`"The Southern Cross"

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HERMANUS ASTRONOMY CENTRE NEWSLETTER

APRIL 2021

Monthly meeting This months **Zoom meeting** will take place on the evening of **Monday 19 April,** starting at **19.00.** Access details will be circulated to members closer to the time. The presenter is Dr Vanessa McBride, astronomer at the International Astronomical Union (IAU) Office for Astronomy Development in Cape Town. The title of her talk is 'Black holes: fact or fiction?'. See below for further details.

Important notice 2021 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 you will not be sent invitations to joint Zoom monthly or interest group meetings. All is not lost, however. You are welcome to rejoin the Centre at any time by contacting the Membership Secretary at johanretief@gmail.com

2021 meeting dates For your diaries. The remaining dates of the monthly meetings for 2021 are as follows: 19 April, 17 May, 21 June, 19 July, 16 August, 20 September, 18 October and 15 November.

WHAT'S UP?

Heavenly twins The two brightest stars in Gemini, which form the heads of the upside-down twins, can be seen low towards the north to the lower right of Orion. The one closer to the horizon is Castor (Alpha Geminorum). Higher in the sky, its neighbour Pollux (Beta Geminorum) forms the second of the twins born to Zeus and Leda in Greek mythology. Despite being awarded alpha status Castor is actually fainter than Beta Geminorum (Pollux). Both are located relatively close to Earth at 50 ly (Castor) and 34 ly (Pollux). Castor is a complex triple system, consisting of two large blue-white stars in binary orbits and a small, pale red dwarf. While Pollux is one star, a yellow-orange giant, it has the distinction of being one of the few stars visible to the naked eye known to have an orbiting planet. Discovered in 2006, the extrasolar planet (exoplanet) Pollux bhas a mass about 2.3x that of Jupiter.

LAST MONTH'S ACTIVITIES

Monthly centre meeting At the Zoom meeting on 15 March, Dr Kechil Kirkham, astronomer at the Inter-University Institute for Data-Intensive Astronomy (IDIA) at the University of Cape Town, gave a fascinating talk on 'How to make sense of all this stuff:

astronomical visualisation in the era of Big Data'. Kechil explained that IDIA focuses on ways to manage high performance data, particularly that derived from astronomical telescopes like KeerKAT. Imaging astro-data is all about making the "invisible visible". She outlined the numerous stages involved in the so-called 'pipeline', digital procedures which convert raw data to manageable visual formats which can be presented visually eg graphs, colour images and studied by scientists. Central to data processing is the essential need to maintain scientific integrity. Information contained within the raw data must be presented authentically and faithfully, without being altered or corrupted by the pipeline. The issue of 'visual literacy', ways in which people physiologically 'see' and interpret colour based on their cultural backgrounds also needs to be addressed. The international multi-national nature of astronomical research makes addressing this particularly important.

Kechil then opened a live window from the software programme being used by astronomers and demonstrated how changing different aspects of visualisations eg colour can provide them with greater detail about the object they are analysing. The capacity for computers to present images in 3-dimensions has given astronomers access to even more information than 2-dimensional images can. Finally, Kechil considered the challenge of data storage. Lengthy debate within the astronomical fraternity has reluctantly recognised that there is currently insufficient capacity to store all the raw data produced by modern telescopes. Instead, processed data ie the output of pipeline processes will be stored.

Interest groups

Cosmology Two Zoom meetings were held this month, as the April date falls on the Easter weekend. At the meeting held on 1 March, Derek Duckitt presented the next two lectures in the DVD series 'Blackholes, tides and curved spacetime: Under-standing gravity presented by Prof Benjamin Schumacher of Kenyon College. The topics were: L21: 'Which universe is ours?^ and L22: 'Cosmic antigravity: inflation and dark energy'. A the meeting held on 29 March, the final two lectures in the series were presented. The topics were: L23: 'The force of creation' and L24: 'The next revolution'.

Astro-photography At the Zoom meeting on 8 March, members. At the meeting on 13 continued discussing processing of astro-images.

Other activities

Educational outreach No activities took place during March.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's **Zoom meeting**, will take place on the evening of **Monday 19 April,** starting at **19.00**. Access details will be circulated to members. The presenter is Dr Vanessa McBride, astronomer at the International Astronomical Union (IAU) Office for Astronomy Development in Cape Town. Her talk sistitled 'Black holes: fact or fiction?' She writes: "The existence of black holes is predicted by Einstein's theory of gravitation, yet the very concept of black holes is mind boggling. This talk will take you on a journey of the discovery of black holes, presenting some of the evidence for their existence through astronomical observations, including the recent results from the Event Horizon Telescope. We will also explore some of the interesting effects that black holes have on light and matter nearby."

