"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

SEPTEMBER 2019

Monthly meeting This month's meeting will take place on **Monday 16 September** at the **Catholic Church Hall** starting at **19.00.** Dr Pieter Kotze, Research Fellow at SANSA and a new HAC member, will be talking on 'A magnetic planet in the shadow of a variable star'.See below for more details.

Stargazing No event is planned, yet, for September.

Cosmology New material on the concept of Loop Quantum Gravity will be presented and discussed at upcoming meetings. See below for more details.

WHAT'S UP?

Ophiuchus and Jupiter Until mid-November, Jupiter, the third brightest object in the night sky after the Moon and Venus, is in the constellation Ophiuchus. Its reddish colour and the four Galilean moons can be observed with binoculars, while some of its banding is also visible through a small telescope. Ophiuchus is the 11th largest of the 88 constellations. Although it straddles the celestial equator, Ophiuhcus is not regarded as a member of the zodiac. Although it does include a few bright stars, overall, it is a generally faint constellation. Representing a man holding a snake, it is named for the 'serpent holder/bearer'. It appears upside down in the southern hemisphere, its feet facing Scorpius. The snake the man is holding is actually the snake which forms the constellation Serpens, which Ophiuchus cuts in half. Serpens is the only constellation which has two parts. The snake's tail section (Serpens Cauda) is held in the holders' right hand and the body and head part (Serpens Caput) in his right hand. Ophiuchus and Seprens were two of the original 48 Greek constellations.

LAST MONTH'S ACTIVITIES

Monthly centre meeting The presenter at the 19 August meeting was Centre member, Jenny Morris. She presented 'More unusual curvaceous geographical wonders of Earth'. These included a bright multi-coloured hot spring in Yellowstone Park, USA, marble chapels in the middle of a glacial lake in Chile, fairy circles in the arid north-west corner of Namibia, the sculpted Remarkable Rocks in Australia, brilliant white travertine terraces in Turkey and a noisy blue-white glacial cave in Iceland. Peter Harvey reports: 'August's monthly meeting, 'More unusual curvaceous geographical wonders of Earth", presented by Jenny Morris, was a sequel to her presentation of April 2018. We were treated to an exhibition of Nature's artistic talents in the form of combinations of geologic and organic

features from high lakes in volcano peaks, sandstone, limestone and marble architecture, 'indoor' beaches down to 'undersea lakes' and a vertical cave over 2km deep. The artistry, using astonishing palettes of colour, comes with the compliments of the dedicated work of meteors, caldera, wind, rain, water flow, seasonal changes, glaciers and above all, time. These images can be regarded as gentle reminders of the astonishing beauty, and the fragility, of our planet Earth.'

Interest groups

Cosmology At the meeting on 5 August, Pierre Hugo presented the final part in the series on 'Natural philosophy: science for non-scientists'. The topic was 'Space-time and general relativity'.

Astro-photography The scheduled meeting for August was cancelled.

Other activities

Educational outreach

Hawston Secondary School Space Cadets Meetings continue to take place weekly.
Lukhanyo Youth Club Work continues on the construction of analemmatic sundials here and other schools in the Overstrand.

Stargazing Unfortunately, adverse weather conditions mean that the events planned for 30 or 31 August had to be cancelled.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting, will take place on **Monday 16 September** at the **Catholic Hall** starting **19.00**. The guest speaker will be Dr Pieter Kotze, Research Fellow in the Science Research and Applications Unit at SANSA. He will repeat the keynote presentation he is giving at Scopex in Johannesburg on 14 September. Titled "A magnetic planet in the shadow of a variable star", it will explore the influence on and interaction between the magnetic fields of Earth and the Sun.

Pieter Kotzé was born in Cape Town and grew up on a wine farm near Vredendal, where he attended school and matriculated in 1973. He obtained a BSc degree in physics and mathematics from the University of the Orange Free State in 1976. He completed his post-graduate studies in physics at the University of Stellenbosch where he graduated with a PhD in 1981. He started his research career as a scientist at the Atomic Energy Corporation (1981-1989) and subsequently joined the Hermanus Magnetic Observatory (HMO) in 1989 as a research physicist. His research activities are in the field of geomagnetism, in particular the time-varying characteristics of the geomagnetic field of southern Africa, as well as geomagnetic storms resulting from the solar wind's interaction with the Earth's magnetic field. In the process, he uses data from ground surveys and magnetic observatories, as well as satellite observations.

