`"The Southern Cross"

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HERMANUS ASTRONOMY CENTRE NEWSLETTER

MARCH 2021

Monthly meeting This months **Zoom meeting** will take place on the evening of **Monday 15 March,** starting at **19.00.** Access details will be circulated to members closer to the time. Dr Kechil Kirkham, astronomer at the Inter-University Institute for Data-Intensive Astronomy (IDIA) at the University of Cape Town, will be talking on How to make sense of all this stuff: astronomical visualisation in the era of Big Data' See below for details.

Membership renewal for 2021 – final reminder
There will be no increase in fees this year.

The 2021 fees will remain at:
Member: R160
Member's spouse/partner/child, student: R80

Payment can be made in cash (directly to the Treasurer), or via online transfer. The Standard Bank details, for the latter, are as follows:
Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001
If you make an online donation, please reference your name and 'subs' or 'membership', or it is not possible to attribute the payment to you.

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

WHAT'S UP?

Mars passes between Pleides and Hyades During the first three weeks of the month, Mars will be passing between the two iconic open clusters of the Taurus constellation – Pleides and Hyades. The planet's reddish colour is easily visible to the naked eye. The colour is a result of the high iron content in its surface rock. The virtual absence of an atmosphere means that the rocky surface is clearly visible. In contrast, Mars's two poles are covered with permanent white ice-caps. Although not currently active, Mars has a history of volcanic activity which has created huge plains of lava, and, most noticeably, the tallest volcano in the solar system. Olympus Mons is three times the height of Mt Everest. A number of space missions to Mars have provided evidence that Mars was previously a wet planet. These include the icy polar regions, surface channel systems created by moving water and water ice found beneath the dusty surface. The planet is 228 million km from the Sun, and its cold; surface temperatures averages -60ºC. Despite the many challenges, including how to manage damaging radiation, active work is being done to fulfil the goal of landing humans on the surface of the red planet.

LAST MONTH'S ACTIVITIES

Monthly centre meeting The Centre's AGM was held via Zoom on 15 February. In his report, chairman Pierre de Villiers described 2020 as a year of three parts: January – March (normal activities), April – July (no activities) and August – December (modified activities). Monthly meetings and cosmology, astro-photography and study group meetings resumed successfully via Zoom, from August. While publications - sky notes, newsletter and website – continued throughout the year, group activities like star gazing were not able to take place due to government restrictions and health concerns. A couple of carefully managed outreach events did take place, but these were the exception. Pierre noted the passing of John Heyns, noting has valuable contribution to the Centre over the years, particularly for establishing the study group. He then thanked the committee members, and others involved in leading Centre activities, noting that they have agreed to continue in their roles for another year. Spaces still exist on the committee and he invited members to consider volunteering to join.

The treasurer, Laura Norris, then presented the summary finances for the year. While lockdown and moving meetings to Zoom meant reduced income from meeting attendance, money was saved on paying rent for the use of the hall. Overall, the financial records confirmed the healthy position of the Centre's finances.

Interest groups

Cosmology At the Zoom meeting, held on 1 February, 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: L19: 'Gravitomagnetism and gravitational waves' and L 20: 'Gravity's horizon: anatomy of a black hole'

Astro-photography There was no meeting in February.

Other activities

Educational outreach No activities took place during February.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's **Zoom meeting**, will take place on the evening of **Monday 15 March,** starting at **19.00**. Access details will be circulated to members. Dr Kechil Kirkham, astronomer at the Inter-University Institute for Data-Intensive Astronomy (IDIA) at the University of Cape Town, will be talking on 'How to make sense of all this stuff: astronomical visualisation in the era of Big Data'.

Biography "Kechil Kirkham has had the great fortune to work in the South African space industry in the field of astronomy, and now works for the Inter-University Institute for Data-Intensive Astronomy at the University of Cape Town, and at the South African Radio Astronomy Observatory. Her work is on the IT and engineering side of astronomy. She is a long-standing member and erstwhile Chair of the Cape Centre and is currently on the committee. She was raised in a village on the Scottish border, and has a degree from Cambridge University in Anthropology. A couple more degrees along the way and an

abiding passion for the stars, brought her to Cape Town from Uganda in 2003 where she was managing an Information Systems company.
She has been broadcasting *Looking Up*, a weekly astronomy and space radio show, on Fine Music Radio 101.3 since 2006 http://www.fmr.co.za/podcasts/looking-up/. As a member of the Astronomy Advisory Committee to the South African government she often speaks about astrotourism, having run Over The Moon for 10 years – a side gig introducing tourists to the night skies. In recent years she became a founder member of the Centre for Astronomical Heritage, devoted to the conservation of astronomical artefacts. She was elected as Fellow of the Royal Astronomical Society in 2016."

