`"The Southern Cross"

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HERMANUS ASTRONOMY CENTRE NEWSLETTER

APRIL 2020

Monthly meeting There will be no meeting in April, due to the coronavirus pandemic.

Important notice **2020 membership renewal window closed**
If you have not already renewed your membership, from this month, your details will be removed from the Centre's membership list. The implications of this are that you will no longer receive the monthly sky maps or Southern Cross newsletter, no longer be eligible to join Centre trips, and, if you wish to attend monthly or interest group meetings, on each occasion, you will have to pay the R25 visitor's fee. All is not lost, however. You are welcome to rejoin the Centre at any time by contacting Laura Norris, the Treasurer, at meetings, on 028 3164453 or at dunorris@whalemail.co.za

2020 meeting dates For your diaries. Remaining meeting dates are: 18 May, **22 June**, 20 July, 17 August, 21 September, 19 October and 16 November. **Note:** the June date has been changed because of the long weekend the previous week.

WHAT'S UP?

Venus in Pleiades From 2 – 4 April, towards the West, Venus will be visiting some of her stellar sisters in the conspicuous Pleiades open cluster (M45) in the Taurus constellation. Its ancient Greek name probably comes from 'plein' (to sail) because of the role of the cluster in determining the sailing season in the Mediterranean. It is commonly known as the 'Seven Sisters', although only six of its hot, bright, blue stars are easily visible to the naked eye. Located 400 light years away, the cluster is best viewed through binoculars, when many more of its 100 or so stars can been seen. Pleiades is around 80 million years old, its stars embedded in a reflection nebula (clouds of interstellar dust which reflect the light of nearby stars). It had been thought that the nebula was a leftover from formation of the cluster. Current thinking is that the nebula and stars are not related and that the cluster is coincidentally passing through it. The cluster is predicted to survive for about another 250 million years before its stars are dispersed by gravitational effects.

LAST MONTH'S ACTIVITIES

Monthly centre meeting At the meeting held on 16 March, Dr Gyula (Josh) Józsa, radio astronomer at the South African Radio Astronomy Observatory (SAAO) in Caoe Town, gave an absorbing and informative talk on 'MeerKAT and neutral hydrogen in galaxies'. Following the stages of the Big Bang, he explained when hydrogen was formed and its concentration and distribution as other elements, then stars and galaxies formed.

Interestingly, unlike the massive gas giants, Earth and its atmosphere contain little atomic hydrogen because our less massive planet's gravity is not strong enough to retain very light hydrogen atoms. In galaxies, molecular hydrogen is present in large clouds of gas and dust which are areas of star formation), while lighter neutral (atomic) hydrogen occurs in more diffuse interstellar clouds. These regions are cool and emit no visible light. However, they do emit an important radio spectral line at a long wavelength; 21 cm.

Radio telescopes, like MeerKAT, are able to 'see' hydrogen, and images clearly show that the material of galaxies extends far beyond what is visible at non-radio wavelengths. Josh outlined some of the new knowledge about galaxy dynamics which large radio telescopes, particularly MeerKAT, are revealing about galactic formation, dynamics and interactions, including the possible nature of dark matter.

Interest groups

Cosmology At the meeting on 2 March, Derek Duckitt presented the next two lectures in the DVD series 'Blackholes, tides and curved spacetime: Understanding gravity presented by Prof Benjamin Schumacher of Kenyon College. The topics were L7:'Stars in their courses: orbital mechanics' and L8: 'What are tides? Earth and beyond'.

Astro-photography There was no meeting in March.

Other activities

Educational outreach On 3 March, Learners and teachers from several local schools attended a Moonwatch evening on Rotary Way. Pierre de Villiers reports: "Five members of the Hermanus Astronomy Centre conducted a hugely successful First Quarter Moon observation for educators and Grade 7 learners from three local primary schools [Lukhanyo Primary, Mount Pleasant Primêr and Zwelihle Primary] on Rotary Drive above Hermanus on a balmy and perfectly cloudless and windless Tuesday evening on 3rd March. All attendees (26 learners and 7 educators) were given a brief summary of Moon facts and then requested to identify and observe 13 targets on the first quarter moon. Printed handouts contained images and brief descriptions of each target, with the specific request that each attendee should share this information with their families, co-learners and educator colleagues. The sequence of naked eye (1 x magnification, 180° field of view), binocular (10 x magnification, 5+° field of view) and telescope observations (50 x magnification and <≈ 1°) was accentuated. Each telescope/binocular focussed and explained the details of 2/3 targets.

Only four of the attendees had looked through a telescope before. The consequential amazement, enthusiasm and decibel level was extremely rewarding to experience. As always the intensity and depth of the questions from learners were both surprising and gratifying.

Derek's photos illustrate the nuance of the observation session. His photo of the Moon was is an image taken with a Samsung S10 handheld mobile against a Televue Ethos 100° FOV eyepiece on a Φ200 mm f4 SkyWatcher Newtonian telescope.

The evening was enjoyed by both HAC members and all attendees, who learnt a lot about our nearest neighbour. It also re-ignited the educators' enthusiasm for astronomy specifically, and hopefully science in general."

Analemmatic sundials at schools , Work continues on others at several Overstrand schools.

Stargazing The event planned for 27 March was cancelled, due to the coronavirus pandemic.

THIS MONTH'S ACTIVITIES

Monthly centre meeting The presentation scheduled for 20 April has had to be 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 April, 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 April, 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 on this group.

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

Other activities

Stargazing No events will take place during the coronavirus pandic.

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:

20 April	Cancelled.
18 May	Topc: TBA Presenter: Dr Vanessa McBride, SAAO, CT
22 June	Topic: TBA. Presenter: Dr Kechil Kirkham, IDIA, CT
20 July	'Designing and building a mobile home observatory." Presenter: Pierre de Villiers, Centre chariman
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.