He has spent extensive periods as visiting scientist at the Max Planck Institute for Plasma Physics in Garching, the Max Planck Institute for Solar System Physics in Lindau, the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, the British Geological Survey in Edinburgh, as well as the GeoForschungsZentrum located in Potsdam. He is currently serving as the South African representative at the International Association for Geomagnetism and Aeronomy (IAGA) where he is also a member of the Executive Committee. He also served as co-chair and chair of IAGA Division V Working Group on Magnetic Observations from 2004 till 2011 and from 2011 till 2015 as the co- chair of IAGA Division V, responsible for geomagnetic observatories, surveys and analyses.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. The next meeting is on **Monday 3 September** at the **Catholic Hall**, starting at **19.00.** It will be the first of two meetings exploring Loop Quantum Gravity. The excellent, easily understandable layman's level course is presented, in this DVD series of short modules, by Carlo Rovelli, one of the founders of the Loop Quantum Gravity (LQG) theory, which most consider to be the next best theory superseding string theory.

Module 1 – 'Gravity as we know it' covers Newton's theory of gravity, how the situation changed dramatically in the 19th century, how Einstein applied Maxwell's ideas about electromagnetism to gravity, and the ways in which Einstein's spacetime has some unusual consequences. Module 2 – 'The granular world' outlines how quantum mechanics established the discrete nature of light, how Werner Heisenberg made the key insight of quantum theory, and how almost every aspect of reality has proven to be fundamentally discrete. Each presentation will be followed by discussion and the answering of follow-up questions presented in short answer videos.

There is an entrance fee of R10 per person for members, R25 per person for non-members, and R10 for children, students and U3A members. For further information on these meetings, or any of the group's activities, please contact Pierre Hugo at pierre@hermanus.co.za

Astro-photography This group meets on the second Monday of each month. There is no meeting in September. The next meeting will be on **Monday 14 October.**

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

Hermanus Youth Robotic Telescope Interest Group Developmental work on this will resume soon.

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

Other activities

Stargazing No events have been planned, yet, for September. Details will be circulated to members, if this changes.

FUTURE TRIPS

Planning is underway for an outing later this year. Members will be sent details once the arrangements have been made.

2018 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month at the **Catholic Church Hall**, beginning at **19.00**.

16 September	'A magnetic planet in the shadow of a variable star'. Presenter: Dr Pieter Kotze, Research Fellow, SANSA
21 October	'A home observatory'. Presenter: Pierre de Villiers, Centre chairman
18 November	'The Cassini family dynasty and their Saturnian legacy'. Presenter: Jenny Morris, centre member
9 December	TBA

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\

NASA rocket launch set to aid search for signs of alien life 2 August: When astronomers look for signs of life outside of the solar system, they are mostly looking for what researchers call biosignatures. These are tell-tale indicators that something is living on another world. So, while the Search for Extraterrestrial Intelligence (SETI) draws headlines for hunting alien communications like radio waves, most astronomers today are actually looking for the chemical fingerprints of materials tied to life. On Earth, for example, oxygen is our clearest biosignature. It is the biggest outward change to our planet since the rise of life more than three and a half billion years ago. However, life is not the only way to make oxygen and astronomers do not want to be misled if they find an oxygen-rich world.

To understand what life-signs astronomers read from a planet, they must first understand the planet's star.NASA/GSFC/C. Meaney/B. Monroe/S. Wiessinger

That is prompting NASA to launch a project called SISTINE on a sounding rocket that will fly briefly into space next week before falling back to Earth. The idea is to test a new way to observe the stars that exoplanets orbit to better understand how they might scatter false life signs onto their planets. SISTINE will make its first test launch on 5 August, with a second launch planned in 2020.

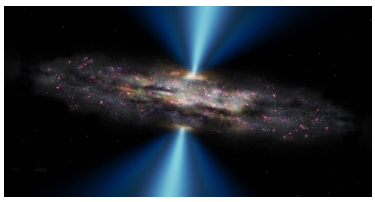
SISTINE stands for Suborbital Imaging Spectrograph for Transition region Irradiance from Nearby Exoplanet host stars. By sending a rocket just barely into outer space, astronomers can take spectra of nearby stars that host planets. The spectrum of a star tells astronomers exactly what kind of light they give off. In particular, SISTINE will target ultraviolet light in a range other orbiting telescopes cannot see. This particular colour of

light can interact with carbon dioxide, splitting away the carbon to leave behind molecular oxygen (two oxygen atoms stuck together). Or, it can strike water vapour, separating hydrogen and oxygen, some of which recombines as molecular oxygen. In these cases, astronomers may be able to spy an atmosphere rich in oxygen, even with no life at all present.