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. The next meeting, on the evening of **Monday 1 March** will be shown **via Zoom**. Access and start time details will be circulated to members. The next two lectures in the DVD series 'Black holes, tides and curved spacetime: Understanding gravity' presented by Prof Benjamin Schumacher of Kenyon College will be shown. The topics are: L21: 'Which universe is ours?^ and L22: 'Cosmic antigravity: inflation and dark energy'.

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 8 March**.

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: 15 March, 19 April, 17 May, 21 June, 19 July, 16 August, 20 September, 18 October and 15 November.

Speakers for 2021 include Dr Kechil Kirkham (March), Dr Vanessa McBride (April), Clyde Foster (May), Dr Rob Adam (June), Case Rijsdijk (September), Pieter Kotzé (October). The remaining 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.

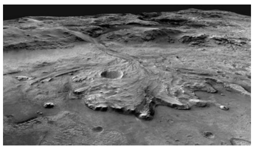
ASTRONOMY NEWS\

A closer look at Jezero Crater, Perseverance's landing site 9 February: Billions of years ago, an enormous space rock struck Mars and excavated a 1,200 kilometre crater now called the Isidis impact basin. However, the cosmos was not done yet. Another smaller strike inside the basin later produced an embedded crater that has since been dubbed Jezero Crater. The overlapping pair of impacts uniquely changed the rocks in the region, helping to create a special landscape that scientists think may have once been friendly to life. In just a few short weeks, NASA's Perseverance rover will begin to survey the area 'in person'.


Mars' Jezero Crater was once home to a river delta. NASA/JPL-Caltech

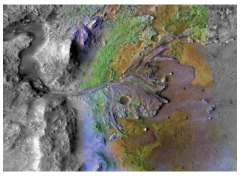
Based on spacecraft imagery, researchers think Jezero Crater was once home to a lush river delta. Deltas form as rivers drop sediment into relatively placid, larger bodies of water - like lakes and oceans. And that process of deposition creates a number of varied environments. When Mars was still young and wet, and life was likely just taking hold on Earth, Jezero Crater was home to a 500 m lake. Scientists think a network of rivers probably fed into this site, making it a prime place for life to have evolved on the Red Planet. That is why NASA chose to explore it. The idea of a persistent wetland on Mars was enough to convince astronomers to select Jezero Crater as the landing site for NASA's Perseverance rover, as well as its companion the Ingenuity helicopter.

Jezero Crater - named after the small town of Jezero, Bosnia - spans roughly 45 km, giving the rover plenty of room to roam. (More than a decade ago, the International Astronomical Union, the organisation responsible for naming planetary bodies, decided to name a number of scientifically important Mars craters after small towns around Earth.) Perseverance is a nearly car-sized rover that is designed to characterises Mars' geology and study its ancient climate. Along the way, it will hunt for signs of ancient alien life - specifically, microbial life - and collect soil and rock samples that will eventually be sent back to Earth for further study at world-class laboratories. Jezero Crater provides the perfect place for Perseverance to pick up an array of promising samples.

 NASA's Mars Perseverance rover will land in this ancient river delta inside Jezero Crater. NASA/MSSS/USGS

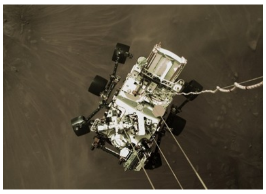
In 1976, NASA’s twin Viking landers touched down on Mars within just a few months of each other. They did not have wheels to roam the surface, yet the missions still changed how astronomers looked at Mars. The Viking landers found clear signs of river valleys, wet weather, and erosion. Plus, a soil experiment on Viking even found tentative evidence of microbial life. Scientists later determined that was a false detection, but taken together, the Viking missions’ discoveries served to build excitement for better understanding Mars’ ancient climate. That excitement help spur further exploration. In the decades since, NASA has sent a handful of rovers to Mars to build on those findings. And each one has been more sophisticated than the last. The latest robotic roamer before Perseverance, NASA’s Curiosity rover, landed in 2012 with the goal if determining "if Mars was ever able to support microbial life.” The robot traversed more than a dozen miles within Gale Crater, a former lakebed, providing new insights into Mars' ancient climate, current geology, and watery past. That has helped whet astronomers’ appetites for exploring other ancient sites on Mars that once held water. So, in preparation for Perseverance's trip, astronomers considered some 60 candidate landing sites over the course of several years. Different groups of researchers had their own ideas about which location was best, and the landing site debate was often contentious. As it played out, it became increasingly clear Jezero Crater has once been a vast wetland.