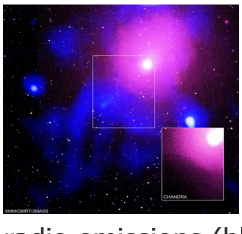
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer,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

Astronomers spot the universe's biggest known explosion 2 March: A black hole about 390 million light-years away has caused the biggest eruption ever seen in the universe. The supermassive black hole sits at the centre of a galaxy located in the Ophiuchus galaxy cluster. Its eruption was about five times greater than the last record-holder.

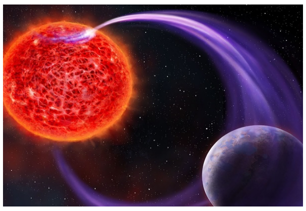


Ophiuchus galaxy cluster is filled with hot gas, seen here in X-ray (pink) and radio emissions (blue). Within the brightest (white) spot is a galaxy hosting a supermassive black hole, which belched out the largest explosion ever seen. That explosion carved out a cavity whose boundary appears where the pink and blue edges meet. X-ray: NASA/CXC/Naval Research Lab/Giacintucci, S.; XMM:ESA/XMM; Radio: NCRA/TIFR/GMRTN; Infrared: 2MASS/UMass/IPAC-Caltech/NASA/NSF

Black holes suck up matter that comes close to them, but they often expel matter as well. When matter falls toward the black hole, it is sometimes redirected into beams or jets that blast into space and slam into surrounding material. Suspicions of an explosion arose in 2016 when NASA's Chandra X-ray Observatory reported evidence there was an unusual curved edge in the Ophiuchus cluster. Scientists thought such a structure could be carved out by the jets from the supermassive black hole, but only if there was a massive explosion of unprecedented magnitude. The 2016 study could not confirm whether that was the case.

Then followed the radio evidence: A new team of scientists looked at the cluster with radio telescopes and their data showed the same curved edge. Based on their observations, the edge is the boundary of a cavity in the hot gas filling the cluster, which could only have been cleared out by an intense blast from a supermassive black hole. “The radio data fit inside the X-rays like a hand in a glove,” Maxim Markevitch, said. “This is the clincher that tells us an eruption of unprecedented size occurred here.” Ultimately, the discovery used data from a number of instruments - including Chandra, the European Space Agency’s X-ray observatory, XMM-Newton, the Murchison Widefield Array in Australia, and the Giant Metrewave Radio Telescope in India. The eruption is no longer going on, according to the researchers, as the radio data do not show any evidence of current jets, which most likely ran out of fuel for growth. By: Hailey Rose McLaughlin

Hunting aurorae: Astronomers find an exoplanet using a new approach 4 March: Astronomers have discovered a terrestrial-mass exoplanet orbiting a tiny red dwarf star less than 30 light-years from Earth. Although finding yet another exoplanet is nothing new, what is unique is exactly how the researchers discovered the exotic world: they hunted for radio waves emitted by glowing aurorae.


Artist's concept of the magnetic interaction between a red dwarf and its exoplanet, and the resulting aurora. Danielle Futselaar (artsource.nl

The new observations - made with the Low Frequency Array radio telescope (LOFAR) in the Netherlands - indicate a planet less than about five times the mass of the Earth is in a quick orbit around a petite red dwarf named GJ 1151. Thanks to the stars’ magnetic field interacting with the close-in planet’s atmosphere, the researchers were able to detect the tell-tale radio signatures of aurorae.

Aurorae are caused by magnetic fields, but the processes that produce them can take different forms. The well-known aurora borealis (the northern lights) and aurora australis (the southern lights) is caused when Earth’s magnetic field funnels charged particles from the solar wind to Earth’s poles, where they strike atoms in our atmosphere. On Jupiter, however, brilliant aurorae arise in response to charged particles from its moon Io, accelerated by the gas giant’s powerful magnetic field, colliding with its upper atmosphere. In the case of the new-found world around GJ 1151, the researchers paint a picture of a planet magnetically connected to its star, producing aurorae as the two interact. According to Joseph Callingham, a Veni Fellow at Leiden Observatory at Leiden University, these exoplanetary aurorae are expected to look brighter and more intense than anything seen on Earth, sporting purple and yellow hues that only appear in Earth’s strongest light shows.

This sort of magnetic activity produces radio emissions, which radio astronomers have long hoped to use to find and study exoplanets. In 2018, for instance, astronomers discovered the impressive auroral activity of a rogue exoplanet called SIMP J01365663+ 0933473 (or simply SIMP). This marked the first detection of aurorae on a planet-sized object outside our own solar system. If confirmed, the recent observations of GJ 1151 will go on to serve as the first detection of star-exoplanet interaction at radio frequencies. “All previous methods of detecting exoplanets around main-sequence stars use optical telescopes,” says Benjamin Pope, a NASA Sagan Fellow at New York University who was involved with the research. “By opening the radio window, we don’t necessarily know what we will find!” Because most red dwarf stars - which are thought to account for roughly 75 percent of the stars in the universe - have exceptionally strong magnetic fields, this new method of detecting exoplanets based on their auroral activity could be particularly revealing.

The team uncovered the radio emissions from this planet by trusting the idea - inspired by results from the Kepler Space Telescope - that nearly every star has orbiting planets. When Callingham was working on the LOFAR Two-meter Sky Survey (LoTSS), which aims to survey the whole northern sky, he and his team got the idea of scouring the data for signatures that are suggestive of aurorae caused by star-planet interactions. Once they found the planet around GJ 1151, though, they had to make sure it really was an exoplanet. Specifically, that meant ruling out other explanations for the radio emission, such as the possibility that it is caused by GJ 1151 interacting with a distant giant planet or a binary star. Based on their follow-up investigations, the team believes they have found an Earth-sized planet too small to detect with optical instruments.