If SISTINE can prove the presence of UV light in the star, it would help astronomers better understand these false positives of ET life. This particular type of ultraviolet light is not common enough from our sun to have a strong effect on Earth's chemistry, which is why it took life to create large amounts of oxygen in our atmosphere. However, that is not necessarily the case everywhere. Smaller, dimmer stars called M-dwarfs have a tendency to flare more often than our sun, producing bright streams of ultraviolet light that might well oxygenate their nearby planets.

The first launch of SISTINE will be a mere calibration run, to make sure the telescope can find the right kind of UV light. And instead of an exoplanet, their test targets a cloud of gas called NGC 6826 that's bright in UV light. If that goes well, they will launch again in 2020 to check out the Alpha Centauri system. This is the closest star system to ours, and scientists already know it has exoplanets, too. The test will also try out new mirror coatings and detector plates and offer new insights into how astronomers can use exoplanets' host stars to understand false biosignatures. After all, oxygen is not the only gas associated with life on Earth; methane is another big one, too, and it can also be mimicked by non-biological processes. By better understanding when and where these substances appear in the absence of life, scientists will be one step closer to knowing the real thing when they see it. By: Korey Haynes

Hubble settles an old debate about galaxies with supermassive black holes 8 August: Every large galaxy has a supermassive black hole at its centre. Some of those black holes are actively ejecting huge amounts of high-energy light out into the cosmos. Astronomers divide some of these active galaxies, which otherwise look like normal spirals, into two types, so-called Seyfert 1 and Seyfert 2 galaxies. Seyfert 1 galaxies have distinctive light signatures that emerge from the fast-moving material just outside the black hole. Seyfert 2s lack these signals.


Galaxies with central black holes can take various forms depending on the angle at which astronomers see them. NASA

For three decades, however,astronomers have suspected that these two types of galaxies may, in fact, be the same, we are just seeing them from different angles. The thought was that a dusty ring around the black hole could hide certain features, making a Seyfert 1 appear like a Seyfert 2. However, a few stubborn galaxies persisted in hiding those features apparently without any dust ring. That made some astronomers think there may really be a class of 'true Seyfert 2 galaxies', whose features were not hidden but genuinely lacking.

Now, astronomers have ruled out one of the last remaining "true Seyfert 2" stragglers,

proving it was a Seyfert 1 after all. This means there' is no such thing as a Seyfert 2, just Seyfert 1 galaxies viewed from different angles. Seyfert galaxies look like normal spiral galaxies when viewed in visible light. However, when astronomers observe them at high-energy wavelengths like X-rays and ultraviolet light, their cores light up as hotbeds of activity, revealing the energetic black holes powering their centres. When astronomers peer at the galaxies' chemical fingerprints in detail, they notice two sub-groups, Seyfert 1 and 2 galaxies.The idea is that Seyfert 2 galaxies are really Seyfert 1 galaxies, with their cores hidden behind an obscuring wall of dust. This dust only gets in the way from certain angles, since it sits in the plane of the galaxy like a doughnut, the black hole at centre.

However, a few galaxies, especially one called NGC 3147 appeared to be missing the signals from the fast-moving material just outside the black hole, while also showing no sign of a dusty doughnut to hide them. That left NGC 3147 as a shining example of a 'true' Seyfert type 2 galaxy. Thus,, the debate has lingered. Now, using just one hour of time on NASA's Hubble Space Telescope, astronomers have finally observed the missing signals from NGC 3147. Because it was so dim, the signals coming from that fast-moving material just outside the black hole were masked by brighter starlight nearby. Hubble's keen vision spotted them anyway.

The astronomers led by Stefano Bianchi, from the Università degli Studi Roma Tre in Italy, point out that since NGC 3147 was the best known example of a true Seyfert 2, this new result quite likely rules out their existence entirely. "What's most important to astronomers is pruning this dead branch," said Robert Antonucci. The researchers have been awarded six more hours of time using Hubble to study NGC 3147 in even greater detail, and perhaps unlock any remaining secrets about its central black hole. By: Korey Haynes

SETI to use deep-sea vents for practice hunting alien life 9 August: Some of the most intriguing possibilities for finding life outside Earth are on water worlds like Europa or Enceladus - ocean moons orbiting Jupiter and Saturn. However, those worlds are encased in layers of ice, meaning any ocean exploration will take place far beneath the surface. On our own planet, these deep-sea zones teem most reliably with life. That life is most often found near hydrothermal vents. These cracks in the seafloor release heat and chemicals that fuel intense biozones far from any sunlight. Now, the Search for Extraterrestrial Intelligence (SETI) has received a NASA grant to fund a new project called In-situ Vent Analysis Divebot for Exobiology Research (InVADER). It will explore deep-sea vents on Earth in preparation for the day that scientists can send a similar craft out into the solar system to explore alien oceans and their own hydrothermal vents.

