirus pandemic.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. There will be no meeting in July, due to the coronavirus pandemic.

There is an entrance fee of R10 per person for members, R25 per person for non-members, and R10 for children, students and U3A members. For further information on these meetings, or any of the group's activities, please contact Derek Duckitt at derek.duckitt@gmail.com

Astro-photography This group meets on the second Monday of each month. There will be no meeting in July, due to the coronavirus pandemic.

To find out more about the group's activities and the venue for particular meetings, please contact Deon Krige at astronomy.hermanus@gmail.com

Hermanus Youth Robotic Telescope Interest Group There is no update.

For further information, please contact Deon Krige at deonk@telkomsa.net

Other activities

Stargazing No events will take place during the coronavirus pandemic.

FUTURE TRIPS

No outings are being planned, at present.

2019 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month at the **Catholic Church Hall**, beginning at **19.00**. Details for the first part of the year are:

17 Aug	'Further unusual curvaceous geographical wonders of Earth." Presenter: Jenny Morris, Centre member
21 Sept	Topic: TBA. Presenter: Eddy Nijeboer, Cape Centre, CT
19 Oct	'Cosmic ray astronomy.' Presenter: Dr Pieter Kotze, SANSA
16 Nov	'1820 and all that: Establishment of the observatory, and scientific connections with the Cape' Presenter: Jenny Morris, Centre member

ASTRONOMY SELF-GUIDED EDUCATION CENTRE (ASEC)

Work continues on planning and administrative requirements for work to begin on the proposed Astronomy Self-guided Education Centre, to be located within the existing whale-watching area at Gearing's Point.

The **Friends of the Observatory campaign** was launched several years ago when preliminary work began on plans to construct an astronomical observatory in Hermanus. Over the years, members have been very generous, for which we are deeply grateful. It may seem logical to assume that, now money has been awarded by the National Lotteries Board, pledge monies are no longer needed. Unfortunately, that is not the case. NLC funds can only be used once the plans have been formally approved by the Municipality.

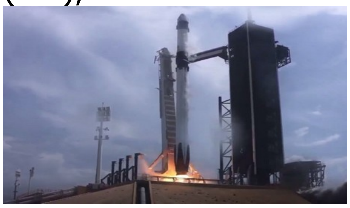
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer, The Standard Bank details are as follows:

Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

If you make an online donation, please include the word 'pledge', and your name, unless you wish to remain anonymous.

ASTRONOMY NEWS\

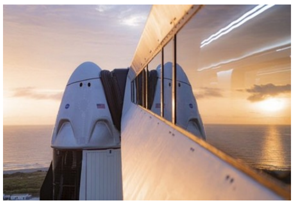
In historic first, SpaceX's Crew Dragon successfully delivers NASA astronauts to the space station 31 May: Elon Musk's rocket company, SpaceX, made history on Saturday 30 May when its Crew Dragon capsule safely reached space carrying two NASA astronauts. It was the first time a private company put a human into orbit. On Sunday, 31 May, Crew Dragon went on to successfully dock with the International Space Station (ISS), which the astronauts are now safely aboard.


Falcon 9 launches carrying the Crew Dragon into orbit on May 30, 2020. NASA

The historic launch marks the first time that NASA astronauts have blasted off from American soil since the Space Shuttle Program ended in 2011. That final flight of space shuttle Atlantis was piloted by astronaut Doug Hurley, who commanded Saturday's Crew Dragon Demo-2 mission. He was accompanied by fellow astronaut Robert Behnken. The two will now spend a yet-to-be-determined amount of time onboard the ISS.

For nearly a decade, NASA has bought seats on Russian Soyuz spacecraft to reach the International Space Station, which was built with roughly $200 billion of US taxpayer's money, according to some estimates. To celebrate the return of crewed US launches, the space agency promoted Saturday's event as 'Launch America'. "This is a unique opportunity to bring all of America together in one moment in time and say look at how bright the future is. That's what this launch is all about," NASA administrator Jim Bridenstine said. Roughly 10 million people watched Crew Dragon's launch online and on television, as the event was livestreamed and carried by all the major TV news networks. In 2019, over 100,000 people had travelled to Cape Canaveral in Florida for the prior, uncrewed demonstration flight. The crowds at the Kennedy Space Center on Saturday were significantly smaller this time around as a result of social distancing restrictions in place due to the COVID-19 pandemic. Nonetheless, a palpable silence, followed by raucous cheers, rang out at Launch Pad 39A as the astronauts reached orbit. The same launch site was used to vault the Apollo missions to the moon and space shuttle flights into orbit.