Biography Vanessa McBride is an astronomer at the Office of Astronomy for Development, where she works towards bridging the gap between the community of professional astronomers and the development world with a view to helping astronomers apply their skills to socio-ecoomic issues. She has a PhD in Astrophysics from the University of

Southampton and her research focuses on optical and X-ray observations of binary stars in which one of the stars is a neutron star. She is head of research at the South African Astronomical Observatory and adjunct associate professor at the University of Cape Town.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. Because the scheduled date for April coincided with the Easter weekend, this month's meeting was held at the end of March. The next meeting is on 3 May.

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 normally meets on the second Monday of each month. Members are currently communicating digitally about image processing they do at home. The next meeting will take place **via Zoom** on **Monday 12 April**.

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

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

Other activities **Stargazing** While no events will take place during the coronavirus pandemic, members are encouraged to submit their own images for circulation to the membership. Please e-mail them to petermh@hermanus.co.za

FUTURE TRIPS

No outings are being planned, at present.

2021 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month. For the present, they will be presented via Zoom. The remaining dates for this year are as follows: 19 April, 17 May, 21 June, 19 July, 16 August, 20 September, 18 October and 15 November.

Remaining external speakers for 2021 include Dr Vanessa McBride (April), Clyde Foster (May), Dr Rob Adam (June), Case Rijsdijk (September) and Pieter Kotzé (October). The other presenters are Centre members: Pierre de Villiers, Johan Retief and Jenny Morris. Details will be circulated closer to the time, each month.

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.

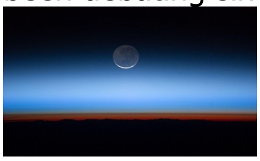
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer,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

The Kármán Line: Where does space begin? 5 March: These days, spacecraft ar venturing into the final frontier at a record pace. A deluge o paying space tourists should soon follow. To earn their astronaut wings, high-flying civilians will have to make it past the so-called Kármán line. This boundary sits some 100 kilometres above Earth's surface, and it is generally accepted as the place where Earth ends and outer space begins. From a cosmic perspective, 100 km is a stone's throw; it is only one-sixth the driving distance between San Francisco and Los Angeles It is also well within the clutches of Earth's overpowering gravitational pull and expansive atmosphere. So, how did humans come to accept this relatively nearby location as the defining line between Earth and space? The answer is partly based on physical reality and partly based on an arbitrary human construct. That is why the exact altitude where space begins is something scientists have been debating since before we even sent the first spacecraft into orbit.

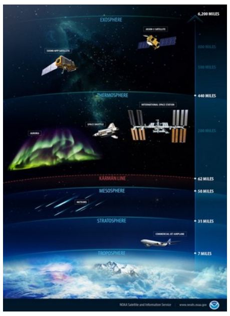

In this photograph captured aboard the International Space Station on 31 July 2011, the oblique angle reveals the layers of Earth's atmosphere, along with a thin crescent Moon illuminated by the Sun sitting below the horizon. NASA Earth Observatory

Experts have suggested the actual boundary between Earth and space lies anywhere from a mere 30 km above the surface to more than 1.6 million km away. However, for well over half a century, most - including regulatory bodies - have accepted something close to our current definition of the Kármán Line. The Kármán line is based on physical reality in the sense that it roughly marks the altitude where traditional aircraft can no longer effectively fly. Anything travelling above the Kármán line needs a propulsion system that does not rely on lift generated by Earth's atmosphere - the air is simply too thin that high up. In other words, the Kármán line is where the physical laws governing a craft's ability to fly shift. However, the Kármán line is also where the human laws governing aircraft and spacecraft diverge. There are no national borders that extend to outer space; it's governed more like international waters. So, settling on a boundary for space is about much more than the semantics of who gets to be called an astronaut. The United Nations has historically accepted the Kármán line as the boundary of space. While the US government has been reticent to agree to a specific height, people who fly above an altitude of 100 km typically earn astronaut wings from the Federal Aviation Administration. Even the Ansari X-prize chose the Kármán line as the benchmark height required to win its $10 million prize, which was claimed when Burt Rutan's SpaceShipOne became the first privately-built spacecraft to carry a crew back in 2004.

The Kármán line gets its name from Hungarian-born aerospace pioneer Theodore von Kármán. In the years around World War I, the engineer and physicist worked on early designs for helicopters, among other things. Then, in 1930, von Kármán moved to the United States and became a go-to expert in rockets and supersonic flight around World War II. Eventually, in 1944, Kármán and his colleagues founded the Jet Propulsion Laboratory, now a pre-eminent NASA lab. In addition to the boundary line of space, von

Kármán’s name is attached to a number of engineering equations, laws, constants, and aerospace designs, as well as a handful of awards in the field. However, the Kármán line is by far his most famous claim to fame, which he earned by being among the first to calculate the altitude above which aerodynamic lift could no longer keep an aircraft aloft.