InVADER aims to explore a hydrothermal vent area called Axial Seamount. This is an active volcano a kilometre and a half underneath the surface, and the biggest one on the western edge of the Juan de Fuca tectonic plate. InVADER will have three major goals during its mission. The first is to produce actual science near Axial Seamount, to better understand the geology, chemistry, and biology around the vent system. By better understanding deep-sea vents on Earth, scientists hope they'll be more prepared to understand whatever they find when deep-sea missions to other planets become a reality.

The second goal is to practice their science operations, testing different ways to answer the science questions they want to explore. They are prepared to use lasers to analyse the different materials they encounter, as well as experiment with different strategies for collecting and analysing data. That can be tricky when your instrumentation is so far

underwater, much less hundreds of millions of kilometres away, as it would be on Enceladus or Europa. InVADER can also take pictures and even provide 3-D mapping of its environment so researchers can better understand the other readings the underwater robot sends back. The last goal is a technology demonstration. The team wants to prove that InVADER can actually perform in its deep-sea environment, both in terms of on-site science, and in its ability to gather samples and bring them back to the lab.

SETI expects to launch InVADER in the summer of 2020. A prototype is already being tested at the University of Washington. And once deployed, the mission will remain at its underwater research site for a full year, taking daily measurements and eventually returning with samples from the rocks and water it collects. While InVADER will remain safely on Earth, the lessons it learns from Earth's own underwater vents will prepare researchers for the eventual trip to the oceans of watery moons that planetary scientists and astrobiologists alike are keen to explore. By: Korey Haynes

Supernova dust found hidden in Antarctic snow 13 August: Antarctica is one of the most pristine places on the planet. Thanks to its generally inhospitable nature, as well as its natural isolation, it is a good place for astronomers to search for meteorites and other materials that fall from the sky. They tend to sit undisturbed for long periods of time. A team of astronomers from Germany and Austria recently made use of that preservation by collecting over 500 kg of snow laid down in the past 20 years. After analysing all the various dust and grains they found within the snow, they discovered a suspicious amount of iron-60. This particular radioactive strain of iron told astronomers that the dust wasn't local, but instead came from outer space. Furthermore, they suspect it came from a supernova that exploded sometime in the recent cosmic past.


Artist illustration, the Sun (the yellow star at centre) moves through a clump of interstellar gas. NASA/Goddard/Adler/U. Chicago/Wesleyan

Our solar system sits in one particular spiral arm of the Milky Way, and it orbits the galactic centre every 230 million years or so. Astronomers suspect that as the Sun and Earth traversed the local galactic neighbourhood, they would have ploughed through the cloud of debris that this supernova left behind, causing the materials to rain down on Earth. The same type of iron has been found buried in deep sea beds and other ancient rocks, but those were laid down millions of years ago. This is the first find of such interstellar iron laid down in recent years, and it could shed more light on exactly where and when the supernova that created the metal occurred.

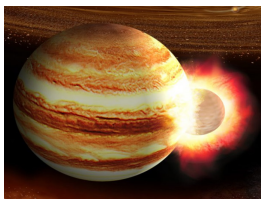
To analyse the cosmic dust they were seeking, astronomers melted their 500kg of Antarctic snow. Then, they ran it through an instrument called a mass spectrometer to determine the precise chemical makeup of any materials caught inside. This told them not only that there was iron and manganese in the sample, but specifically iron-60 and manganese-53. These special isotopes, or varieties, of the elements have different numbers of particles in their nucleus than normal iron or manganese atoms (most iron is iron-56, and most manganese is manganese-55). Both are radioactive, meaning they are not stable with that number of particles, and will at some point decay into other atoms –

though for iron-60, it will take 2.6 million years for half of it to decay into something else, making it fairly long-lived for a radioisotope.

Once astronomers found the iron-60 and manganese-53, they had to figure out where it came from. Space was one option, but it is actually quite common for that combination of elements to occur when cosmic rays strike the dust that fills the solar system. However, when that happens, there is a particular ratio of iron to manganese scientists have come to expect, and that wasn't the ratio researchers saw from the Antarctic snow – instead, they saw an excess of iron-60.