As Crew Dragon continued off into orbit, the rocket boosters from the Falcon 9 launch vehicle landed safely nearby and were retrieved for use in future missions. That re-usability has proven to be the key feature that makes SpaceX's technology cheaper than anything that's come before it. "We're bringing America back, as it relates to human spaceflight," Bridenstine said. "There was a day when there was grass growing out of the runways [at Kennedy Space Center]. But now we not only have the policy directive from the administration, we also have the budgets to match that policy directive to put America preeminent in space."


Crew Dragon set for launch on 30 May 2020. SpaceX

After successfully docking with the ISS on Sunday, the crew are now aboard the orbiting research laboratory. However, it is not clear exactly when Behnken and Hurley will return to Earth. NASA plans to make that call after the two arrive on station and can evaluate their next opportunities to put astronauts on ISS. The return trip will also be a pivotal test for Crew Dragon, as the capsule must survive being superheated by Earth's atmosphere before decreasing its re-entry speed even further using a collection of parachutes. If the mission finishes successfully, it will complete SpaceX's validation to fly crewed missions to orbit - another first for a private company. It should also allow the company to start flying tourists into orbit in the not-too-distant future.

While this was the first time a private company successfully launched a human into orbit, another American company beat them in being the first to send an astronaut into space. Back in 2004, aerospace engineer Burt Rutan's SpaceShipOne flew a suborbital trip, crossing the accepted boundary of space called the Karman line - which is at an altitude of 160 km - and winning the $10 million Anasari XPRIZE. The space plane's next-generation model, SpaceShipTwo, now operated by Virgin Galactic, also sent two commercial astronauts just beyond the edge of space in 2018.

SpaceX's path to this success was marked by extreme highs and lows. Musk founded the company in 2002 on the dream of affordable spaceflight, primarily Mars travel. By 2006, after a number of delays, they attempted to launch their Falcon 1 rocket into space from the Marshall Islands carrying a government satellite. The rocket exploded a minute into the trip. It took three more tries before a Falcon 1 rocket delivered a satellite into orbit in 2008, a first for a privately-funded rocket. Next, the company turned its gaze to creating a reusable rocket - one that could be flown, landed, and then flown again. That launch vehicle, the Falcon 9, made its first flight in 2010, and these rockets have now flawlessly flown 85 out of 87 missions, landing more than 50 times.

As SpaceX slowly built a track record of successful flights, they started winning larger and larger NASA contracts. First, the US space agency hired them to carry cargo back and forth to the ISS. Eventually, SpaceX and its larger competitor, Boeing, were hired as part of the agency's Commercial Crew Program. The idea was to let private companies replace the space shuttle's services in the aggregate, while NASA focused on other priorities, like reaching deep space. "We want to establish a commercial environment in low-Earth orbit so that we can focus on the hard job of exploring beyond our home planet," NASA Kennedy Space Center director Bob Cabana said. "We can't do that if we're locked here in low-Earth orbit. Commercial Crew, with both SpaceX and Boeing - that's the beginning of a whole new era of spaceflight." Rather than buy the spacecraft from SpaceX and run it themselves, as NASA has done for more than half a century, Musk's engineers would be in charge of building, launching and operating the capsules. The plan has faced numerous delays, as both SpaceX and Boeing have given vague timelines and repeatedly pushed back test dates.

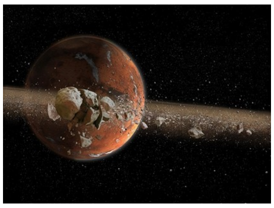
 Cheers rang out at SpaceX headquarters as Crew Dragon's parachutes deployed during a test on 1 May 2020. Shortly after, the capsule splashed down in the Atlantic Ocean, shown here. NASA

Then, in March of 2019, CrewDragon sailed flawlessly though its initial, uncrewed demonstration flight to ISS. The Falcon 9 delivered the capsule into orbit along with its mannequin and cargo, where Crew Dragon ultimately docked with the space station. The reusable rocket boosters even landed back on Earth. However, less than two months later, the Crew Drago capsule exploded due to a leak and a faulty valve during a test of its 'SuperDraco' thrusters, which are meant to propel the capsule away from the rocket in the case of an emergency. The company was forced to miss a targeted July launch for sending crew into orbit, and SpaceX spent much of the last year proving its spacecraft is safe. That history of blowing things up reared itself again on the eve of the Crew Dragon's launch. On Friday, a SpaceX Starship prototype exploded during a static fire test of the spacecraft that the company hopes can carry them into the future, ultimately ferrying humans beyond the space station to the moon and Mars.

However, for NASA, there was also good reason to think Saturday's Crew Dragon mission would succeed. SpaceX had already flown to ISS roughly two dozen times using its cargo version of the same capsule, the Cargo Dragon. The two share the same architecture but have significantly different internal blueprints and safety features. Saturday's flight was the first successful crewed mission under the initiative. However, NASA has already contracted six additional Crew Dragon flights.