In 2015, research showed that now-dry Jezero Crater was home to water twice in Mars’ past. The scientists used satellite observations to conduct what geologists call a ‘source to sink’ analysis, where they trace a variety of minerals in the Martian watershed back to their original source upstream. For example, clays, which form in the presence of water, seem to have been picked up from surrounding areas and dropped into the crater lake by flowing water. Interestingly, the team's analysis showed the Jezero Crater served an active watershed during two separate time periods before the water dried up around 3.5 billion years ago, upping the chances of Martian life once gaining a foothold. The water was likely so high at one point that it spilled over the crater walls. A number of papers since then have backed up those findings.

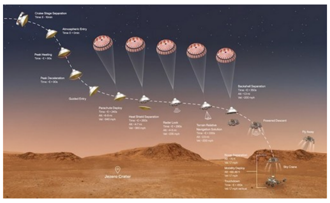
 Mars' Jezero Crater is the future landing site for NASA's Mars 2020 rover. NASA/JPL-Caltech/MSSS/JHU-APL

Astronomers now envision Jezero Crater as a dynamic system, with water flowing both in and out over long periods of time in the past. NASA would love to sample the rocks at the centre of the delta, where the water would have been the deepest. The muddy deposits there could preserve a record of organic matter, the way similar rocks do on Earth. Perhaps the most intriguing possibility is that Jezero Crater might have once been home to microbial mats, like pond scum forming at a lake's edge. Certain minerals could have preserved that pond scum, forming what scientists call stromatolites - a kind of layered rock that's essentially a fossil. The Perseverance rover will keep a careful eye out for this kind of Mars fossil deposits. As it pokes, prods, and samples the soil, the rocks in Jezero Crater should offer new clues about whether life once existed in the early, wet days on Mars. By: Eric Betz

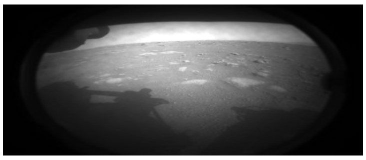
Success! NASA safely lands Perseverance on Mars 19 February: At approximately 3:55 pm EST on Thursday, 18 February 2021, NASA mission control erupted in jubilation upon receiving confirmation that their latest interplanetary rover made it to the Martian surface unscathed. Perseverance itself actually landed some 11 minutes before NASA was able to confirm its touchdown. The vast distance between Earth and Mars meant it took the rover's OK signal nearly a dozen agonizing minutes to race between the planets. However, those 11 minutes are just blink of the eye compared to the roughly seven-month spaceflight Perseverance endured while travelling to the Red Planet. The landing went about as well as possible, too. According to Thomas Zurbuchen, Associate Administrator of NASA's Science Mission Directorate: "What you should know is that every time we do a launch or do a landing, we get two plans. One plan is the one we want to do. And then there's that second plan, which is right here - that's the contingency plan." Zurbuchen then stood up, lifted a thin stack of lightly leafed-through papers into the air, and triumphantly tore them apart while calling out, "Here's for the contingency plan!"


Perseverance captured video of its entire landing stage. NASA/JPL-Caltech

NASA's latest rover was actually the third spacecraft to arrive at Mars this month. On 9 February, the United Arab Emirates' Hope probe entered orbit around the Red Planet - marking the start of the country's first interplanetary mission. Then a day later on 10 February, China's Tianwen-1 spacecraft entered orbit around Mars, though the onboard rover is not expected to attempt a landing until around May.


This graphic depicts the entry, descent, and landing sequence of NASA's Perseverance rover, which successfully landing on Mars February 18, 2021. NASA/JPL-Caltech

Though Perseverance was the last of the trio to arrive, it wasted no time tearing through the Red Planet's thin atmosphere at a blistering 19,300 kilometres per hour, protected by a robust heat shield. But because Mars' atmosphere is just about 1 percent as thick as Earth's, drag did not entirely slow down the craft. That is why Perseverance next deployed a massive supersonic parachute while still travelling at some two times the speed of sound. This further decelerated the craft's descent, allowing the vehicle to utilize its cutting-edge Terrain Relative Navigation system, which compared real-time images to a pre-stored global map to help the rover get its bearings. After jettisoning its parachute roughly 1.6 km above the surface, the craft was still travelling at some 250 km/h. That was when the rocket-powered descent vehicle took over, firing its multiple thrusters to slow Perseverance's descent speed to just a few kilometres per hour. Finally, the hovering craft carried out its famed Skycrane manoeuvre - first utilised during the Curiosity rover's landing - which gently lowered Perseverance via tethers to the floor of Jezero Crater, a fascinating ancient lakebed that may have once served as an abode to Martian life.



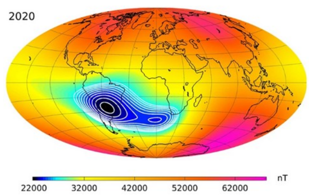
This first image sent back from NASA's Perseverance rover upon safely landing on Mars on 18 February 021, was taken by one of the rover's Hazard Cameras. NASA/JPL-Caltech

With its safe touchdown marked off the rover's to-do list, Perseverance will next undergo a number of tests to ensure everything is working properly before kicking of its mission in earnest. Within the next few months, Perseverance is expected to drop off its tag-along experimental helicopter Ingenuity, before rolling away to a safe distance while the rotor-craft carries out a series of tests. From there, Perseverance will continue with its primary mission: investigating areas of interest throughout Jezero Crater in an attempt to both characterise the site's past geology, as well as search for signs of ancient Martian life.