So they next tested to see if the extra iron might come from a more local source – fallout from nuclear weapons or power plants that might have drifted south. Further investigations showed that the amount of iron-60 scientists should expect from such sources is negligible, and cannot explain the amounts researchers measured. Researchers have seen iron-60 like this before, in older rocks embedded in the seafloor or even on the Moon. In those cases, they put it down to a long-ago supernova, a dying star whose explosion would have created all kinds of exotic elements, including iron-60. Knowing that the iron-60 is still falling to Earth today can help astronomers connect the long-ago iron fall to the one that's probably still happening today, and figure out where and when the supernova occurred that created the iron in the first place. By: Korey Haynes

Jupiter might have been hit by a massive proto-planet long ago 15 August: In 2016, NASA's Juno spacecraft arrived at Jupiter with the goal of peering through Jupiter's dense clouds to reveal the giant planet's inner secrets. Along with the stunning pictures Juno has sent back, it has also used its instruments to gaze deep into Jupiter's heart. One of the spacecraft's biggest discoveries was a core less compact than scientists expected. Instead of a sharp transition between a dense core and the more gaseous outer layers, Juno's readings imply a fuzzy boundary, with the core bleeding into the atmosphere out to nearly half the planet's radius.


Artist's image of a massive planet slamming into Jupiter in its infancy..K. Suda & Y. Akimoto/Mabuchi Design Office/Astrobiology Center, Japan

Now, astronomers led by Shang-Fei Liu from Sun Yat-sen University in China have put forward an explanation for that fuzzy core: the young proto-Jupiter was involved in a head-on collision with a large proto-planet, roughly the size of Uranus. Modelling shows that even if the event happened 4.5 billion years ago, when the planets were still forming, the fuzzy core that resulted could persist today.

The most common story of Jupiter's formation is that it collected its heavy elements first, forming a dense core. At that point, it was heavy enough to attract the massive amounts of lighter hydrogen and helium gases that make up most of its bulk, and did so prodigiously. However, that scenario would result in a modern Jupiter with a compact, dense core surrounded by lighter gases – which is what planetary scientists, for many years, thought it had. It took Juno's extremely precise gravity measurements to learn that Jupiter's core is actually fuzzy, with the outer core bleeding into the gas around it for

thousands of miles. That finding was a shock to astronomers when Juno scientists first reported the finding in 2017.

For that fuzzy core to occur naturally, scientists say that some 10 to 20 Earth masses of heavy materials would had to have glommed onto Jupiter after the core finished forming and after half its gas envelope had already developed. However, this is physically unlikely – once Jupiter started gaining an atmosphere, it should have done so quickly, and that very atmosphere would have repelled heavier dust grains from settling onto the planet. So scientists began considering how else Jupiter's fuzzy core might have formed, and Shang-Fei Liu presented the idea of a massive collision in Jupiter's past. Specifically, that a proto-planet some 10 to 20 times the size of the Earth, made of reasonably dense materials, crashed head-on into Jupiter's core at some point early in the gas giant's history.

"It sounded very unlikely to me," said Andrea Isella, one of the researchers,, "like a one-in-a-trillion probability. But Shang-Fei convinced me, by sheer calculation, that this was not so improbable." For one thing, it is becoming more and more clear that the early solar system was a violent place where planetary collisions were fairly common. Jupiter's heavy mass acts almost as a guidance system, meaning head-on collisions are actually more likely than glancing blows, if an object veers close enough.

Liu's modelling also showed that if such a large, head-on impact occurred, it could indeed take billions of years for the core to settle back down again, well within the current lifetime of the solar system. While there is no way to run the clock backwards and be certain a major collision is what caused Jupiter's fuzzy core, the theory holds for now, and is an intriguing explanation for Jupiter's otherwise mysterious centre. By: Korey Haynes

New date for 'Late Heavy Bombardment' may change life's timeline on Earth 15 August: The solar system once experienced a meteor shower of epic proportions: Asteroids whizzed around the inner planets, crashing down in a rain of fire that left their surfaces scarred for billions of years. Astronomers typically call this period the Late Heavy Bombardment. Exactly when that fiery assault happened has been a matter of intense debate. The answer has big implications for the evolution of the solar system as a whole, and even for the timeline of life on Earth.

Asteroids may have stopped pummeling Earth some 600 million years earlier than scientists thought, giving life more time to evolve. NASA/JPL-Caltech

Finding evidence of such a bombardment here on Earth is difficult. Our planet regularly melts and recycles its crust, destroying detailed evidence that might give us a concrete age for the period of heavy meteor impacts. Farther off, on Mercury, Mars, and the rocky or icy moons of the outer solar system, scientists are left to count craters, an imprecise dating method. The other option is to use an objective dating method – radiometric rock dating, for instance – on bodies that have kept cleaner records than Earth. The Moon and asteroids – or the meteorite pieces of them that fall to Earth – are the most accessible.