The company currently has two surviving Crew Dragon capsules it can use to ferry astronauts. In addition to its NASA contracts, SpaceX has already been in talks with space tourism companies about bringing tourists to orbit, too. Each ship is designed to hold four NASA astronauts or seven tourists, so humanity's presence in space should increase in the years ahead. Actor Tom Cruise could be among the first non-astronauts to take one of those seats. SpaceX and NASA are reportedly in talks about filming an upcoming movie in space. Byy: Eric Betz

Ancient Mars might have once had rings, then moons, then rings … 2 June: For a long time after their discovery in 1877, scientists assumed Mars' two puny moons - Deimos and Phobos - were captured asteroids. This belief persisted until evidence revealed both moons formed at the same time as the Red Planet itself, and that the smaller one, Deimos, has a mysteriously tilted orbit. It was not until 2017 that researchers put forth a new idea that could explain why Deimos's orbit is slanted by 2 degrees. "The fact that Deimos' orbit is not exactly in plane with Mars' equator was considered unimportant," said SETI Institute research scientist and lead author Matija Ćuk. "But once we had a big new idea and we looked at it with new eyes, Deimos' orbital tilt revealed a big secret."

 Someday, Mars’ moon Phobos will slip past a certain point in its degrading orbit and get ripped apart by tidal forces, forming a ring. This illustration depicts Phobos midway through that process. Astronomy: Ron Miller

Previous theories suggested that Mars’ moons formed out of debris ejected when a giant impactor struck Mars between 100 million and 800 million years after the planet's creation. However, this new twist on the theory suggests that after the original collision and over the course of billions of years, generations of Martian moons have since been recycled into rings, which, in turn, were moulded into new, smaller moons. For Phobos, the cycle may be starting back up. At just 200 million years old - which is relatively young by astronomical standards – Phobos is gradually spiralling inward as it dances around Mars. One day, likely in the next 30 million to 50 million years, Phobos will get too close to to Mars and tidal forces will tear if apart. According to this new theory, the shattered remains of Phobos will then disperse around the Red Planet, creating a new Martian ring.

With no rings to see for the time being, this cyclic Martian moon theory also explains why the orbit of Deimos is tilted the way it is. Such an askew orbit could not be the result of a captured moon that spiralled toward Mars. It instead would have required a newborn moon migrating outward to disrupt Deimos’ orbit. Ćuk and collaborators believe that just over 3 billion years ago, a ‘grandparent’ moon to Phobos caused the tilt in Deimos’ orbit we see today. This pushy grandparent moon may have been up to 20 times as massive as modern-day Phobos. (Phobos is only about 20 km, so it has so little mass that a 90 kg person standing on its surface would weigh less than 75 g) This older moon’s mass, combined with its outward migration, would have set it up to have an orbit three times smaller than that of Deimos. The ratio of the two moons’ orbits set them up to consistently interfere with each other gravitationally, giving Deimos its unusual tilt. Once Phobos’ ancestor gave Deimos its tilt, it eventually began an inward journey, leading to its destruction. This was followed by two more ring-to-moon cycles, the latest of which created Phobos.

In 2024, Japanese space agency JAXA plans to send a spacecraft to Phobos as part of their Martian Moons eXploration (MMX) mission. The ambitious craft will venture to Phobos, collect detailed data on the moon, and even gather samples from its surface for return to Earth. Scientists will then study these samples using some of the most sophisticated lab equipment available, helping researchers probe the murky past of the Martian moons. “I do theoretical calculations for a living,” said Ćuk. “And they are good, but getting them tested against the real world now and then is even better.”

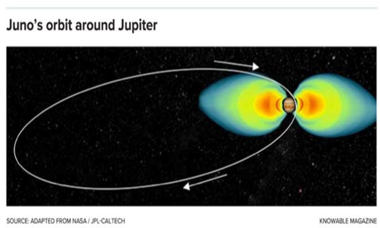
Four of the planets in our solar system currently have rings: Jupitar, Neptune, Uranus, and, most famously, Saturn. However, of the thousands of exoplanets discovered so far, only one has strong evidence of a ring system: J1407b. By studying past and current rings in our own solar system, scientists aim to get a better grasp on why certain worlds wear rings, as well as how to spot them in distant star systems. By: Caitlyn Buongiorno

What has the Juno spacecraft taught us about Jupiter? 8 June: In the four years since NASA’s Juno spacecraft went into orbit around Jupiter, it has slowly been coaxing the king of all the planets to reveal its deepest secrets - an astonishing catalogue that includes daisy chains of continent-sized cyclones circling both of Jupiter's poles; vast hailstorms of ammonia-laden 'mushballs'; a bloated, fuzzy core at the planet's centre; and a convoluted magnetic field like nothing else in the solar system.