To do this, Perseverance comes equipped with a number of high-tech instruments. There is PIXL and SHERLOC, which are mounted to the end of the rover's arm and will create detailed spatial maps of both the elemental and molecular compositions of notable rock outcroppings. If Perseverance finds a particularly intriguing target, the rover will then use its coring drill to collect and store a sample from the site, which it will later deposit at designated cache depots until a future sample-return mission can bring the samples back to Earth. Lori Glaze, Director of NASA's Planetary Science Division, put it best during the press conference: "Now that we're on the ground, now the fun really starts."

By: Jake Parks

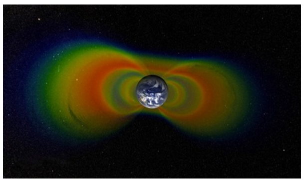
The spacecraft-killing anomaly over the South Atlantic 19 February: Radiation is a colourless, tasteless, and odourless enemy to both humans and electronics alike. Thanks to a quirk in Earth's magnetic field, a region called the South Atlantic Anomaly (SAA) regularly exposes orbiting spacecraft to high levels of dangerous particles.
Over the years, the SAA has been responsible for several spacecraft failures and even dictates when astronauts can and cannot perform spacewalks. As the space around Earth becomes filled with an increasing number of craft, what does the SAA mean for the future of spaceflight?



The European Space Agency's Swarm satellites measure the strength of Earth's magnetic field. In this image, cooler colours (blue) mean lower strength than warmer colours (pink). The large dark region is called the South Atlantic Anomaly. Finlay et al., *Earth, Planets and Space* volume 72, 156 (2020)

Earth's magnetic field is the result of a self-sustaining process called a geodynamo. As molten iron sloshes around our planet's outer core, it generates massive electrical currents that, in turn, create and reinforce the magnetic field. Earth's magnetic field itself extends tens of thousands of miles into space, and the area in which the magnetic field interacts with charged particles is called the magnetosphere. The magnetosphere protects life on

Earth by deflecting solar wind and cosmic rays, which would otherwise strip away much of the atmosphere, among other detrimental effects. Not all incoming particles are deflected. Some instead become trapped in two doughnut-shaped regions called the Van Allen Radiation Belts. The inner of the two Van Allen Belts sits an average of about 645 kilometres above the surface of Earth. The Van Allen Belts are located symmetrically about Earth's magnetic axis, which is not perfectly aligned with Earth's rotational axis. The result: The Belts' distance from Earth's surface varies around the globe.


The Van Allen Belts are two doughnut-shaped regions where high-energy particles are trapped around Earth by its magnetic field. NASA's Goddard Space Flight Centre

The SAA is the region where the inner Van Allen Belt dips closest to Earth - a mere 190 km above the surface. At that altitude, spacecraft in low Earth orbit (LEO) may periodically pass through the SAA, exposing them (and, in the case of manned missions, their occupants) to large amounts of trapped high-energy particles — ie potentially damaging doses of radiation. Radiation from the SAA has undoubtedly affected spacecraft, sometimes leading to their doom. One notable example is the Japan Aerospace Exploration Agency's (JAXA) X-ray Astronomy Satellite. Also called Hitomi, it was launched into LEO in February 2016 to study high-energy X-rays from extreme processes throughout the universe. However, AXA lost all contact with the probe on 26 March of that same year. Shortly after, the US Joint Space Operations Centre publicly confirmed that it had seen Hitomi break up into at least five pieces. The largest piece was tumbling, eventually dislodging even more fragments. Hitomi, which had cost upwards of $270 million, was a total loss. Although the exact details of the problems leading up to the loss are still debated, it is known that Hitomi's star tracker, which told the spacecraft how it was oriented in space, repeatedly experienced problems when the craft flew through the SAA. It is possible that radiation-induced damage to this system ultimately caused the spacecraft to rotate itself to death, making itself spin too fast as it tried to correct for positional problems that didn't actually exist. Similarly, in 2007, the satellite-based phone and data communications company Globalstar experienced the loss of several of their first-generation satellites. Again, the loss is believed to be related to degradation of electronic components by radiation damage incurred while passing through the SAA. It is not just satellites that have had problems, either. Computers and instruments aboard Skylab, the International Space Station (ISS), the space shuttle, and even SpaceX's Dragon craft have all experienced glitches or other issues when passing through the SAA.