When astronauts first brought back samples of the Moon, 50 years ago this summer,

scientists found that they all showed evidence of massive and intense impacts at about 3.9 billion years ago. Later lunar missions returned more samples, and all agreed: some disaster occurred on the Moon that indicated a massive slew of impacts less than 4 billion years ago. For decades, scientists sought to explain what might have caused a sudden influx of asteroids and comets into the inner solar system. More recent evidence has hinted that Earth might have had liquid surface water before this period. It is hard to reconcile how our planet maintained a surface cool enough to host water while undergoing a massive cataclysm. Also, dates from meteorites never agreed with the 3.9 billion-years-ago date from lunar rocks.

Now, astronomers led by Stephen Mojzsis from the University of Colorado, Boulder, have shown that the bombardment might have happened much earlier: 4.48 billion years ago. That would leave plenty of time for Earth to cool and life to emerge. Most researchers think the Late Heavy Bombardment was caused by the giant planets moving around, orbiting closer to and farther from the sun and pushing lots of smaller solar system objects like asteroids along with them. However, Mojzsis points out that there is no timeline inherently attached to such a reshuffling. "So look to the asteroid belt," Mojzsis suggests. "The asteroids predate the planets, by definition. And we have 60,000 meteorites from the asteroids."

His study, he says, is the first to consider the ages of all those meteorites on Earth. "And we find no uptick at 3.9 billion," the time of the proposed Late Heavy Bombardment, he says. But his team did see that most of the rocks had been "reset" — basically melted to such an extent that it restarts the radiometric clocks researchers use to figure out a rock's age. That melting is a sign of massive impacts, and they found the clocks reset at 4.48 billion years ago, only 80 million years after the start of the solar system. "The best explanation is that's when giant planet migration occurred," Mojzsis says. Instead of one big spike, this earlier period of asteroid bombardment would have been a slow tapering-off from the early days when the solar system was little more than rocks crashing into each other. In Mojzsis' timeline, the giant planets still migrated, but much earlier than previous theories suggested. This means there was no giant spike of meteors, but rather a flux of incoming asteroids that blended into the general chaos of the young solar system.

The best – and only real – argument for a more recent spike of impactors comes from lunar samples, which do show signs of some cataclysm occurring 3.9 billion years ago. However, as Mojzsis explains, "If you look at the bombardment record from craters from Mercury, the Moon, Mars, satellites of the outer solar system, none of them show an uptick in bombardment. It's only the lunar samples, which were all collected and returned to the Earth from a small patch of the Moon, just some 12 percent of the lunar surface, and all collected near Mare Imbrium [Crater]."

That geographical clustering, more than anything else, hurts the reliability of the lunar samples. It's clear something catastrophic happened in the Mare Imbrium area, but it's not as obvious that it must have been a Moon-wide — let alone solar system-wide — event. If NASA – or any of the other actors in the increasingly crowded race back to the Moon – succeeds in visiting the Moon's more remote South Pole-Aitkin Basin and returning samples from that oldest known crater, it would "complete the puzzle," according to Mojzsis. In the meantime, he thinks his results lay to rest the idea of a Late Heavy Bombardment. Instead, Mojzsis prefers a history where the influx of asteroids and comets

slowly wound down from the solar system's wild earlier days to a gentle drift of space dust and the occasional stray impactor that still occurs today.

Mojzsis' work does not only depend on measuring meteorite ages. Because there is a lot of evidence for a migration of giant planets, Mojzsis' team modelled what it would look like if the event had happened early enough to explain the 4.48 billion years ago date he saw in the meteorites. "We dynamically modelled what we'd analysed geochemically. If this is correct, can this predict the reset ages we see on the Earth, Moon, and Mars? And it does. At 4.48 [billion years ago]," he says. That, in turn, pushes back the age of a hospitable Earth. If space more or less ceased pelting our planet with asteroids by 4.48 billion years ago, that allows the Earth to cool and form water. The oldest rocks scientists have found on Earth come from zircons, and these indicate Earth had water some 4 billion years ago. The first hints of life appear at 3.8 billion to 3.9 billion years ago, an age hard to reconcile with the idea of a massive meteor bombardment happening at the same time.

Earth would have still suffered the occasional asteroid blow – we see them even today, and we have strong evidence that one killed off the dinosaurs. However, Mojzsis' work means that Earth would not have suffered the kind of strikes that would boil away entire oceans and liquefy the whole surface more recently than 4.48 billion years ago. "I think this resolves the conversation," Mojzsis says of his work. By: Korey Haynes

3 Earth-sized exoplanets found just 12 light-years away 21 August: There is a triplet of Earth-sized planet candidates orbiting a star just 12 light-years away, and one appears to be in the habitable zone.