NASA's Juno spacecraft (illustrated) has been orbiting Jupiter for four years, probing the giant planet's internal layout. NASA

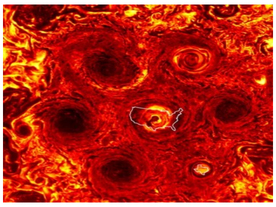
Named after the goddess Juno, who was Jupiter's wife in Roman mythology, the spacecraft was launched in August 2011 with the goal of understanding the giant planet's origin and evolution. That story could have profound implications for everything else in the solar system. Jupiter has more mass than all the other planets combined. Its far-reaching gravity has shaped the orbits of planets, comets and asteroids throughout the solar system's history. Also, its interior may harbour clues about what conditions were like when the planet arose from primordial gas and dust over 4.5 billion years ago. "Jupiter is central to understanding how planets in our solar system formed," writes Caltech planetary scientist David Stevenson "And it has secrets still to be unlocked." With a little over a year left in the probe's primary mission, Juno scientists are busy trying to understand how all the intriguing disparate discoveries mesh into a coherent picture of Jupiter's inner life. The primary mission is scheduled to last until July 2021, though the team hopes to extend Juno's visit for a few more years beyond that.

Juno is justly famous for its surreal photos of Jupiter's swirling cloudscapes. While the probe does have an excellent camera, not to mention a fanbase of amateur Jupiter enthusiasts ready to transform its images into science art, what makes these photos truly unique is Juno's highly elongated, 53-day orbit: a trajectory that maximizes the spacecraft's science potential while minimizing its exposure to Jupiter's fierce radiation belts. Juno accomplishes both these tasks by coming in over the north pole where the radiation is weak; whipping halfway around the planet at altitudes as low as a few thousand kilometres from the cloud tops, well below the strongest part of the belt; and then departing just two hours later through another weak-radiation region over the south pole. This path not only gets Juno far closer than any of the nine spacecraft that have visited Jupiter before, it has also provided researchers with the first clear views of the poles — which reveal a sight not seen anywhere else in the solar system.



Juno orbits Jupiter along a series of elongated paths (one shown) that take it over both poles, allowing it to get close to Jupiter while minimizing the time it spends in the planet's harsh radiation belts (shown in false colors here).

Around the planet's south pole, Juno spied five cyclones, each wider than the United States, parked around a central cyclone of the same size. Not to be outdone, the north pole revealed eight similar cyclones encircling their own polar vortex. Remarkably, the storms did not seem to be going anywhere. With each of Juno's flybys, the storms stayed put. Then, in November 2019, during Juno's 22nd loop around the planet, it discovered that a new, smaller cyclone - merely the size of Texas - had sprung to life in the south and joined the others. It is not clear how these vortices form or how they stay so stable. Researchers hope to get a better look under the storms in the extended mission. The physics of orbital motion keeps nudging Juno's closest approach to Jupiter a bit northward with each orbit. In the years to come, that means the spacecraft will inch closer and closer to those vortices, enabling its instruments to get a better look.


The six cyclones that encircle one continent-sized central storm at Jupiter's south pole show up vividly in this infrared image, captured by Juno on November 4, 2019. NASA/JPL-CALTECH/SWRI/ASI/INAF/JIRAM

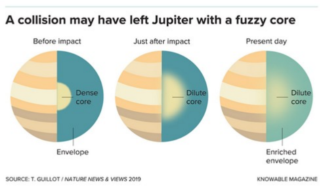
Because Jupiter is what astronomers call a gas giant planet, there is no point asking what conditions are like on its surface: It does not have one. Instead, the hydrogen and helium gas that make up the bulk of Jupiter's atmosphere simply get denser and denser the farther down you go, until the hydrogen becomes a liquid metal. However, there is still plenty of action in Jupiter's swirling clouds, which are thought to be a mix of water and ammonia. As researchers have discovered via a microwave instrument that lets Juno probe beneath the clouds, there is plenty of complexity underneath as well.


Jupiter's swirling, multicolored clouds wind through this colour-enhanced close-up taken by Juno's visible-light camera in 2018, as the probe soared about 11,000 km above the cloud tops. Enhanced image by Gerald Eichstädt and Sean Doran (CC BY-NC-SA) based on images provided courtesy of NASA/JPL-CALTECH/SwRI/MSSS