Could the high radiation levels of the SAA put astronauts a t risk, too? Because the ISS does occasionally pass through the SAA, it was constructed with ample radiation shielding to protect astronauts from harm. Although the now-defunct space shuttles also sometimes passed through the SAA, the short nature of shuttle flights made this less of a concern. Nonetheless, given the high exposure to radiation that astronauts could incur if they had direct exposure to the SAA, ISS spacewalks are planned so that they do not take place during transits across the SAA. As scientists and engineers have gained more experience, both in dealing with the SAA and in building spacecraft, they have developed strategies to counter the potential damage high-energy particles can wreak. Engineers can add more radiation shielding, although this often increases spacecraft weight and, in turn, pumps up launch costs. Semiconductors called self-annealing gallium-arsenide circuit chips are more resistant to radiation damage. And simply placing delicate electronic components deeper in the body of a spacecraft, where they are surrounded by other denser, hardier components, offers additional protection as well. By: Doug Adler

SpaceX vs. NASA: Who will get us to the Moon first? 22 February: No-one has visited the Moon since 1972. But with the advent o commercial human spaceflight, the urge to return is resurgent and generating a new space race. NASA has selected the private company SpaceX to be part of its commercial spaceflight operations, but the firm is also pursuing its own space exploration agenda. How do they differ and which one is more powerful?


Super Heavy separating from Starship. Wikimedia Commons

SpaceX's Starship Rockets go through multiple stages to get into orbit. By discarding spent fuel tanks while in flight, the rocket becomes lighter and therefore easier to accelerate. Once in operation, SpaceX's launch system will be comprised of two stages: the launch vehicle known as Super Heavy and the Starship. Super Heavy is powered by the Raptor rocket engine, burning a combination of liquid methane and liquid oxygen. The basic principle of a liquid fuel rocket engine is that two propellants, – a fuel such as kerosene and an oxidiser such as liquid oxygen – are brought together in a combustion chamber and ignited. The flame produces hot gas under high pressure which is expelled at high speed through the engine nozzle to produce thrust. The rocket will provide 15 million pounds of thrust at launch, which is approximately twice as much as the rockets of the Apollo era. Atop the launcher sits the Starship, itself powered by another six Raptor engines and equipped with a large mission bay for accommodating satellites,

The Starship is designed to operate both in the vacuum of space and within the atmospheres of Earth and Mars, using small moveable wings to glide to a desired landing zone. Once over the landing area, the Starship flips into a vertical position and uses its on-board Raptor engines to make a powered descent and landing. It will have sufficient thrust to lift itself off the surface of Mars or the Moon, overcoming the weaker gravity of these worlds, and return to Earth – again making a powered soft landing. The Starship and Super Heavy are both fully reuseable and the entire system is designed to lift more than 100 tons of payload to the surface of the Moon or Mars. The spacecraft is maturing rapidly. A recent test flight of the Starship prototype, the SN8, successfully demonstrated a number of the manoeuvres required to make this work. Unfortunately, there was a malfunction in one of the Raptor engines and the SN8 crashed on landing. Another test flight is expected in the coming days.

Nasa's Space Launch System The Space Launch System (SLS) from NASA will be taking the crown from the discontinued Saturn V as the most powerful rocket the agency has ever used. The current incarnation (SLS block 1) stands at almost 100 metres tall. The SLS core stage, containing more than 3.3 million litres of liquid hydrogen and liquid oxygen (equivalent to one-and-a-half Olympic size swimming pools), is powered by four RS-25 engines, three of which were used on the previous Space Shuttle. Their main difference from the Raptors is that they burn liquid hydrogen instead of methane. The core stage of the rocket is augmented by two solid rocket boosters, attached to its sides, providing a total combined thrust of 8.2 million pounds at launch - about 5% more than the Saturn V at launch. This will lift the spacecraft to low Earth orbit. The upper stage is intended to lift the attached payload – the astronaut capsule – out of Earth's orbit and is a smaller liquid fuel stage powered by a single RL-10 engine (already in use by ATLAS and DELTA rockets) which is smaller and lighter than the RS-25.


Artist's concept of NASA's Space Launch System (SLS). NASA

The Space Launch System will send the Orion crew capsule, which can support up to six crew for 21 days, to the Moon as part of the Artemis-1 mission – a task that current NASA rockets are currently not capable of performing. It is intended to have large acrylic windows so astronauts can watch the journey. It will also have its own engine and fuel supply, as well as secondary propulsion systems for returning to the Earth. Future space stations, such as the Lunar Gateway, will serve as a logistical hub, which may include refuelling. The core stage and booster rockets are unlikely to be reusable (instead of landing they will drop in the ocean), so there is a higher cost with the SLS system, both in materials and environmentally. It is designed to evolve to larger stages capable of carrying crew or cargo weighing up to 120 tonnes, which is potentially more than Starship.