GJ 1061 is a cool red dwarf similar to the star TRAPPIST-1. This artist's concept imagines a view from the surface of one of TRAPPIST-1's multiple exoplanets. M. Kornmesser/ESO

All three candidates are thought to be at least 1.4 to 1.8 times the mass of Earth, and orbit the star every three to 13 days, which would put the entire system well within Mercury's 88 day orbit of the Sun. The planet orbiting the star every 13 days, dubbed planet d, is most interesting to scientists — it falls within the star's habitable zone where liquid water could exist on the surface. "We are now one step closer [to] getting a census of rocky planets in the solar neighborhood," said Ignasi Ribas, researcher at the Institute of Space Sciences in Barcelona, Spain.

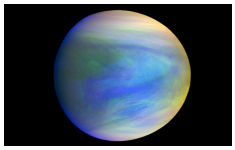
The planets' host is GJ 1061, a type of low-mass star called an M dwarf that is the 20th nearest star to the Sun. The star is similar to Proxima Centauri, the star closest to Earth, which was discovered to host a planet in 2016. GJ 1061, however, shows less violent stellar activity, suggesting that it may currently provide a safer environment for life than Proxima Centauri. To assess habitability, a star's whole history needs to be accounted for and M dwarf stars could have had stronger activity levels in the past and also have much longer lifetimes than Sun-like stars. This means that a close-orbit planet, like planet d, might have spent many millions of years being blasted by intense radiation from its star, so it may not retain a life-sustaining atmosphere.

The new planets were discovered with the radial velocity method - a technique that uses tiny wobbles in a star's orbit to revel the gravitational presence of exoplanets. This

technique typically reveals giant exoplanets close to their host star, but increasingly, this method is being used in long-term campaigns to reveal smaller exoplanets. Using the HARPS instrument on the 3.6-metre telescope at the European Southern Observatory in La Silla, Chile, astronomers observed the star over 54 nights from July to September in 2018. The star was one target of a larger campaign called the Red Dot project, which since 2017 has surveyed small nearby stars to look for terrestrial planets like Earth. The data showed the signatures of three, and possibly four, candidate planets. The scientists suspect the fourth signal is just stellar activity — not a real planet. However, after calculating the remaining three planets' orbits, the scientists could not rule out an additional, unseen fourth planet. This undiscovered planet would have a much longer orbit, so further observations would be need to determine if there really is a fourth planet farther out.

By: Mara Johnson-Groh

Mysterious dark patches in Venus' clouds are affecting the weather there 29 August: Something mysterious swirls amidst the clouds of Venus. The planet's hot, harsh atmosphere is thick with carbon dioxide and sulphuric acid. Atmospheric gases circulate amid cloud layers according to patterns that scientists do not fully understand. Venusian clouds also contain strange, dark patches, called 'unknown absorbers' because they absorb large amounts of solar radiation. No one has yet determined what these dark patches are, but scientists have speculated that they may be forms of sulphur, ferric chloride or even microscopic life.



Composite image of the cloud-covered planet Venus using data from the Japanese probe Akatsuki. Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency

A team of scientists led by Yeon Joo Lee, a researcher in the Centre for Astronomy and Astrophysics at the Technical University of Berlin, has shown that the unknown absorbers are affecting Venus's weather. On Venus, as on Earth, the energy that drives the atmosphere's winds comes from the Sun. By studying more than a decade of data from Venus Express, Akatsuki, Messenger and the Hubble Space Telescope, the researchers found a relationship between Venus' clouds and its winds. The clouds absorb solar radiation, which causes temperature changes that affect wind patterns. The unknown absorbers seem to play a role in this process by affecting the planet's albedo, or how much energy is reflected back to space. "It is hard to conceive of what would cause a change in the albedo without a change in the absorbers," said Sanjay Limaye, a planetary scientist at the University of Wisconsin-Madison.

In part because it is difficult to explain the absorbers' changes inorganically, Limaye has explored the possibility that they might be microorganisms. He is in good company. The idea of life in the Venusian atmosphere dates back to a 1963 paper co-authored by Carl Sagan. Limaye observed that the particles making up the dark patches in Venus's clouds resemble microorganisms in Earth's atmosphere. "Since there are few species which have physical, chemical and spectral properties that are consistent with the composition of the Venus clouds, they may have evolved independently on Venus." He pointed to the possibility that liquid water might have survived on Venus for as long as two billion years, while at the same time volcanoes erupted and hydrothermal vents may have existed. "If similar conditions elsewhere led to the evolution of life, why not on Venus?" Limaye said.

However, the extraterrestrial explanation remains just one possibility. Emilie Royer, a research scientist at the Planetary Science Institute who was not involved in the study, said that no proposed theory about the absorbers has yet fully explained them. "This new result is very important because every piece of information we obtain from atmospheric levels from the upper clouds and above will help resolve the enigma" of the planet's mysterious atmosphere, she says.