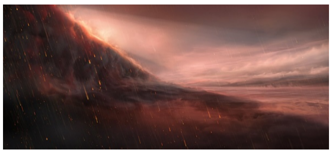
Other radio astronomers, however, responded to the findings with both caution and excitement. Evgenya Shkolnik, a professor of astrophysics at Arizona State University who is an expert on star-planet interactions, says, “It’s only now that we have these sensitive detectors that people are staring at stars and trying to figure out if the star itself can do this without the presence of a planet.” To truly confirm that this is an exoplanet and this method of detection works, she says, the team will have to prove that the radio signal matches the suspected planet’s orbital period. But she adds that the team has statistics on their side and that the planet probably exists.

Detecting this radio emission is a big result in its own right, says Melodie Kao, a Hubble Postdoctoral Fellow at Arizona State University who led the study on SIMP. If these results are confirmed, it could suggest that the magnetic fields of terrestrial planets can be much stronger than previously predicted, which opens up exciting possibilities for understanding these processes and interactions. “If this proves to be correct and real, this team will find a lot more of these objects, and it could be a whole new way to find exoplanets orbiting [red] dwarfs,” says Gregg Hallinan, an astronomer at Caltech who helped detect SIMP’s magnetic field. Hallinan adds that “the next big step will be detecting direct radio emission from exoplanets themselves.” Doing that would open up the possibility of studying the physics and atmospheres of these exoplanets.

In addition to working to confirm signs of the orbital period of GJ 1151’s planet, the team is seeking evidence of similar emissions from other stars. They’re also looking forward to what this method could teach them about red dwarfs and their exoplanets. “Radio aurorae have the potential to be a new mode of exoplanet discoveries, as well as a powerful probe of their interiors. If we want to make the most of the new discoveries that radio exo-aurorae can open up, we need our communities and businesses to help us ensure that our skies remain clear for raio observations,” says Kao.

By: Erica Naone

Astronomers find an exoplanet where iron rains from the sky 11 March: Astronomers have discovered a bizarre exoplanet that rains iron at night. The daytime side of this world, dubbed WASP-76 b, is not any less hellish, either. Temperatures can reach up to 2,400 degrees Celsius - hot enough to vaporize metal. "One could say that this planet gets rainy in the evening, except it rains iron," University of Geneva astronomer David Ehrenreich, who led the new study, said.


Iron rain on the gas giant planet WASP-76 b. Credit: ESO/M. Kornmesser

WASP-76 b is slightly smaller than Jupiter and sits some 640 light-years from Earth in the constellation Pisces. Its horrifying weather is caused by its truly extreme orbit. Gas giant worlds like WASP-76 b are called hot Jupiters because they orbit uncomfortably close to their home stars - in this case, nearly 10 times closer than Mercury is to our Sun. That proximity leaves WASP-76 b 'tidally locked' to its star, with one side permanently baking in light and the other stuck in eternal darkness. "Surprisingly, however, we don't see iron vaporu on the other side of the planet in the morning," University of Geneva researcher Christophe Lovis said in a media release. "The conclusion is that the iron has condensed during the night. In other words, it rains iron on the night side of this extreme exoplanet."

It is the first time astronomers have detected this kind of day-to-night chemical difference on a hot Jupiter like WASP-76 b. Researchers found the planet using the European Southern Observatory's Very Large Telescope VLT) in Chile. Specifically, the discovery was made possible thanks to an instrument called the Echelle Spectrographic for Rocky Exoplanets and Stable Spectroscopic Observations (ESPRESSO). Astronomers originally planned to use this VLT instrument to study Earth-like planets around stars like our Sun. However, they suspected that the VLT's extreme size would be perfect for studying the atmospheres of other exoplanets. It turns out they were right. Their discovery of iron rain on WASP-76 b was made during ESPRESSO's first-ever science observations. And that means there's likely many more bizarre worlds out there just waiting to be revealed. "What we have now is a whole new way to trace the climate of the most extreme exoplanets," Ehrenreich said. By: Eric Betz

Hubble celebrates 30 years of science 12 March: It is hard to believe that nearly half the people alive today have never known a world without the Hubble Space Telescope. The space shuttle Discovery blasted off with its precious cargo from Kennedy Space Center on 24 April 1990, and the next day, the shuttle's five-person crew deployed the school-bus-sized observatory in low Earth orbit. In the 30 years since, Hubble has helped redefine our universe, tackling problems that had plagued astronomers for decades, as well as discovering new mysteries no one imagined.


One of the Milky Way's premier star factories is the Carina Nebula (NGC 3372), which came to life about 3 million years ago when stars first ignited in a cloud of molecular

hydrogen. In this view, jets of gas erupt from infant stars emerging from their birthplaces. NASA/ESA/M. Livio and the Hubble 20th Anniversary Team (STScI)

Of course, Hubble's history has not been without glitches. The most critical appeared within weeks of its deployment. Early images revealed that the telescope's 2.4-meter mirror was flawed - its edges were too flat by 2 micrometers, or roughly 1/50 the width of a human hair - and could not focus light sharply. For a telescope whose whole raison d'être was to deliver crystal-clear views of the cosmos from above the distorting effects of Earth's atmosphere, the imperfection was more than disheartening.


The Hubble Space Telescope floats free in low Earth orbit after astronauts completed the fifth and final servicing mission in May 2009. NASA

Fortunately, NASA designed Hubble to be serviced regularly. On 3 December 1993, a team of seven astronauts rocketed into orbit aboard the space shuttle Endeavour. Their most important task: install two new instruments that would serve as 'eyeglasses' and transform fuzzy images into crystal clarity. Four subsequent servicing missions - the final one in May 2009 - have completely revamped the observatory and made it into a 21st-century science machine. It has captured more than 1 million images of the cosmos, exploring objects as near as the Moon and as distant as some of the first galaxies to form in the early universe. It has also studied myriad examples of almost every type of target that lies between.