Lift is largely generated by an airplane’s wings as it flies through the air, creating a force that opposes the plane’s weight, keeping it airborne. However, this concept does not work in space. Without enough air, there is no lift, which is why spaceships do not usually resemble aircraft. (The Space Shuttle and Virgin Galactic's SpaceShipTwo look a bit like planes because they were designed to glide back to a runway on Earth after venturing to space.) Von Kármán suggested that the most reasonable edge of space would be near where orbital forces exceed aerodynamic ones. Opting for a nice, round altitude, he decided that 100 kilometres was a good boundary. Despite now having his name attached to the boundary of space, von Kármán himself never actually published this idea.



The Kármán line is widely considered the ‘edge of space’, but it is really an inner edge. Earth's atmosphere continues far beyond. NOAA

The Kármán line is more of a ‘folk theorem’, according to spaceflight historian Jonathan McDowell, who published a paper on the subject in 2018. Folk theorems are usually described as well-known ideas in mathematics that were not published in their complete form. Von Kármán’s original work came out of a conference discussion, but the first fully-fledged publications on the boundary of space were done by Andrew Gallagher Haley — the world’s first practitioner of space law. In the early 1960s, Haley applied von Kármán’s criteria (orbital forces exceeding aerodynamic ones) more specifically, determining the actual boundary of space is some 84 km above the ground, according to McDowell. This altitude corresponds with the mesopause, which is the outermost physical boundary of Earth's atmosphere where meteors typically burn up. It is also roughly the altitude that was used by the US Air Force in the 1950s when it gave out astronaut wings to test pilots who flew over 80 km high.

In fact, if the Air Force specified the Kármán line as the defining boundary of space, it would strip astronaut wings from some of those earliest pioneering test pilots. That is partly why some experts have argued for a return to the original definition of roughly 80 km. From McDowell's perspective, the lower altitude is also just more accurate. The boundary between Earth and space shouldn't be arbitrary; it should be based on physics. As von Kármán himself wrote in his posthumously published autobiography, The Wind and Beyond: “This is certainly a physical boundary, where aerodynamics stops and astronautics begins, and so I thought why should it not also be a jurisdictional boundary? Below this line, space belongs to each country. Above this level, there would be free space.”

By: Eric Betz

'Super Soaker' rocket creates gleaming cloud at the edge of space 8 March: On 26 January 2018, a trio of NASA sounding rockets launched from Fairbanks, Alaska, on a mission to create an artificial noctilucent cloud. Also known as polar mesospheric clouds (PMCs), these twilight spectres are wisps of ice crystals that form roughly 80 kilometres high and glimmer during summer twilight, reflecting sunlight from their high-altitude perch. As seen in this long-exposure photograph, the main rocket - dubbed the 'Super Soaker' - deployed an explosive canister containing about 220 kilograms of water at an altitude of about 85 km. Two support rockets fired vapour tracers — streams of trimethyl aluminium gas which react with oxygen in the atmosphere and luminesce - to help track winds.

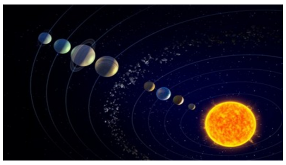

NASA's Wallops Flight Facility/Poker Flat Research Range/Zayn Roohi

The research was intended to investigate why PMCs are so often caused by water exhaust from rocket launches. A single space shuttle launch - and the exhaust from its three main engines could produce roughly 10 to 20 percent of all PMCs observed over the Arctic or Antarctic in a season. The results iindicate that water exhaust does more than simply provide material for the icy clouds: The explosive injection of water also cooled its immediate surroundings by roughly 25 degrees Celsius within seconds, inducing the PMC to form. By: Mark Zastrow

The asteroid belt: Wreckage of a destroyed planet or something else? 9 March: Just outside the orbit of Mars sits our Sun's premier collection of space rocks. The asteroid belt has captivated the imaginations of science fiction authors and scientists alike who have considered the possibilities of mining ore, water and other material from the region to boost further space exploration. How was this orbiting field of debris formed? Does it represent the rocky bones of a former planet from aeons past, or is it a type of gathering place for a planet-to-be? Scientists have considered both responses as possibilities over the decades. More recent theories contend that the vast ring of space rocks likely never was a whole planet and is unlikely to be so in the relatively near galactic future. Why? There simply is not enough material there. "This is the cool place in our solar system where all the small bodies go," says William Bottke, director of Space Studies at the Southwest Research Institute, a non-profit research and development organization headquartered in San Antonio, Texas.