A lot of the technology being used in SLS is so-called "'egacy equipment' in that it is adapted from previous missions, cutting down the research and development time. However, earlier this month, a test fire of the SLS core stage was stopped a minute into the eight-minute test due to a suspected component failure. No significant damage occurred, and the SLS program manager, John Honeycutt, stated: "I don't think we're looking at a significant design change."

So which spacecraft likely to reach carry a crew to the Moon first? Artemis 2 is planned as the first crewed mission using SLS to perform a flyby of the Moon and is expected to launch in August 2023. In contrast, SpaceX has no specific date planned for crewed launch, it is running #dearMoon – a project involving lunar space tourism planned for 2023. Musk has also stated that a crewed Martian mission could take place as early as 2024, also using Starship. Ultimately it is a competition between an agency that has had years of testing and experience but is limited by a fluctuating taxpayer budget and administration policy changes, and a company relatively new to the game but which has already launched 109 Falcon 9 rockets with a 98% success rate and has a dedicated long-term cash flow. By: Gareth Dorrian and Ian Whittaker, The Conversation

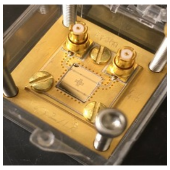
The search for dark matter gets a boost from quantum technology 23 February: Nearly a century after dark matter was first proposed to explain the motion of galaxy clusters, physicists still have no idea what it's made of. Researchers around the world have built dozens of detectors in hopes of discovering dark matter. However, despite decades of experimental effort, scientists have yet to identify the dark matter particle. Now, the search for dark matter has received an unlikely assist from technology used in quantum computing research. In a new paper, my colleagues on the HAYSTAC team and I describe how we used a bit of quantum trickery to double the rate at which our detector can search for dark matter. Our result adds a much-needed speed boost to the hunt for this mysterious particle.


Dark matter can be inferred from an assortment of physical clues in the universe. NASA, ESA, M. J. Jee and H. Ford et al. (Johns Hopkins Univ.)

There is compelling evidence from astrophysics and cosmology that an unknown substance called dark matter constitutes more than 80% of the matter in the universe. Theoretical physicists have proposed dozens of new fundamental particles that could explain dark matter. To determine which – if any – of these theories is correct, researchers need to build different detectors to test each one. One prominent theory proposes that dark matter is made of as-yet hypothetical particles called axions that collectively behave like an invisible wave oscillating at a very specific frequency through the cosmos. Axion detectors – including HAYSTAC – work something like radio receivers, but instead of converting radio waves to sound waves, they aim to convert axion waves into electromagnetic waves. Specifically, axion detectors measure two quantities called electromagnetic rield quadratures. These quadratures are two distinct kinds of oscillation in the electromagnetic wave that would be produced if axions exist.


The HAYSTAC detector is searching for the axion, one of the hypothetical particles that could make up dark matter. Kelly Backes, CC BY-ND

The main challenge in the search for axions is that nobody knows the frequency of the hypothetical axion wave. Imagine you are in an unfamiliar city searching for a particular radio station by working your way through the FM band one frequency at a time. Axion hunters do much the same thing: They tune their detectors over a wide range of frequencies in discrete steps. Each step can cover only a very small range of possible axion frequencies. This small range is the bandwidth of the detector. Tuning a radio typically involves pausing for a few seconds at each step to see if you have found the station you are looking for. That is harder if the signal is weak and there is a lot of static. An axion signal – in even the most sensitive detectors – would be extraordinarily faint compared with static from random electromagnetic fluctuations, which physicists call noise. The more noise there is, the longer the detector must sit at each tuning step to listen for an axion signal. Unfortunately, researchers cannot count on picking up the axion broadcast after a few dozen turns of the radio dial. An FM radio tunes from only 88 to 108 megahertz (one megahertz is one million hertz). The axion frequency, by contrast, may be anywhere between 300 hertz and 300 billion hertz. At the rate today's detectors are going, finding the axion or proving that it does not exist could take more than 10.000 years.

 Special superconducting circuits used for quantum computing can help detectors sift through noise that might be hiding an axion signal.

On the HAYSTAC team, we do not have that kind of patience. So, in 2012, we set out to speed up the axion search by doing everything possible to reduce noise. By 2017 we found ourselves running up against a fundamental minimum noise limit because of a law of quantum physics known as the uncertainty principle. The uncertainty principle states that it is impossible to know the exact values of certain physical quantities simultaneously – for instance, you cannot know both the position and the momentum of a particle at the same time. Recall that axion detectors search for the axion by measuring two quadratures – those specific kinds of electromagnetic field oscillations. The uncertainty principle prohibits precise knowledge of both quadratures by adding a minimum amount of noise to the quadrature oscillations. In conventional axion detectors, the quantum noise from the uncertainty principle obscures both quadratures equally. This noise cannot be eliminated, but with the right tools it can be controlled. Our team worked out a way to shuffle around the quantum noise in the HAYSTAC detector, reducing its effect on one quadrature while increasing its effect on the other. This noise manipulation technique is called quantum squeezing. In an effort led by graduate student KellyBackes and Dan Palken, the HAYSTAC team took on the challenge of implementing squeezing in our detector, using superconducting circuit technology borrowed from quantum computing research. General-purpose quantum computers remain a long way off, but our new paper shows that this squeezing technology can immediately speed up the search for dark matter.