It turns out, for example, that the east-west winds that are known to tear through Jupiter's cloud tops are not just a high-altitude phenomenon: The winds actually penetrate thousands of kilometres down. Likewise with Jupiter's famous Great Red Spot - a vortex a bit wider than Earth that' has been churning for at least two centuries that astronomers can be sure of, and probably for much longer: It extends downward for about 300 km. Then there is the case of the missing ammonia. "We had assumed … that as soon as you drop below the [clouds], everything ought to be well mixed," says mission lead Scott Bolton, a planetary scientist at Southwest Research Institute in San Antonio, Texas. Jupiter is, after all, a rapidly spinning ball of fluid (a day lasts just under 10 hours). But Juno's microwave readings show that this mixing picture holds true only near the equator. It falls apart as you move north or south into Jupiter's mid-latitudes, where there is nowhere near as much ammonia as researchers expected. To see why, Tristan Guillot, a planetary scientist at Côte d'Azur Observatory in France, and others developed computer models of Jupiter's atmosphere and found that, away from the equator, ammonia may readily dissolve into water ice particles lofte up from below. This would reduce the amount of ammonia gas in these areas. It also means that the weather in Jupiter's mid-latitudes may feature hail-like storms of ammonia-soaked 'mushballs': frozen nuggets of roughly one part ammonia and two parts water.

Although Jupiter does not have a surface, researchers had a running argument before Juno's arrival as to whether the planet had a core - a solid ball of heavier elements gathered at the planet's centre. They could argue it either way. In one common tale of Jupiter's birth, rocky debris slowly coalesced into a solid mass up to 10 times as hefty as Earth. The gravity of that mass then hoovered up all the gas in its vicinity, surrounding itself with the deep hydrogen-helium atmosphere we see today. In a different origin story, a pocket of gas swirling around the infant sun collapsed in on itself, creating a more-or-less pure hydrogen-helium world without a rocky core.

Juno seems to have ruled out the latter scenario, Bolton says. By tracking how the spacecraft subtly speeds up and slows down in response to variations in the planet's gravitational field, scientists have been able to deduce how mass is distributed in Jupiter's depths. Their maps show that Jupiter does indeed have a core - just not one that looks anything like what they expected. Instead of being a compact ball, the actual core is a fuzzy sphere spread across nearly half of Jupiter's diameter. "We don't actually know why that is," Stevenson says. "But I think whatever that explanation might be, it's telling us something important about how Jupiter formed." Things could have been stirred up by the impact of another huge proto-planet, he says. "Or it could be that somehow Jupiter moved around and more planetesimals were added at a particular stage during formation. There are many different stories you could conjure up."



Juno discovered that Jupiter's core is not solid and compact but rather spread out across nearly half the planet's diameter.

Jupiter's huge fuzzy core undoubtedly has implications for other aspects of the planet's behaviour - one of them being the planet's unusual, contorted magnetic field. For decades, the textbook picture of the Jovian magnetic field was that it resembled Earth's - which is to say that it looked like the field of a really big bar magnet, with a well-defined magnetic north pole on one end and a well-defined south pole on the other. Quick peeks from earlier spacecraft seemed to confirm that picture. However,the textbooks were wrong. Juno's measurements show that the magnetic field in Jupiter's northern hemisphere looks completely different from its southern counterpart. It is as if someone took a bar magnet, bent it almost in half, frayed one end, split the other end, and then stuck the whole thing in the planet at a cockeyed angle. In the north is the frayed end: Rather than emerging around one central spot, the magnetic field sprouts like weeds along a long high-latitude band. In the south is the split end: Some of the field plunges back into the planet around the south pole while some is concentrated in a spot just south of the equator.

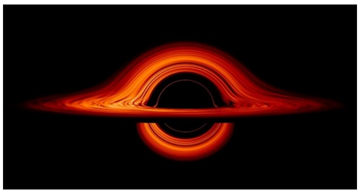
This magnetic field geometry is not seen anywhere else in the solar system. The southern hemisphere resembles Earth's field, which scientists call dipolar (because it has two poles).

The north has more in common with Uranus and Neptune, where the fields are more complex. "It was weird to have essentially … one hemisphere Earth and one hemisphere Uranus and Neptune," says Kimberly Moore, a Caltech astrophysicist and a lead author of several studies of Juno's magnetic findings. Planetary magnetic fields are generated by electrically conductive fluids in their interior. The unusual fields at Uranus and Neptune may be due to these fluids being restricted to a thinner region of the planet, relative to their size. Something similar might be happening at Jupiter thanks to its dilute core, says Moore. The north-south dichotomy may also emerge from all this complexity. "That can really change the geometry of the patterns you can come up with," she says. But that's just one idea. Helium rain might also wreak havoc on the magnetic field, as could penetrating winds.

If Juno has taught us nothing else, it is that no two giant planets are alike. At first glance, Jupiter has a lot in common with Saturn, for example. However, despite both being big balls of mostly hydrogen and helium, they have gone down quite different paths. Jupiter has conga lines of polar cyclones; Saturn has just one vortex per pole (one of which is six-sided!). Jupiter's magnetic field is a hodge-podge; Saturn's is pretty boring. Jupiter's atmosphere is multicolored and banded; Saturn's is relatively unblemished. "Giant planets must come in different flavours," Bolton says. "We need to understand that if we're going to understand them in general, because the same physics must dictate everything."