Andrea Danti/Shutterstock

Billions of years ago, our solar system was far from being a stable and organised place. Planets were still forming, throwing their neighbour's orbits out of whack in the process. In light of all this action, some astronomers used to believe a planet that orbited our Sun between the trajectories of Mars and Jupiter was blasted into pieces and formed the asteroid belt that floats in space today. Scientists thought that "maybe there was a planet there and it got blown to smithereens," explains Sean Raymond, an astronomer at the Astrophysical Laboratory of Bordeaux, in France. However, after researchers began to examine the patterns in iron meteorites that fell to the Earth as meteors, Raymond says, it became clear they did not come from one parent body. As a result, the thinking began to shift toward the idea that the asteroid belt was full of planetesimals, or pieces of a planet that either had not formed or failed to form. The trouble with this theory is that there just is not enough material in the belt to create such a mass. Ceres is the single largest asteroid in the belt, roughly the size of Australia with a mass nearly half that of all the material of the belt, according to Raymond. “It’s like tiny little crumbs,” Raymond says.


Mopic/Shutterstock

Just because the asteroid belt does not represent the leftovers of a former planet does not mean scientists have abandoned the idea entirely. The belt might have come from parts of other planets that still exist, or be part of a planetesimal - which is like a baby planet - that never completely formed before being smashed apart. “It used to be kind of a simple story, but in recent years it’s gotten increasingly more complicated as we learn more about planet formation,” Bottke says. Raymond says that these bits could have been left over from when Jupiter and Saturn were still forming. Later on, these planets may have migrated around the solar system until they eventually reached their present orbits. This would have resulted in a dynamic instability, with chaotic orbits and gravitational forces. “The solar system of today looks very different from the way it looked 4.5 billion years ago,” Bottke says.

We now know the asteroid belt does not contain material from a single source. Some of its components might have been derived from the general region of space it currently inhabits. Other material might have come from sources beyond the orbit of Jupiter, Bottke says. Still other asteroids might have arrived from the inner-planets zone, as bits that broke off at some point. The movements of planets during the solar system’s early period of instability could have resulted in the gravities of Saturn and Jupiter sucking in some material, while sending other asteroids careening into other planets or right out of our solar system entirely. Some researchers even believe that water-rich asteroids banged into Earth in this period, leading to the creation of the oceans we still have today. Raymond says a fraction of these rocks would have been sent off in the right trajectory and speed to join the asteroid belt. “In that context, we sometimes call the asteroid belt the blood spatter of the solar system,” he says. Whatever violence might have resulted in sending these bits and pieces to the asteroid belt, the reason they stay put is because Mars and Jupiter's orbits eventually stabilsed. So if an asteroid manages to find its way there, it is likely not going anywhere, Bottke says.

According to Raymond, the solar system question that most astronomers are concerned with is how the planets formed. The composition of asteroids, their position and their orbits continue to reveal clues about the distant past of the planets. “Even though we care more about the planets than the asteroids in general, the asteroids are a really good tool for trying to figure out what happened with the planets,” Raymond says. “They’re a really key piece of evidence in that story.” By: Joshua Rapp Learn

Space hurricane of plasma spotted above Earth’s North Pole 19 March: The morning of 20 August 2014 was a quiet one in Earth’s ionosphere. The solar wind was calm and slack, and the orientation of the Sun's magnetic field was stable, not conducive to producing much space weather. Then, hundreds of kilometres above the North Pole, the ionosphere suddenly whipped itself into a fury, spawning a massive space hurricane some 1,000 kilometres wide - a cyclone of plasma swirling above Earth for eight hours. The phenomenon was captured in real-time by US military weather satellites. However, it was only recently uncovered in archival data by a team led by researchers at Shandong University in China. "Until now, it was uncertain that space plasma hurricanes even existed, so to prove this with such a striking observation is incredible," said co-author Mike Lockwood of the University of Reading.


Plasma and the spiral auroral arms of a space hurricane twirl high Earth's polar region in this artist's concept. Qing-He Zhang, Shandong University

The moniker 'space hurricane' is not just a catchy nickname - the physics of how it formed are actually analogous to how 'normal' hurricanes gather and focus energy in the lower atmosphere. Like their atmospheric counterparts, this space storm was instigated by an area of low pressure that gave rise to rapid convection. On Earth, that convective process occurs from below: heat from warm ocean waters drives evaporation and rising air, dumping energy into the atmosphere that gets focused by inrushing wind. In space, though, that convective energy comes from above - thanks to the magnetic fields of the Earth and Sun interacting and shearing across one another. The Sun's magnetic field has a wavy pattern as it stretches out into the solar system, meaning it can be aligned northward or southward depending on where Earth sits in it. On that August day in 2014, the region of the Sun's magnetic field around Earth happened to be aligned northward. That means it does not neatly connect to Earth's magnetic field, which is also aligned northward - the field lines tend to repel each other, typically leading to calm space weather conditions. However, these conditions sometimes give rise to a spot of aurora near the poles, where electrons rain downward and electric current flows up, just like the convection at the heart of a hurricane. This caused the surrounding plasma to begin flowing around the central spot of convection, forming 'rain bands' of electrons that produced spiral auroral arms around a stable eye. At the core of the system was a corkscrew-shaped magnetic field that funnelled magnetic energy from space into Earth's ionosphere - and it lasted eight hours before dissipating.