Our team succeeded in squeezing the noise in the HAYSTAC detector. How did we use this to speed up the axion search? Quantum squeezing does not reduce the noise uniformly across the axion detector bandwidth. Instead, it has the largest effect at the edges. Imagine you tune your radio to 88.3 megahertz, but the station you want is actually at 88.1. With quantum squeezing, you would be able to hear your favourite song playing one station away. In the world of radio broadcasting this would be a recipe for disaster, because different stations would interfere with one another. However, with only one dark matter signal to look for, a wider bandwidth allows physicists to search faster by covering more frequencies at once. In our latest result we used squeezing to double the bandwidth of HAYSTAC, allowing us to search for axions twice as fast as we could before.

Quantum squeezing alone is not enough to scan through every possible axion frequency in a reasonable time. However, doubling the scan rate is a big step in the right direction, and we believe further improvements to our quantum squeezing system may enable us to scan 10 times faster. Nobody knows whether axions exist or whether they will resolve the mystery of dark matter; but thanks to this unexpected application of quantum technology, we are one step closer to answering these questions. By: Benjamin Brubaker

Hidden in plain sight: Scouring the notebooks of the Harvard's 'human computers' 24 February: More than 100 years ago, Harvard astronomer Edward Charles Pickering decided he was going to take a picture of the entire night sky. Or, rather, many thousands of pictures, each capturing a tiny rectangle of the universe as seen through a telescope. Today, these photos survive on hundreds of thousands of glass plates at the Harvard College Observatory, the oldest comprehensive record of the cosmos. Though it was Pickering's idea, the actual work of studying these photographs was done by a group of women known as the Harvard Computers. Before the days of silicon and circuits, actual humans performed the laborious mathematical endeavour of physics and astronomy. "Someone had to go look at every plate covered in thousands of little stars, and they had to look at every star on that plate and catalogue it," says Daina Bouquin, head librarian at the Harvard-Smithsonian Center for Astrophysics. "So this team of women, over the course of a couple of decades, basically analysed and created the first all-sky catalogue."

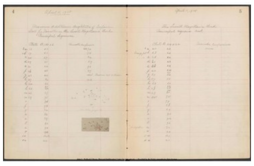
Like the women memorialised in the movie 'Hidden Figures', the Harvard Computers toiled in relative obscurity, yet they produced groundbreaking work fundamental to the field of astronomy. Women like Henrietta Swam L:eavitt and Annie Jump Cannon produced some of the first rigorous examinations of the motion and brightness of stars. Today that data is foundational to our understanding of the basic structure of the universe."In the late 1800s and early 1900s, astronomy was undergoing a revolution," Bouquin says. "We were shifting from mapping the sky and what we see and trying to describe it, to trying to understand the physics of the sky. How does it work?" Now Bouquin is leading an initiative known as Project PHaEDRA. Its goal is to digitize and catalogue those decades of work from the Harvard Computers.


Williamina Fleming (standing) supervised the women "computers" at Harvard College Observatory. Harvard College Observatory/Wikimedia Commons)

The collection of notebooks is far too extensive for researchers to manage alone. So, the project relies on thousands of volunteers to help comb through decades of invaluable astronomical observations and turn them into something usable for researchers today. Citizen scientists can get involved with Project PHaEDRA from anywhere in the world — all you need is a computer. Volunteers transcribe notebook pages from astronomers that have been languishing in obscurity for decades and add them to a growing collection of searchable data in a NASA archive. These historic observations are sought after by scientists today, who are continuing the work the computers started.

While astronomers have learned a lot about how stars, planets, galaxies and more interact and evolve, there is much that is still unknown. The cosmos changes slowly, so having a night sky record dating back more than 100 years could help provide data for astronomers to compare and contrast against modern-day observations. Without such a reference, Bouquin says, "It's like you didn't have the fossil record, but you were trying to do paleontology. This gives you that record." Currently, the bulk of the Harvard Computers' work is locked inside thousands of notebooks at the Harvard College Observatory. They contain precise notations and measurements comprising decades of work as the women studied each glass plate in detail and noted the positions, movements and characteristics of the stars it captured. Project PHaEDRA is opening that data up to astronomers for the first time by transcribing the notebooks and converting them into a digital, searchable format. Citizen scientists working with PHaEDRA are turning the notebooks into a corpus of data that astronomers can reference to see what the night sky looked like over a century ago. That is important because much of our understanding of the universe comes from watching objects like stars move over time. The further back astronomers can look, the more they can learn. "Volunteers are the way the whole thing works," Bouquin says. "We would not be able to do much of anything without the volunteers."