When people think of Hubble, most picture stunning images of Milky Way nebulae and colourful galaxies. However, scientists often set their sights closer to home. No spacecraft has visited Uranus or Neptune since the 1980s, leaving Hubble and large ground-based telescopes to take up the slack. The space telescope has shown Uranus, which appeared as a bland, bluish ball when Voyager 2 flew past in 1986, to be an active world boasting bright clouds of methane. In Neptune's atmosphere, Hubble has tracked massive storms, some as big as Earth, propelled by winds that average 1,450 km/h. Hubble also has tracked storms on Jupiter and Saturn, augmenting observations made by orbiting spacecraft. Also, it was the space telescope that first detected evidence that water vapour may be erupting from Jupiter's moon Europa. The plumes likely represent material from an underground ocean venting through the moon's icy crust.

Hubble played a key role in the success of NASA's New Horizons' mission to Pluto. Between 2005 and 2012, the orbiting observatory discovered four new targets for New Horizons: the small moons Hydra, Nix, Kerberos, and Styx. More importantly, observations made over several years mapped light and dark regions on the dwarf planet's surface. The brightest of these areas so intrigued New Horizons scientists that they targeted the flyby so it would be front and centre at closest approach in July 2015. That is how we learned so much about the heart-shaped, nitrogen-ice glacier now known as Tombaugh Regio. Hubble also discovered the Kuiper Belt object 2014 MU69, since named Arrokoth, that New Horizons flew past on 1January 2019.


Stellar winds from a massive star (the image's brightest star) carved the intricate contours of the Bubble Nebula (NGC 7635). The bubble has a bluish tinge, thanks to short-wavelength radiation emanating from ionized oxygen atoms. NASA/ESA/The Hubble Heritage Team (STScI/AURA)

Beyond the solar system, Hubble opened a new window into star birth and star death. Raised above Earth's obscuring atmosphere, the space telescope collects not only visible light but also ultraviolet and infrared radiation (light with wavelengths slightly shorter and longer, respectively, than what we can see). The extra information lets scientists probe deeper into the thick clouds of gas and dust that harbour young stars. Now astronomers can observe fledgling stars in gaseous nebulae as they emerge from their birth cocoons. They can watch the hottest of these stellar youths excavate cavities in their surroundings and erode dust-filled pillars where new stars are trying to form. In the nearby Orion Nebula, Hubble revealed protoplanetary disks surrounding dozens of baby stars. These dusty disks appear to be the raw material nature uses to create planets.

When Hubble launched, scientists counted only nine planets in the universe. (This was before Pluto's demotion to dwarf planet status in 2006.) Since the early 1990s, astronomers have discovered more than 4,000 planets orbiting other stars. Although the space telescope contributed only a handful to this total, its spectrographs have analysed the atmospheres of several exoplanets. Perhaps most intriguingly, Hubble has detected significant amounts of water vapour on a few of these worlds.

The lives of stars play out over millions, billions, and sometimes trillions of years, and the space telescope has given astronomers front-row seats to study nearly every stage of stellar evolution. A star like the Sun will eventually puff off its outer layers, creating a glowing death shroud known as a planetary nebula. Hubble has explored dozens of these beautiful structures and found them to be far more complex than previously suspected. Instead of exhaling one dying breath, many Sun-like stars experience multiple death throes. Intricate shapes develop as newly ejected gas interacts with material from older eruptions.


Galaxies like the Whirlpool (M51) played a key role in many of Hubble's cosmological discoveries. NASA/ESA/S. Beckwith (STScI)/The Hubble Heritage Team (STScI/AURA)

Not all stars are destined to die in relative peace. Stars that begin life with more than 8 or so solar masses exit this universe in violent supernova explosions. These titanic blasts seed the cosmos with heavy elements while leaving behind a highly compressed stellar core - either a neutron star or black hole. Hubble has studied the remnants of these explosions, tracing the elements ejected in the blasts and watching as their gaseous tendrils evolve slowly with time. Perhaps most importantly, the space telescope has tracked the remnant developing around the site of Supernova 1987A, a supergiant star that exploded in the Large Magellanic Cloud (LMC) - the Milky Way's largest satellite galaxy - in February 1987. Over the past 30 years, Hubble has witnessed the supernova's blast wave lighting up gas ejected by its progenitor star some 20,000 years earlier, and watched as the budding supernova remnant has taken shape.


Spiral galaxy M106 in Canes Venatici helped nail down the Hubble constant. NASA/ESA/The Hubble Heritage Team (STScI/AURA)/ R. Gendler (for the Hubble Heritage Team)

The telescope's sharp eye has roamed all over the LMC. Its investigation of the Tarantula Nebula - the largest known star-forming region in the universe - resolved one longstanding mystery about the cluster in the Tarantula's heart. The cluster's core, dubbed R136a, appeared to be a single star weighing 1,000 solar masses or more, far bigger than astrophysicists deem possible. Hubble resolved the cluster's dense core into several smaller stars. Although many tip the scale at more than 100 solar masses, making them among the heftiest stars known, they no longer violate physical law. Hubble's LMC observations show the telescope can see objects in nearby galaxies in the same detail once possible only in the Milky Way.

As Hubble cast its eye deeper into the universe, it made one discovery after another. Perhaps none stirred the public's imagination more than confirmation that black holes exist, and that they play vital roles in the evolution of galaxies. This signature achievement came in the 1990s, when Hubble examined the cores of M84 and M87, two of the largest galaxies in the nearby Virgo Cluster. This collection of thousands of galaxies lies some 50 million light-years from Earth. Using spectrographs to examine the rapid gas motions in the cores of these galaxies, the telescope revealed a supermassive black hole lurking at the centre of each. Although earlier observations had hinted that black holes might exist in some galaxies, Hubble provided ironclad proof.


Like the Milky Way, NGC 1300 in Eridanus is a barred spiral galaxy that spans over 100,000 light-years. NASA/ESA/The Hubble Heritage Team (STScI/AURA)

Even more importantly, Hubble found supermassive black holes to be common. Essentially every galaxy that possesses a dense, spherical bulge of stars surrounding its center hosts one of these beasts. These black holes range in size from perhaps 100,000 solar masses in dwarf galaxies to several billion solar masses in the biggest island universes. Hubble also showed that a black hole and its host galaxy are intimately linked: The masses of the stellar bulge and black hole grow in tandem.