Though space hurricanes do not have the same kind of deadly impact that atmospheric cousins can, the influx of energetic particles such storms bring to the ionosphere could interfere with satellites, even affecting their orbits by creating more drag on them. Because this particular storm popped up during a relatively quiet period of geomagnetic activity, the researchers say space hurricanes may be even more common than we thought. "Plasma and magnetic fields in the atmosphere of planets exist throughout the universe, so the findings suggest space hurricanes should be a widespread phenomena," said Lockwood. By: Mark Zastrow

Physicists "cautiously optimistic" about CERN evidence for new fundamental particle 23 March: When CERN's gargantuan accelerator, the Large Hadron Collider (LHC), fired up ten years ago, hopes abounded that new particles would soon be discovered that could help us unravel physics' deepest mysteries. Dark matter, microscopic black holes, and hidden dimensions were just some of the possibilities. However, aside from the spectacular discovery of the Higgs boson, the project has failed to yield any clues as to what might lie beyond the standard model of particle physics, our current best theory of the micro-cosmos. So our new paper from LHCb, one of the four giant LHC experiments, is likely to set physicists' hearts beating just a little faster. After analysing trillions of collisions produced over the last decade, we may be seeing evidence of something altogether new - potentially the carrier of a brand new force of nature. However, the excitement is tempered by extreme caution. The standard model has withstood every experimental test thrown at it since it was assembled in the 1970s, so to claim that we're finally seeing something it cannot explain requires extraordinary evidence.


Particle collisions are starting to reveal unexpected results vchal/Shutterstock

The standard model describes nature on the smallest of scales, comprising fundamental particles, known as leptons (such as electrons) and quarks (which can come together to form heavier particles such as protons and neutrons) and the forces they interact with. There are many different kinds of quarks, some of which are unstable and can decay into other particles. The new result relates to an experimental anomaly that was first hinted at in 2014, when LHCb physicists spotted 'beauty' quarks decaying in unexpected ways. Specifically, beauty quarks appeared to be decaying into leptons called 'muons' less often than they decayed into electrons. This is strange because the muon is in essence a carbon-copy of the electron, identical in every way except that it's around 200 times heavier. You would expect beauty quarks to decay into muons just as often as they do to electrons. The only way these decays could happen at different rates is if some never-before-seen particles were getting involved in the decay and tipping the scales against muons. While the 2014 result was intriguing, it was not precise enough to draw a firm conclusion. Since then, a number of other anomalies have appeared in related processes. They have all individually been too subtle for researchers to be confident that they were genuine signs of new physics, but tantalizingly, they all seemed to be pointing in a similar direction.

The big question was whether these anomalies would get stronger as more data was analysed or melt away into nothing. In 2019, LHCb performed the same measurements of beauty quark decay again but with extra data taken in 2015 and 2016. However, things were not much clearer than they had been five years earlier. Today's result doubles the existing dataset by adding the sample recorded in 2017 and 2018. To avoid accidentally introducing biases, the data was analysed 'blind' - the scientists could not see the result until all the procedures used in the measurement had been tested and reviewed. Mitesh Patel, a particle physicist at Imperial College London and one of the leaders of the experiment, described the excitement he felt when the moment came to look at the result. "I was actually shaking", he said, "I realised this was probably the most exciting thing I've done in my 20 years in particle physics." When the result came up on the screen, the anomaly was still there - around 85 muon decays for every 100 electron decays, but with a smaller uncertainty than before. What will excite many physicists is that the uncertainty of the result is now over 'three sigma' - scientists' way of saying that there is only around a one in a thousand chance that the result is a random fluke of the data. Conventionally, particle physicists call anything over three sigma ‘evidence’. However, we are still a long way from a confirmed ‘discovery’ or ‘observation’ - that would require five sigma.

Theorists have shown it is possible to explain this anomaly (and others) by recognising the existence of brand new particles that are influencing the ways in which the quarks decays. One possibility is a fundamental particle called a ‘Z prime’ - in essence a carrier of a brand new force of nature. This force would be extremely weak, which is why we haven’t seen any signs of it until now, and would interact with electrons and muons differently. Another option is the hypothetical ‘leptoquark’ - a particle that has the unique ability to decay to quarks and leptons simultaneously and could be part of a larger puzzle that explains why we see the particles that we do in nature.