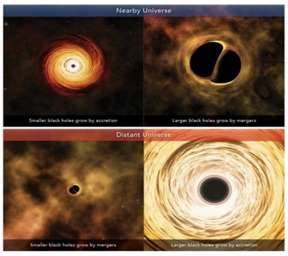
By: Christopher Crockett

How do black holes grow into the varied beasts we see today? 17 June: The first black holes began to emerge some 13.5 billion years ago. How did these baby beasts grow into the varied population of black holes we 'see' today? Thanks to a new theoretical model developed by scientists from the Black Hole Initiative and the Harvard-Smithsonian Centre for Astrophysics (CfA), astronomers think they have a better grasp on how different types of black holes grow - both in the infant universe and the modern cosmos.


A visualization shows how an accretion disk likely looks due to the extreme gravity of a black hole. NASA's Goddard Space Flight Center/Jeremy Schnittman

"In the [modern, nearby] universe, small black holes are mostly adding mass via accretion. And large black holes - above 100 million times the mass of the Sun — are mostly adding mass via mergers," astronomer Fabio Pacucci of the CfA said. "This is somehow reversed in the [early, distant] universe," he adds. In the young cosmos, small black holes grew mostly through mergers, while massive ones relied on accretion. This reversal may seem strange, but, according to Pacucci, it has a simple explanation: the availability of 'food'.

When a black hole grows via accretion, it is essentially feeding on nearby gas that is pulled in by the black hole's intense gravity. In the early universe, there was plenty of gas available, and once the first stars formed, that remaining gas got easily jostled around. This readily available gas served as a smorgasbord for large black holes, which have wide gravitational reaches that allow them to snag lots of food. Smaller black holes in the early universe, however, formed from the deaths of short-lived massive stars. And after a dying star collapses into a petite black hole, there isn't a lot of leftover gas nearby that it can feed on. This means smaller black holes in the early universe couldn't easily gorge on gas; they needed to merge with other small black holes to grow.



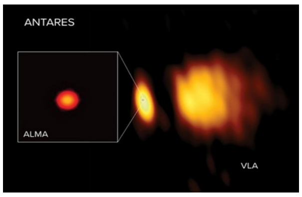
This artist's concept shows how small and large black holes in both the nearby and distant universe form. M. Weiss

Today, though, there is less gas freely floating around the universe. This is because much of it has been incorporated into multiple generations of stars, the researchers say, and existing black holes have gobbled up a significant amount of the rest. In other words, today's largest black holes have had to employ an alternative feeding strategy: cosmic cannibalism. Although the modern universe is no longer a giant, untapped reservoir of gas, the cosmos has provided plenty of time for black holes to grow to truly epic sizes. "In every galaxy that we know of, at the centre, there is a supermassive black hole that co-evolved with the galaxy," says Pacucci.

These supermassive black holes are now thought to be so common that one is expected in the heart of nearly every large galaxy in the universe. Due to their astounding gravitational pulls, these galaxies often cannot help but barrel into one another. So, because supermassive black holes are now both prevalent and attracted to their nearest neighbours, modern-day mergers between giant black holes are quite common. "Ultimately, understanding how black holes grow over the cosmic time helps us understand the history of galaxies," Pacucci says, "[which] are the building blocks of the universe."

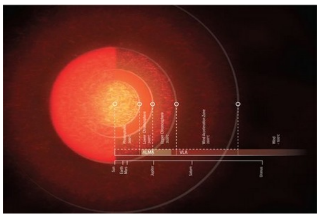
"It would be interesting to see if these relations are also valid [even earlier in the] universe," says Pacucci, as this study only ranges from 13 billion years ago to today. "And a second goal would be to use this model to guide future observations." Fortunately, the next generation of space-based X-ray and gravitational-wave observatories, including Lynx, Athena, AXIS and LISA, will be instrumental in mapping the broad population of black holes and how they grew across cosmic time. By: Caitlyn Buongiorno

An unprecedented look at the atmosphere of the supergiant star Antares 19 June: Sparkling near the heart of the constellation Scorpius lies ruby-red Antares, the 15th-brightest star in the night sky. Like its bloated cousin Betelgeuse, Antares is a red supergiant nearing the end of its life. These enormous yet relatively cold stars sport strong stellar winds that fire heavy elements like carbon and nitrogen into space, providing many of the building blocks for life as we know it. Exactly how these winds are cast off has largely remained a mystery, but it may not stay that way for long. Thanks to both the Atacama Large Millimeter/submillimeter Array (ALMA) and the National Science Foundation's Karl G. Jansky Very Large Array (VLA), astronomers have peered deep within the atmosphere of Antares, and the insights their observations reveal help bring them one step closer to solving the mystery of superpowered winds from supergiant stars.