Of course, Hubble does not restrict its gaze to the hearts of galaxies. It routinely explores individual stars known as Cepheid variables in nearby galaxies to pin down the expansion rate of the universe. Known as the Hubble constant after American astronomer Edwin

Hubble, who discovered this expansion and for whom the space telescope is named, the rate plays a fundamental role in cosmology. Cepheids serve as a critical rung on the cosmic distance ladder because the period of their pulsations tracks with their intrinsic luminosity. Observe how bright one appears in the sky and you can calculate how far away it is. Then measure how fast its host galaxy recedes from Earth and you get the expansion rate. Thirty years of Hubble observations have pinpointed the expansion rate at 73 kilometers per second per megaparsec (one megaparsec equals 3.26 million light-years). Oddly enough, measurements from the European Space Agency's Planck satellite give a value of 67, and scientists have yet to figure out how to bridge the gap. (See "Tension at the heart of cosmology" in the June 2019 issue.)

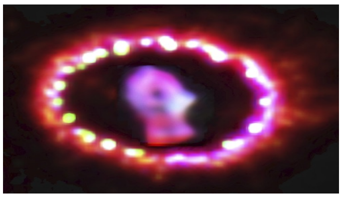

Tidal forces have pulled material from this pair of interacting spiral galaxies. .NASA/ESA/H. Ford (JHU)/G. Illingworth (UCSC/LO)/M. Clampin (STScI)/ G. Hartig (STScI)/The ACS Science Team

When the space telescope looks at galaxies in full, it usually finds a neighbor or two. In fact, Hubble has shown that collisions between galaxies are more the rule than the exception. Some of these collisions are in their early stages. For example, the Whirlpool Galaxy and its companion, NGC 5195, show only subtle traces of an initial interaction. Others, such as the Mice, display the distorted shapes and long tidal tails that develop as gravity acts over longer periods of time. And still others, exemplified by the Antennae galaxies, are experiencing a full-blown impact. Here, the galaxies have lost much of their individual identities as gas clouds ram into one another and trigger a maelstrom of star birth.

Speaking of galaxy collisions, Hubble has verified that the Milky Way is not immune. Detailed observations of our large neighbour, the Andromeda Galaxy, show that it is on a collision course with our galaxy and will not merely pass closely. Over the next several billion years, these two behemoths will act out the same scenes now being performed by the Mice and Antennae. It is not surprising that galaxies collide frequently. After all, Hubble observations show that the universe holds at least 100 billion galaxies. The number comes from the study of several 'deep fields' the telescope has taken by turning its cameras on small areas of apparently empty sky and exposing for days at a time. Each deep field captures thousands of galaxies, from which astronomers can estimate the universe's total number

Hubble's sensitive detectors only pick up the light coming from celestial objects. However, clever scientists have used its observations to map out the darkness that dominates our universe. Dark matter is a mysterious material that radiates no light but whose gravity serves as the glue that holds individual galaxies and galaxy clusters together. It makes up 27 percent of the mass-energy content of the universe, more than five times what the normal matter that forms stars, planets, and people contributes. The space telescope has been able to map the distribution of cosmic dark matter despite its invisibility. When astronomers look at large galaxy clusters, they often see wispy arcs and, sometimes, multiple images of background galaxies gravitationally lensed by material in the foreground cluster. These lenses magnify and distort light from more distant objects.

Astronomers dissect Hubble's images and calculate where dark matter has to be to produce the observed distortions.

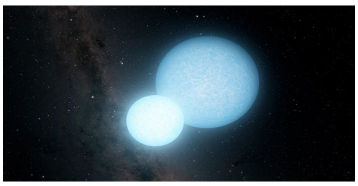

Hubble has studied the aftermath of Supernova 1987A throughout its 30 years in orbit. In this view, released in 2011, the progenitor star's tattered remains appear as an irregular blob at center, while the bright ring surrounding it consists of material the star released 20,000 years earlier that the supernova's shock wave is lighting up. NASA/ESA/Pete Challis (Harvard-Smithsonian Center for Astrophysics)

Although astronomers had seen hints that presaged many of Hubble's notable findings, the telescope's greatest discovery came out of the blue. Two research groups - one led by Saul Perlmutter of the University of California, Berkeley, and the other by Brian Schmidt at the Australian National University - were observing distant type Ia supernovae. These blasts occur in binary star systems in which a white dwarf pulls material from a red giant companion. When the white dwarf reaches around 1.4 solar masses, it explodes. Because type Ia supernovae arise from nearly identical progenitor stars, their peak luminosities match. So, once astronomers see how bright the supernova appears, they can calculate its distance. The teams found that the most distant type Ia explosions were fainter than their distances implied. The only way this made sense is if some force, dubbed 'dark energy', is accelerating cosmic expansion. Planck showed that dark energy accounts for about 68 percent of the universe's mass-energy content, a sign that our universe will expand forever at an ever-increasing rate.

Despite Hubble's wealth of scientific accomplishments, the beauty of its images ranks among its chief legacies. Who is not moved at seeing stars literally come to life in the glowing gas of a nearby nebula, watching the delicate tendrils of a dying star whose path the Sun will follow one day, or viewing the dramatic spiral structure of a nearby galaxy? Nearly every image has its own charm, no doubt because it reflects the beauty inherent in nature. And, with any luck, the hits will keep coming for many more years.

By: Richard Talcott

Rare pulsating white dwarf spotted in a binary star system 23 March: Over the course of its life, our Sun will go through several stages of stellar evolution, eventually ending its life as a white dwarf. Now, based on a new finding made by researchers at the University of Sheffield, we may be able to unlock even more details about our Sun's fate.