LHCb experiment. CERN

So have we finally seen evidence of new physics? Well, maybe, maybe not. We do a lot of measurements at the LHC, so you might expect at least some of them to fall this far from the standard model. We can never totally discount the possibility that there’s some bias in our experiment that we have not properly accounted for, even though this result has been checked extraordinarily thoroughly. Ultimately, the picture will only become clearer with more data. LHCb is currently undergoing a major upgrade to dramatically increase the rate it can record collisions. Even if the anomaly persists, it will probably only be fully accepted once an independent experiment confirms the results. One exciting possibility is that we may be able to detect the new particles responsible for the effect being created directly in the collisions at the LHC. Meanwhile, the Belle II experiment in Japan should be able to make similar measurements.

What then, could this mean for the future of fundamental physics? If what we are seeing is really the harbinger of some new fundamental particles then it will finally be the breakthrough that physicists have been yearning for for decades. We will have finally seen a part of the larger picture that lies beyond the standard model, which ultimately could allow us to unravel any number of established mysteries. These include the nature of the invisible dark matter that fills the universe, or the nature of the Higgs boson. It could even help theorists unify the fundamental particles and forces. Or, perhaps best of all, it could be pointing at something we have never even considered. So, should we be excited? Yes, results like this do not come around very often, the hunt is definitely on. However, we should be cautious and humble too; extraordinary claims require extraordinary evidence. Only time and hard work will tell if we have finally seen the first glimmer of what lies beyond our current understanding of particle physics.

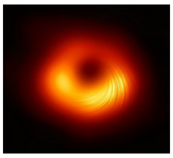
By: Paula Alvarez Cartelle, Harry Cliff, Konstantinos Petridis, The Conversation

Global telescope creates exquisite map of black hole’s swirling magnetic field

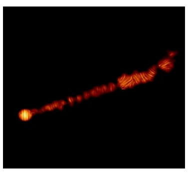
24 March: The elliptical galaxy M87 sits 55 million light-years away, at the heart of the nearby Virgo Cluster. Deep inside this galaxy lurks a supermassive black hole that weighs 6.5 billion times the mass of our Sun. That black hole instantly became famous in 2019 when the Event Horizon Telescope (EHT) collaboration released its portrait — the rist ever direct image of the shadow of a black hole. Now, the EHT collaboration has released

updated views of M87 that offer an unprecedented look at the light streaming from just outside its black hole. These pictures reveal the complex structure of a powerful magnetic field that astronomers believe is responsible for shooting a 5,000 light-year-long jet from the black hole at nearly the speed of light.

When light waves pass near a strong magnetic field, the tug of that field leaves an unmistakable mark on them. Like iron filings lining up to show the invisible magnetic field lines of a bar magnet, light waves 'line up' - or become polarised - in the presence of magnetic fields, which can reveal clues about the field's structure and strength. That is what EHT collaboration researchers have seen. "The polarisation of light carries information that allows us to better understand the physics behind the image we saw in April 2019," explained Iván Martí-Vidal at the University of Valencia in Spain, one of the EHT Polarimetry Working Group's coordinators. "Unveiling this new polarized-light image required years of work due to the complex techniques involved in obtaining and analyzing the data," he added.


The magnetic field around M87's supermassive black hole tweaks the orientation of light waves emitted from the hot, glowing accretion disk (orange) around it. EHT Collaboration

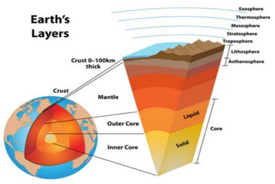
One new image shows the polarisation of the light coming from the accretion disk of hot material surrounding and flowing into M87's black hole. At least part of this ring is significantly polarized. That fact, in turn, tells astronomers the disk contains highly magnetised gas. They estimate the black hole's magnetic field strength is between 1 and 30 Gauss, or roughly 2 to 50 times stronger than Earth's own magnetic field. Furthermore, near the black hole's event horizon, or point of no return, researchers found the magnetic field is so strong it pushes some material away, even as most flows inward, forever disappearing inside the black hole. Based on models of the accretion disk using this new information, researchers calculate that M87's black hole is sucking down material at a rate of 0.0003 to 0.002 solar masses each year. The ability of the black hole's magnetic field to serve as a gatekeeper, preventing at least some material from falling inside, could be key to how M87's black hole spews out extended jets of material, which stretch thousands of light-years beyond the galaxy. Astronomers have long believed that magnetic fields play a crucial role in this process, but they are just now getting a detailed look at how exactly it might occur. Such a close-up view will help researchers better tweak their models of how matter and magnetic fields behave extremely close to black holes.


Data taken with ALMA show the orientation of light within a portion of M87's far-reaching jet. The light's orientation is related to the structure and strength of the magnetic field in that region. ALMA (ESO/NAOJ/NRAO), Goddi et al.