The Atacama Large Millimeter/submillimeter Array (ALMA) observed Antares' optical photosphere, close to the surface of the star while the Very Large Array (VLA) revealed the outer layers of the star's atmosphere. ALMA (ESO/NAOJ/NRAO), E. O'Gorman; NRAO/AUI/NSF, S. Dagnello

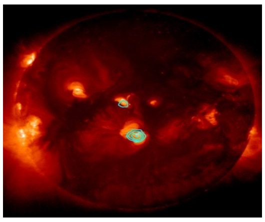
The two radio telescopes revealed that Antares is even larger than we previously believed. In visible light, the star is about 700 times larger than the Sun. However,when ALMA and VLA looked at it in radio light, they saw that the star's chromosphere - the second of a star's three main atmospheric layers - extended out some 2.5 times the star's radius. For comparison, the Sun's chromosphere extends only 1/200 of its radius.


This artist's impression of Antares' atmosphere was created from the most detailed radio map of any star, excluding the Sun. NRAO/AUI/NSF, S. Dagnello

The temperature of Antares' chromosphere, on the other hand, is much lower than the Sun's. Observations in radio light revealed that the area only peaks at about 3,500 degrees Celsius, whereas the Sun's chromosphere reaches temperatures of nearly 20,000 degrees C. "We think that red supergiant stars, such as Antares and Betelgeuse, have an inhomogeneous atmosphere," said Keiichi Ohnaka. "Imagine that their atmospheres are a painting made out of many dots of different colours, representing different temperatures. Most of the painting contains dots of the lukewarm gas that radio telescopes can see, but there are also cold dots that only infrared telescopes can see, and hot dots that UV telescopes see."

Thanks to this data, scientists were able to see a clear distinction between the chromosphere and the solar-wind-forming region. "Our innate understanding of the night sky is that stars are just points of light," said NRAO astronomer Chris Carilli. "The fact we can map the atmospheres of these supergiant stars in detail is a true testament to technological advances in interferometry. These tour de force observations bring the universe close, right into our own backyard.   "By: Caitlyn Buongiorno

The Sun's sizzling corona is so hot thanks to tiny nanoflares, new evidence suggests 29 June: Within Earth's atmosphere, temperatures drop with increasing altitude. On the Sun however, the reverse occurs: its outermost layer, the corona, is nearly 500 times hotter than the underlying layer, the photosphere. To explain this cosmic conundrum, astronomers have long theorized that some unknown mechanism must be vigorously heating the corona. One possible mechanism is nanoflares: tiny explosions on the solar surface that randomly occur and rapidly dissipate. However, while researchers have proposed the existence of nanoflares for some time, it' has been difficult to detect them with current technology.Now, researchers from the National Centre for Radio Astrophysics (NCRA) in India have discovered fresh evidence for nanoflares. They spotted the weakest radio emissions detected yet from our star on a day when the Sun was not flaring - hinting that random, ubiquitous nanoflares indeed exist, and they could explain why the corona is so hot.


Nanoflares (marked in blue) detected by the FOXSI instrument in December 2014. JAXA/NASA/Hinode/FOXSI

The team made the detection by studying the Sun with a radio telescope called the Murchison Widefield Array (MWA). Once they were sure that there were no powerful solar flares occurring on either the near or far side of the Sun, they took 70 minutes of data at four distinct frequencies. During this time, the array captured weak emissions on the quiet Sun - the first observational radio evidence of nanoflares.


The Murchison Widefield Array (MWA) located in Western Australia. MWA Collaboration and Curtin University

Looking at the inactive Sun is important because the corona's constantly high temperature suggests that the extreme heating is not due to larger intermittent flares, which are the type usually studied by astronomers. "Powerful flares, although [they] dump a significant amount of energy, occur less frequently and are associated with localized regions on the Sun, where its magnetic field is strong," said Surajit Mondal, "However, since the corona is always hot, a mechanism is necessary which shall continuously dump energy into the corona and is present everywhere." Nnoflares perfectly fit the bill. In 2017, scientists using the Focusing Optics X-ray Solar Imager (FOXSI) presented evidence that nanoflares may be the cause of the Sun's high coronal temperature. In their study, the FOXI team had observed an extremely hot region of the corona that was not associated with any normal, full-sized flares. They posited that instead, nanoflares had heated the region they observed to more than 10 million kelvins.

Mondal and his team saw emissions similar to those seen in the 2017 study, but at a time when the entire Sun was quiet, increasing the likelihood that nanoflares are the best explanation for the hot corona. "These are exciting results that add to the growing evidence that nanoflares play an important role in heating the solar corona to its multi-million degree temperatures," said James Klimchuk, an astrophysicist at the NASA Goddard Space Flight Centre who is not involved in the NCRA research.