The project is currently about halfway through transcribing the collection of thousands of notebooks, Bouquin says. They have already uploaded a number of their transcriptions to NASA's Astrophysics Data System, a massive repository of data from astronomers where scientists can make use of them. In addition to adding to our knowledge of space, the project is reminding us of the often-overlooked contributions of women in astronomy, Bouquin says. Among other things, Henrietta Swan Leavitt studied variable stars, which change in brightness over time. That work led to the creation of the cosmic distance ladder, a means of measuring things very far away in the cosmos. Her discoveries ultimately helped reveal the age of the universe, and they are instrumental even today in determining how far away things are. Another computer, Cecilia Payne-Gaposchkin, studied the spectra of stars - the wavelengths of light they emit. Her work helped show that stars are made primarily of hydrogen and helium. Before that, astronomers thought stars were made of the same elements as Earth. "Some of them did really, really fantastic work, and all of them contributed to an amazing undertaking," Bouquin says. "The fact that that got erased is wrong."


Astronomer Henrietta Swan Leavitt used this notebook to record stars in the Small Magellanic Cloud. John G. Wolbach Library, Harvard College Observatory

Along with the computers' observations are bits of historical ephemera that were previously lost to history. Sketches, notes, postcards and more have turned up in the margins of the notebooks, a testament to the very real lives these women lived. Project PHaeDRA volunteers, Bouquin says, have proven adept at picking out these personal touches and bringing a broader perspective to the work of the Harvard Computers. If not for the work of these modern-day citizen scientists, the valuable efforts of dozens of pioneering women astronomers might have been lost forever. But today, page by page, their hard-won discoveries are returning to the light. By: Nathaniel Scharping

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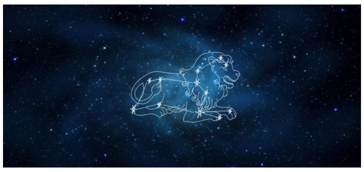
DID YOU KNOW?

Zodiac constellations 13: Leo



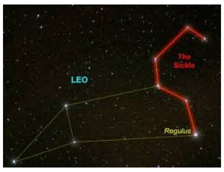
The prominent constellation of 'the lion' is the 12th largest of the 88 modern constellations. Located between Cancer and Virgo, it is easy to recognise as its outline resembles a crouching lion. From the southern hemisphere, Leo appears upside down.
It is one of earliest recognised constellations. Records date back to ca 4,000 BCE in archaeological evidence found in Mesopotamia. In all early cultures,, the names used meant 'lion'. In Greek mythology it represents Nemean, the lion with an impenetrable hide who was slain by Heracles (Hercules in Roman mythology). He did so by breaking the lion's back back, in the first of his twelve labours. Zeus marked this achievement by placing the lion in the sky.

The present Coma Berenices was formerly the tuft of the lion before being created a separate constellation by Tycho Brahe (1602). The Sun passes through Leo from mid-August to late-Sept (5 weeks).

Leo contains many bright stars, many of which were identified in ancient times. Four of these are magnitude 1 or 2. It also contains some of the largest structures in visible universe including several large quasar groups and five Messier objects.

Notable features include:

- Alpha Leonis (Regulus - 'little king'): a naked eye magnitude 1.36 blue-white main sequence star. 79 ly away, it has a faint wide companion dwarf star.
- Beta Leonis (Denbola – 'lion's tail'): marking the lower rear point of the lion, this blue-white star is 36 ly away.



- The Sickle: an asterism of six stars marking the lion's head and shoulders in the shape of a question mark.

- M65 and M66: a pair of spiral galaxies located beneath the lion's hindquarters. Tilted at steep angles from Earth, the appearing elongated when viewed through a telescope.
- M95 and M96: a fainter pair of spiral galaxies, these are also found beneath the crouching lion, but closer to the front of the body. 20 million ly away, they can be observed through a telescope.
- M105: near M95 and M96, this elliptical galaxy is 20 million ly away. Observation also needs a telescope.
- Leonid meteor shower: this radiate from the Sickle area in mid- to late-November. The meteors have the highest geocentric velocities and the most persistent trains of any meteor stream. The parent comet is Tempel-Tuttle, named for its two independent discoverers, in 1865 and 1866. Activity is mostly weak, except during occasional meteor storms which occur at perihelion every 33 years.
- Wolf 359: third closest star to Sun. This red dwarf is 7.8 ly away from Earth.

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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