EHT collaborators also used data from the Atacama Large Millimetre/submillimetre Array (ALMA) in Chile - part of the global, virtually linked network of radio telescopes that make up EHT - to map the polarisation of light in a section of jet farther from the black hole. So now, astronomers not only have an extremely close-in view, but also a zoomed-out picture of how material and magnetic fields in M87's jet evolve as they travel from their point of origin. "We are now seeing the next crucial piece of evidence to understand how magnetic fields behave around black holes, and how activity in this very compact region of space can drive powerful jets that extend far beyond the galaxy," said Monika Mościbrodzka of Radboud University in the Netherlands, another EHT Polarimetry Working Group co-ordinator. Although no EHT observations were made in 2019 or 2020, the worldwide collaboration plans to resume observing this year, with even more facilities linked in as part of its virtual, planet-spanning dish. By: Alison Klesman

Earth has been hiding a fifth layer in its inner core 26 March: One of geology's basic principles is that the Earth is made up of four layers: the crust, the mantle, the outer core, and the inner core. This may be squashed in light of a new study that suggests Earth actually has a distinct fifth layer that hass been under our feet all along. Researchers at the Australian National University (ANU) say that the new layer they uncovered is located within Earth's inner core. Deeper analysis of this discovery could help scientists better understand our planet's history and evolution.

Approximately 4.6 billion years ago, the Earth formed. The story starts with the planet's interior or rocky, which formed through the collision of heavy elements. The core, found at the centre of the Earth, is made up of two parts. The outer layer, comprising liquid iron alloy, is about 2,168 km thick. The outer core is also thought to be responsible for Earth's magnetic field. In contrast, the inner core is made up of solid iron alloy with a radius of 1,216 km Next comes the mantle, which sits directly above the core. This layer is composed of mostly silicate rocks that are rich in magnesium and iron. The mantle has a thickness of about 2,869 km, making it Earth's thickest layer. The thinnest and most brittle layer is the crust, however. It varies between 29.8 and 69.6 km in thickness and forms the outermost layer of our home planet.



Earth's layers before the discovery of the innermost-inner core. The newest layer is situated just below the inner core. OSweetNature/Shutterstock

Scientists have long suspected that Earth's inner core was made of two layers. It was not until ANU researchers took a closer look at what lies below that an 'innermost inner core was confirmed. Their work revealed a distinct change in the structure of iron deep within the inner core at about 5,766 km below the Earth's surface. You may recall from earlier that the inner core consists of solid iron alloy. This is due to high pressure deep within the Earth that stops the iron alloy from melting. However, distinct structural changes were detected in this iron alloy that set apart the newly discovered innermost layer from the rest of the inner core. According to Salon, this discovery led the researchers to believe that the change in structure might have been caused by an unknown, dramatic event early in Earth's history. Further examination of this tiny layer may provide additional details around how our planets formed. "The details of this big event are still a bit of a mystery, but we've added another piece of the puzzle when it comes to our knowledge of the Earths' inner core," said the study's lead author and researcher, Joanne Stephenson.

Seismic monitoring allows us to gain a better understanding of Earth's interior. This is made possible by measuring sound waves that are created by earthquakes and pass through Earth's layers. By analysing how the different layers cause the sound waves to slow down, scientists can catch a glimpse of what lies below. The recent discovery was made with the aid of a special search algorithm that researchers used to compare thousands of models of the inner core with decades worth of data on how long seismic waves take to travel through Earth. This data, gathered by seismograph stations all over the world, helped detect the changes in the structure of iron in the inner core. These findings helped confirm that Earth’s inner core has another layer. Although this work is still being analysed, the discovery of a new layer may pave the way for a new geological principle and prompt textbooks to be rewritten. By: Donna Sarkar

These giant mirrors will help astronomers see to the edges of the universe 30 March: When completed, the Giant Magellan Telescope being built in Chile's Atacama Desert will gather images of the universe that are 10 times sharper than those produced by the Hubble Space Telescope. It will snap photos of distant planets and search them for signs of life, reveal the masses and compositions of infant galaxies and analyse how stars are born and die.


Artist's rendering shows what the Giant Magellan Telescope will look like when fully built GMTO

At around 13 stories tall, and weighing around 6.3 million kilograms, including the supporting structure, the GMT will be part of a new generation of ‘extremely large telescopes’ that astronomers believe will bestow new insights into the unsolved mysteries of the universe. Constructing such a behemoth is a feat of engineering. This month, workers began casting the sixth of the seven enormous mirrors that will be arrayed in a flower shape to form the telescope's primary light-gathering surface. Each mirror takes four years to make. First, engineers and technicians build a honeycomb-shaped mould and fill it with 18 tonnes of extremely pure borosilicate glass from Japan. The honeycomb structure makes the mirror relatively lightweight given its enormous size: nearly 8.4 metres across. Next, a furnace heats the glass to above 1,093 degrees Celsius to make it flow like honey. The furnace spins so that as the glass melts, moving up the sides of the mould to form a curved surface. Carefully cooling the glass back to room temperature takes months.