While studying a system with two white dwarfs, astronomers made an astounding find: one of the objects is pulsating. Caltech/IPAC

Astronomers studying a binary white dwarf system have found a new pulsating white dwarf. "We had no idea that the white dwarf was pulsating when we started the work," said Steven Parsons of the University of Sheffield. "It was a little bit of luck that allowed us to discover the pulsations." That luck came in the form of data from HiPERCAM, a high-speed imaging camera mounted on top of the world's largest telescope, the Gran Telescopio Canarias. The camera is able to take one picture every millisecond in five different colours. That capability allowed an undergraduate student working with the data to spot that one of the white dwarfs in the system is pulsating rapidly. "A lot of the work for this paper was actually done by the undergraduate student," said Parsons. Those pulsations will now help astronomers learn more about how being in a binary star system affects the internal structure of the white dwarf, which will in turn teach us more about these strange stellar remnants.

This binary system is even more special: The two stars are also eclipsing each other, meaning they pass in front of each other as seen from Earth. The white dwarf is the first pulsating star of its kind found in this type of star system. Through the pulsations and the eclipses, the team measured the mass and radius of the white dwarf. That allowed them to determine what it's made of. "It's generally very difficult to determine what a white dwarf is made out of because it's all hidden below a surface layer of hydrogen that we can't see through," said Parsons. "However, the size of a white dwarf is affected by its internal composition."

Most white dwarfs are made out of carbon and oxygen, created when a star runs out of hydrogen and begins fusing helium into heavier elements. However, this one is made mostly of helium. The team believes this strange composition could be because the star's companion stopped its evolution early, before it could fuse helium, leaving it with this strange chemical makeup. The researchers plan to continue watching the white dwarf to record as many pulsations as possible using HiPERCAM and the Hubble Space Telescope.

By: Hailey Rose McLaughlin

Evidence for an exotic dark matter candidate falls flat 26 March: Despite knowing dark matter is out there, astrophysicists are still missing one critical detail. "We know where it is and how much of it there is, but we don't know what it is," says Ben Safdi, an astrophysicist at the University of Michigan. Some think this mysterious substance is made of hypothetical subatomic particles called sterile neutrinos. Unlike regular neutrinos, which interact via both gravity and the weak nuclear force, sterile neutrinos would only interact via gravity. And that seems to be the exact same rules of engagement that dark matter follows.

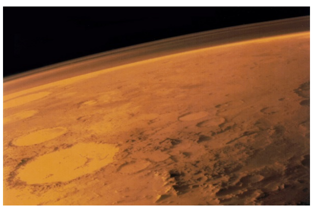
Astronomers searched the Milky Way for a specific X-ray signal that would suggest the existence of a hypothetical particle called the sterile neutrino, which is a proposed candidate for dark matter. NASA

For this reason, some astrophysicists have spent the past few years searching for X-ray signals that would be produced if sterile neutrinos were decaying into normal matter as hypothesized. If such X-ray signatures were found, they would suggest sterile neutrinos are a (if not the) elusive source of dark matter. Since 2014, an unexplained X-ray emission line uncovered in a number of other galaxies has kept some astronomers hopeful we might be close to finally finding a fitting candidate for dark matter. However, after sifting through 20 years' worth of data from the darkest, blackest regions of our own Milky Way in search of that special X-ray signal, Safdi and his research team failed to find it. That means there is currently no experimental evidence that dark matter is made of the sterile neutrino, Safdi and his team concluded. After all, if the extragalactic X-ray signal were produced by dark matter (specifically the decay of the sterile neutrino), and the Milky Way is full of dark matter, then we also should spot the signal in our own galaxy, too.

"We were disappointed. This is not the result we were hoping for," Safdi says. Their results do not mean that sterile neutrinos aren't the source of dark matter - just that they didn't find the X-ray signals that would suggest a connection. So now it is back to the drawing board to see what else might link dark matter to the sterile neutrino. Though other efforts to connect dark matter to those signals had peered into faraway galaxies, Safdi and his co-authors decided to look closer to home. "The leap we made was that if [the X-ray signal is issuing] there, then it should also be [issuing] around our own galaxy." The Milky Way, where our solar system resides, is surrounded by the mysterious substance, Safdi says. The team searched the absolute darkest, blankest portions of our galaxy — parts with presumably only dark matter — for the X-ray signal indicative of decaying sterile neutrinos. But they found no such signal. It is possible this X-ray signature appeared in other dark matter searches as a kind of contaminant, Safdi says. Looking at galaxies far away means interference from gases, stars, and other cosmic materials end up in the data. Dark matter information from our own galaxy is more pure. "We were looking for dark matter radiation on top of nothing," Safdi says.

Safdi and his team think that maybe other kinds of X-rays - ones with different wavelengths - may still prove that sterile neutrinos make up dark matter. They are now applying their same research concept to these different X-rays to see if those might be radiating from the most desolate regions of the Milky Way. "We now have this powerful method we can apply to this data," Safdi says, "And, who knows? Maybe we'll find evidence for dark matter." By: Leslie Nemo

Unlike Earth, Mars might not have had a global ocean of magma 30 March: At least once in its past, Earth existed as a roiling ball of molten rock that might have had the consistency of room-temperature oil, but would been untouchable at some 1,090 degrees Celsius. As magma oceans ebbed and flowed, the tumult might have launched elements conducive for life out of the rock and into our atmosphere. Researchers previously thought that maybe similar fluid dynamics - and the resulting spewing of life-supporting materials - likewise happened on Mars. However, new research suggests that is no the case. "We've had so little time to think about how a planet would evolve without a melting step, it's hard to tell if this is a net positive or net negative for [the possibility of] life," says Francis McCubbin, a NASA national materials coordinator and researcher.