Lee said it is still not known whether Venus's climate variations are being driven by an internal source, such as sulphuric dioxide gas coming up from the surface, or an external source, such as a solar activity cycle. To further unlock the Venusian weather, Limaye says, scientists will need constant, systematic monitoring of the planet's cloud cover over multiple 11-year solar cycles. He also suggests aerial platforms that can sample Venus's cloud layer, search for bio-signatures and take other measurements. By: Erica Naone

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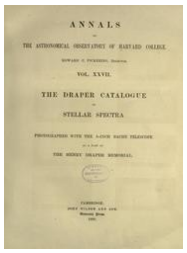
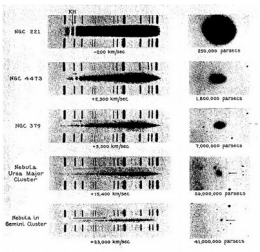
DID YOU KNOW?

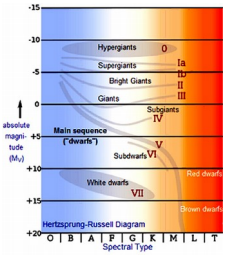
Astronomical catalogues Part 11: Henry Draper catalogue – a novel catalogue of spectra which also founded the current system of stellar classification



1890 Draper Catalogue


Annie Cannon analysing a photographic plate


Example page from Henry Draper Catalogue



Value of the Harvard spectral classification

American Henry Draper (1837-1882) was a pioneer amateur astronomer and photographer. In 1872, he used astro-photography to record the first spectrum of another star, showing distinct spectral lines for Vega. He gave up his profession as a doctor to focus entirely on astro-photography, imaging the Moon, planets, comets and several deep sky objects. After his early death, his widow, Mary, took an interest in the photographic spectroscopy work which was taking place at Harvard College Observatory under the leadership of Edward Pickering.

In 1886, she agreed to fund the work necessary to undertake a full-sky survey, classify the resulting spectra and produce a catalogue, which was to be named after her husband. The result was the 1890 publication of the *Draper Catalogue of Stellar Spectra.* It included the spectra of 10,351 mainly northern hemisphere stars. Most of the classification had been undertaken by one of Pickering's female 'computers', Williamina Fleming. She had developed and used a new classification scheme which included more specific categories than the system then in use. Also in 1890, Harvard established an observatory in Peru to study the spectra of southern hemisphere stars.

An updated edition of the catalogue was published in 1897. This time, the computer who undertook the more detailed study of northern hemisphere spectra as Antonia Maury, Henry Draper's niece. She used an altered form of the new Harvard classification system,

based on newer findings. Data was also coming through from Peru, and, in 1901, Pickering and another computer, Annie Jump Canon, published a list of bright southern hemisphere star spectra. Canon also used the new Harvard classification system, further amending its format in light of new insights.

As new discoveries increased interest in stellar classification, work began formally on the new *Henry Draper Catalogue* (HD). It was compiled by Annie Cannon, as usual under Pickering's supervision. From 1912 – 1915, she and her co-workers classified spectra at a rate of 5,000 per month using only their eyes and their experience to do so.

The catalogue was published between 1918 and 1924. It was notable both as the first large-scale work to catalogue the spectral types of stars and as the first to rely entirely on photographs of the sky. It consisted of 9 volumes, listing the positions, magnitudes and spectral types of 225,300 stars down to 9th magnitude. It included cross-references to the Bonner Durchmusterung. Stars were numbered from 1 – 225,300 in order of right ascension, each number preceded by the letters HD. The classification scheme used was a further refinement of the Harvard system, Cannon adding some new categories for newly identified star types to the scheme she had used in the 1901 list.

Cannon had taken over management of the catalogue following Pickering's death in 1919, and also supervised production and publication of the *Henry Draper Extentsion* (HDE) from 1925 – 1936. It contained 46,850 spectra of fainter stars, down to 11th magnitude. A second supplement, containing another 86,000 stars, was published in 1949. Numbering in the two supplements continued on from the first Draper Catalogue, although the prefix used was HDE. Many stars are still known by their HD and HDE numbers.

From 1937 – 1949, the *Henry Draper Extension Charts* (HDEC) were published. After Cannon's death in 1940, the work was taken over by Margaret Mayall. Data was presented as reproductions of photographic plates, a format which usefully compressed the data. This shortcut saved so much paper that spectra of several thousands of newly discovered stars could be published regularly. Numbering in it continued to be consecutive, making all version of the Draper Catalogue, one unit. By 2017, the Draper Catalogues covered 359,083 stars.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, D W Sobel, D (2016) The glass universe London, 4th Estate, www.en.wikipedia.org

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