After the mirror is cast, it must be ground and polished in a years-long process until it deviates on average by less than one-millionth of an inch from its intended shape. To achieve this extreme accuracy, researchers had to invent new polishing tools and new methods of measuring the mirror's shape. "None of us have a very good feel for what a millionth of an inch is, myself included," said Buddy Martin, a project scientist at the Richard F. Caris Mirror Lab at the University of Arizona where the mirrors are made,. "I like to think of it as, if the mirror were expanded to the size of North America – 3,500 miles in diameter -- then the average hill would be 2/3 of an inch tall and the average valley 2/3 of an inch deep. That's how smooth this mirror has to be for it to make the sharpest images that nature will allow."

In addition to its large primary mirrors, the GMT telescope design includes smaller secondary mirrors that can adjust their shape 1,000 times per second to counteract the 'twinkle' that turbulent air in the atmosphere imparts to the light from the stars. "The leap in sensitivity and resolution that we're going to make with GMT will revolutionise our understanding of all areas of astronomy, from the formation and evolution of objects we can see, like planets, stars, black holes and galaxies, to cosmology and the things we can't directly see, like the nature of dark matter and dark energy," said Rebecca Bernstein, the lead project scientist at GMT. Construction has already begun at the Las Campanas Observatory site that the telescope will call home. Current plans are for the first four primary mirrors to be shipped to Chile in the late 2020s, where they will be coated with an extremely thin layer of reflective aluminium. The telescope should see "first light" with these first four mirrors before the end of the decade and should have all seven primary mirrors in place in the early 2030s. By: Catherine Meyers

Source of these and further astronomy news items: www.astronomy.com/news

DID YOU KNOW?

Zodiac constellations 14: Virgo

The constellation of the 'the virgin' (Latin) is the 2nd largest of the modern constellations (after Hydra) and the largest zodiac constellations.

Virgo has long been associated with fertility. In Babylonian astronomy, it was part of a constellation known as 'the furrow', representing goddess Shala and her ear of grain. In ancient Greece, Virgo was associated with Demeter, the goddess of wheat and agriculture, while the Romans associated it with Ceres, their goddess of agriculture and fertility. The name of the constellation's brightest star, Spica, also reflects the association with fertility. In Greek mythology, Virgo was also sometimes identified as the virgin goddess Iustitia or Astarea, the goddess holding the scales of justice in her hand. The scales were later separated from the Virgo constellation to form Libra. During the Middle Ages, Virgo was also sometimes associated with the Virgin Mary.

The Sun passes through Virgo from late-September to the end of October (5+ wks). Thus, it is in Virgo at the September equinox. Any perceived link between the constellation of the fertility goddess and the autumnal equinox (in the northern hemisphere), which is associated with the harvest, is coincidental. This coincidence is a consequence of precession of the equinoxes. One of the two points in the sky where the celestial equator crosses the ecliptic, the First Point of Libra (autumn equinox point) was originally in Libra, but has moved westward over the centuries (similarly, the other crossing point, the First Point of Aries, is now in Pisces). This point will move out of Virgo to Leo around 2440 CE.

Virgo has at least 29 stars with known exoplanets. It has eleven Messier objects and several galaxy clusters, particularly the Virgo cluster.

Notable features include:

- Alpha Virginis (Spica – 'ear of grain'): a blue-white star of magnitude 1.0. Located 260 ly away. It is, in fact, a spectroscopic binary.
- Virgo cluster: the nearest large cluster of galaxies and centre of the local

supercluster. Mostly all in Virgo, it edges into Coma Berinices. It is an irregular, roughly elliptical cluster of over 2,000 galaxies, with a diameter of 9 million ly. The brightest galaxies giant ellipticals including M49, M60, M84, M86, and M87. M59 and

M89 are also elliptical galaxies. Other galaxies are spirals, including M58, M61 and M90. About 55 million ly away, its detail can be observed through a telescope

- M104 (Sombrero galaxy): a spectacular spiral galaxy, oriented almost edge on to Earth, giving the appearance of a Mexican hat. It is about two-thirds closer to Earth than the Virgo cluster at around 28 million ly away. Its central bulge, made of older stars, is larger than normal. This is surrounded by large bright globular clusters. A very prominent dark lane of dust comprising polycyclic aromatic hydrocarbons runs across the galaxy. Observation requires a telescope.
- Virgo A: this strong radio source in M87 is a highly active galaxy. M87 is the largest galaxy in Virgo. Virgo A is a classical radio galaxy, with tqo lobes, the brighter one fed by a prominent jet 4,000 ly long (also visible at optical wavelengths) arising from the galaxy's central supermassive black hole. Located 60 million ly away, it is observable by telescope.
- Brightest quasar (C3 273): the first quasar identified, is has a magnitude of 12.9 and is located around 3 billion ly away.

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

For more information on the Hermanus Astronomy Centre and its activities, vvisit our website at www.hermanusastronomy.co.za

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