1976 Viking 1 orbiter image of Mars, with its thin atmosphere. NASA

By studying meteorites that came from Mars, McCubbin and his colleagues determined that the planet hosts two regions where the rock contains different ratios of hydrogen varieties. If the planet had once been awash in liquid rock, the same ratio of hydrogen types would be found all over the place, the team concluded. Hydrogen analysis is one way to figure out whether Mars ever had a global magma ocean, McCubbin says. Other, yet-unstudied chemical systems on the planet could reveal ocean formation. That is part of why McCubbin says it is too early to consider this finding a thumbs-down for the possibility of life on Mars - and why their team plans to keep looking for signs of a once-liquid planet.

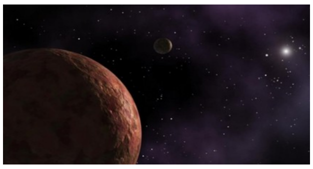
Before our solar system had planets, it had dust and gas. When those particles started clumping together, researchers think the clumps collided again and again until entire planets formed. Eventually, the clusters melted into an ocean of magma. Like a blender mixing strawberries and bananas into a smoothie, liquefying would swirl all the deposits from the early solar system together. The process would also churn material from inside the planet core and release it into the atmosphere, McCubbin says, including elements and chemicals necessary for life. McCubbin and his colleagues, including Jessica Barnes, a University of Arizona cosmochemist, studied whether that potentially life-giving magma formed by first looking at two meteorites. These rock chunks are pieces of Mars' surface, or crust, that crash-landed in Africa and Antarctica. Researchers have calculated that one last interacted with Martian water 3.9 billion years ago, and the other 1.5 billion years ago. The team found that there are different versions of hydrogen in those two rocks, and that the proportions of each element variety are similar. A comparable hydrogen ratio also appears in more recent examinations of the planet's crust, including in data from the Mars rover Curiosity. When the team compared all this information to Mars meteorites that originated from a deeper rocky layer in the planet, however, they saw something else. The hydrogen ratios in the deeper samples didn't share the same ratio.

Two mixes of hydrogen varieties suggest two spots of water formation on Mars that did not ever meet, and that subsurface, molten churns never happened. "A lot of what could have nurtured life in the atmosphere didn't get there — maybe," McCubbin says. There are other ways material from the core of Mars could have reached the atmosphere, like constant volcanic activity or hydrothermal vents, McCubbin says. Additionally, planetary scientists need to look at other chemicals on Mars and see if they counter the hydrogen finds and support the concept of a magma ocean.

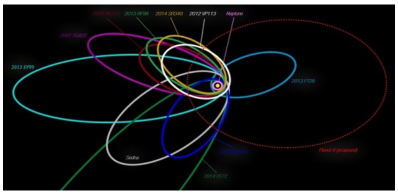
This research project relied heavily on studies from a range of meteorites - "it was sort of fortuitous that we could take a lot of data and compare them to our crustal samples," McCubbin says. Future work will need to keep analysing a whole suite of Mars samples. Fortunately, NASA adds new Mars meteorites to their collection on a regular basis, McCubbin says. We're retrieving more from Mars, too. The Perseverance rover will hit the planet to search for life in 2021, while another project may bring rock samples a decade later.

By: Leslie Nemo

Astronomers find 139 new minor planets in the outer solar system 31 March: Astronomers have discovered 139 new minor planets orbiting the Sun beyond Neptune by searching through data from the Dark Energy Survey. The new method for spotting small worlds is expected to reveal many thousands of distant objects in coming years —- meaning these first hundred or so are likely just the tip of the iceberg. Taken together, the newfound distant objects, as well as those to come, could resolve one of the most fascinating questions of modern astronomy: Is there a massive and mysterious world called Planet Nine lurking in the outskirts of our solar system?


The discovery of 139 new minor planets in the outer solar system, and especially the new method used to find them, might eventually help astronomers determine whether Planet Nine exists or not. NASA/JPL-Caltech

Neptune orbits the Sun at a distance of about 30 astronomical units (AU; where 1 AU is the Earth-Sun distance). Beyond Neptune lies the Kuiper Belt - a comet-rich band of frozen, rocky objects (including Pluto) that holds dozens to hundreds of times more mass than the asteroid belt. Within the Kuiper Belt and past its outer edge at 50 AU orbit distant bodies called trans-Neptunian objects (TNOs). Currently, we know of nearly 3,000 TNOs in the solar system, but estimates put the total number closer to 100,000. As more and more TNOs have been discovered over the years, some astronomers - including Konstantin Batygin and Mike Brown of Caltech - have noticed a small subset of these objects have peculiar orbits. They seem to bunch up in unexpected ways, as if an unseen object is herding these so-called extreme TNOs (eTNOs) into specific orbits. Batygin and Brown - in addition to other groups, like that led by Scott Sheppard of the Carnegie Institution for Science - think these bizarrely orbiting eTNOs point to the existence of a massive, distant world called Planet Nine.



In recent year, astronomers have discovered a number of far-flung objects that all have very similar perihelia, meaning they make their closest approaches to the Sun at about the same location in space. Fauxtoez/WikiMedia Commons

Hypothesised to be five to 15 times the mass of Earth and to orbit some 400 AU (or farther) from the Sun, the proposed Planet Nine would have enough of a gravitational pull that it could orchestrate the orbits of the eTNOs, causing them to cluster together as they make their closest approaches to the Sun. The problem is that the evidence for Planet Nine is so far indirect and sparse. There could be something else that explains the clumped orbits, or perhaps researchers stumbled on a few objects that just happen to have similar orbits. Discovering more TNOs, particularly beyond the Kuiper Belt, will allow astronomers to find more clues that could point to the location of the proposed Planet Nine - or deny its existence altogether. Of the 139 newly discovered minor planets found in this study, seven are eTNOs, which is a significant addition to a list that numbered around a dozen just a few months ago.