Compared to the powerful solar flares you are familiar with, nanoflares are weak. They occur suddenly and fade quickly. So, how could they possibly be responsible for heating - much less maintaining - the Sun's coronal temperature of several million Kelvin? The answer, as Klimchuk explained lies in the large number of nanoflares that occur on the solar surface. "Although puny by solar standards, each one is the equivalent of a 50-megaton hydrogen bomb, the largest ever detonated on Earth. Millions of nanoflares occur every second across the Sun, and together they pack a real wallop," he said. So, although each nanoflare by itself is weak, their ubiquitous presence on the solar surface could explain the high coronal temperature. Mondal and his team observed this. In 70 minutes of data, they detected more than 81,000 events. However, while their research serves as clear evidence for the abundance of nanoflares even in areas with low magnetic field strength, exactly how nanoflares generate the high coronal temperature is still unknown.

"The novelty of our work lies in the fact that we, for the first time, show that impulsive emissions play a significant role in heating the quiet solar corona, and also characterize the nature of these emissions," Mondal says. However, since the work is based only on a single observation, Mondal notes that multiple observations carried out at different times and during varying levels of solar activity are necessary to determine whether nanoflares are indeed the mechanism behind coronal heating. Additionally, "There are definitely weaker emissions which we have not detected," Mondal says.

Engulfed in the Sun's brilliance, the corona reflects little visible sunlight and is barely visible to telescopes near Earth, 150 million kilometres away. While observing the dim nanoflares is hard enough, the task is made harder with limited telescope sensitivity. Missions dedicated to studying the Sun's corona up close, such as NASA's ongoing Parker Solar Probe and the Indian Space Research Organisation's upcoming Aditya-1 will expand current knowledge of exactly how the corona is heated. This knowledge is important for more than simply understanding how the Sun works. "If nanoflares are responsible for heating the corona, as seems to be the case, then they are [also] the source of ultraviolet and X-ray radiation [from the Sun] that is absorbed by the upper atmosphere of the Earth," Klimchuk says. That radiation affects the properties of the upper atmosphere, which in turn influences the amount of drag experienced by satellites and space debris. So, the rate of nanoflares occurring on the solar surface could ultimately affect the efforts made by satellite controllers to avoid collisions in space. By: Sharmila Kuthunur

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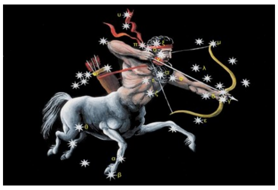
DID YOU KNOW?

Zodiac constellations 5: Sagittarius

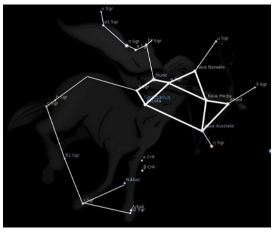


The name of the 15th largest constellation is Latin for 'the archer'. One of Ptolemy's Greek 48 constellations, the half-animal / half-human centaur with a bow represents mythological Crotus, the son of Pan. However, it was the Babylonians who first identified this group of stars as one of their gods, a strange centaur-like creature firing an arrow from a bow. This god had invented archery and went hunting on horseback with his weapon.

The Sun passes through Sagittarius from late December to late-January and is, thus, the constellation of the winter solstice in the northern hemisphere. It is located between Scoprius and Capricornus on the ecliptic. The archer's arrow points at Antares, the 'heart' of Scorpius.

The most recognisable feature of this large, prominent constellation is the 'teapot' (see image . In clear conditions, the dense area of the Milky Way appears to be steam rising from spout. The exact centre of the galaxy is thought to coincide with radio source

Sagittarius A*, a prominent radio source found near where borders of Sagittarius, Ophiochus and Scorpius meet.



Because the sightline to the galaxy centre passes through Sagittarius, the constellation contains numerous clusters and nebulae, including 15 Messier objects.

Notable features include

- Lagoon nebula (M8): a large patch of glowing gas visible to the naked eye.
- Omega nebula (M17): a gaseous nebula taking its name from the similarity in its shape to Greek letter omega (Ω). It is also known as the Swan nebula. It is visible through binoculars.

- Trifid nebula (M20): this spectacular emission nebula is named for the three dark lands of dust that trisect it. It is visible through a telescope.

- M22: an impressive globular cluster. Although visible to the naked eye, it is best viewed with binoculars. A telescope enables observation of individual stars.
- M23: a large open cluster. Binoculars give a general view, while a telescope allows sighting of individual stars.
- M24: a bright Milky Way starfield visible through binoculars.

In the southern hemisphere, these, and other objects in Sagittarius can be observed during the winter months.

Sources: Ridpath, I (Ed) 2012 Oxford dictionary or astronomy Oxford, OUP, Ridpath, I (Ed) 2006 Astronomy London, Dorling Kinderslety, en.wikipedia.org

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