The new TNOs were found by astronomers at the University of Pennsylvania using data from the Dark Energy Survey (DES), which was not originally designed to look for distant minor planets. Gary Bernstein, astronomer at the University of Pennsylvania, has been fascinated by TNOs since "before Planet Nine was a thing" - and even before the Kuiper Belt's existence was confirmed in the 1990s. "Whenever I've gotten my hands on a new camera or something that is a technological advance, I've gone out and tried to figure out how to look for trans-Neptunian objects with it," Bernstein said "And DES, of course, is the biggest, best camera that we've ever had." DES, an international effort to understand dark energy, began observing the southern skies in 2013, using an extremely sensitive camera mounted on the Blanco 4-meter telescope in the Chilean Andes. Bernstein worked with astronomer Masao Sako and graduate student Pedro Bernardinelli, both at the University of Pennsylvania, to adapt the DES date for identifying TNOs.

“Most people, when trying to find TNOs, have a dedicated way of looking at the sky where they take images a few hours apart and you can see the objects move very easily,” Bernardinelli said. The DES data didn’t work that way. Bernardinelli had to design novel algorithms that could identify moving objects by connecting the dots between DES images, helping identify whether TNOs were present. The researchers then validated their movement-spotting algorithm against known TNOs and also confirmed that they could filter out fake objects.

To start with, Bernardinelli has only analysed a small subset of the DES data. When he applies his algorithm to the rest, he expects to find as many as 500 or more TNOs. Then, if the same method is applied to data from even more sensitive surveys on the horizon, such as by the new Vera C. Rubin Observatory, the group expects discoveries of new TNOs to number in the thousands. And with those numbers, astronomers might finally get a definitive answer to whether or not our solar system is harboring a giant planet in its distant reaches. “It’s a fantastic example of how a survey designed for one area of astronomy - to study the expansion history of the universe - can also produce great science in a completely unrelated area,” Alexander Mustill, a theoretical astrophysicist at Lund University in Sweden said.

Batygin, who is still pursuing his hunt for Planet Nine, calls this new method for finding TNOs “a brilliant idea”, adding that the research has uncovered new objects that may have otherwise gone undiscovered for years. Unfortunately, the new objects do not yet lead to anything conclusive about Planet Nine. The researchers released early results analysing whether the orbits of the seven newfound eTNOs support the clustering pattern that points to Planet Nine, but so far, they have turned up nothing. “If this were the first dataset that came out, then no one would have come up with the Planet Nine hypothesis because there appears to be no clustering [in the orbits of the new eTNOs],” says Sako. However, he adds that this does not disprove the existence of Planet Nine either. Their method could uncover other eTNOs that do support the proposed Planet Nine - or even spot the object itself.

Ann-Marie Madigan, an astronomer at the University of Colorado Boulder, says, “TNOs are difficult to detect, and so each one we find tells us that there is a much more massive underlying population [of objects] out there,” she says. The more TNOs we discover, the more we can tell if there’s evidence for Planet Nine. Or, alternatively, if Madigan’s own theory of collective gravity of very distant objects eliminates the apparent need for a Planet Nine. Regardless of whether Planet Nine exists or not, understanding the orbits and properties of TNOs will provide insights into the history of the giant planets, or perhaps past giants that were kicked to the outskirts of the solar system during its early years. “[TNOs] are relics of what happened in the solar system long ago,” Bernstein says. “They are out there in cold storage.” By: Erica Naone

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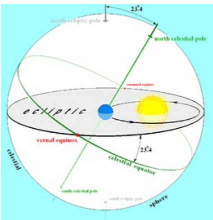
DID YOU KNOW?

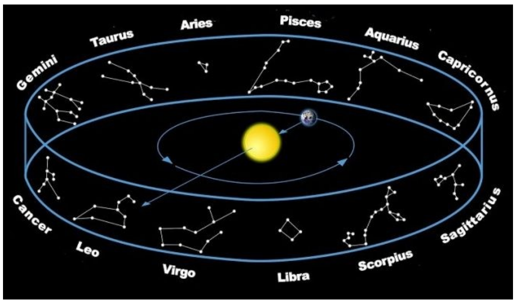
Zodiac constellations 2 – The zodiac



The zodiac is the area of the sky extending approx 8 degrees North and South of the ecliptic (the apparent path of the Sun across the celestial sphere). It is the strip of sky against which the Sun, Moon and planets are seen to orbit.

The ecliptic compared with Earth's tilt

Historically, the zodiac was divided into 12 areas, each occupying 30° of celestial longitude. These blocks correspond roughly to the constellations of Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces. The system forms a co-ordinate system with the ecliptic as the origin of latitude and the Sun's position at the vernal (March) equinox as the point of origin of latitude. As the Sun was in Aries when the system was developed, it is Aries that is considered the first sign in astrology, with that sign beginning on 21 (or 22) March.



'Zodiac' is the Latinised form of the Greek for 'cycle or circle of little animals'.The name reflects the prominence of animals and mythological hybrids among the zodiacal constellations. Although the term 'zodiac' commonly refers to astrology, it is also used in astronomy to identify the zodiacal area encompassing the lunar and planetary orbits. The constellations through which the ecliptic and the adjacent are of sky pass are called the zodiac constellations.

The history of the zodiac goes back to Chaldean (Babylonian) astronomy dating back to around 500 BCE. It draws on star groupings described in earlier Babylonian catalogues. The Babylonians decision to divide the area around the ecliptic into twelve parts because they followed a 12-month lunar calendar. Unlike modern placing of the start of zodiac with Aries at vernal equinox, Babylonian astronomers fixed the zodiac in relation to stars eg Cancer began at the end of a designated star in Gemini, the beginning of Aquarius started at the end of a named star in Capricorn.

The equal divisions did not correspond exactly to where constellations started and ended in sky; this would have created irregular sized divisions. Also, the Sun actually passes through 13 Babylonian constellations. In order to reconcile this with number of months in year, they decided to omit Ophiochus.

In reality, the situation is even more complicated. Modern astronomers have counted at least 21 constellations which, by definition of being within the zodiac, qualify as zodiac constellations. Constellations through which the planets also pass include Orion, Perseus, Auriga, Andromeda, Crater, Sextans, However, only the historic twelve retain their status as zodiac constellations.

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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