"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

SEPTEMBER 2021

Monthly meeting This months **Zoom meeting** will take place on the evening of **Monday 20 September,** starting at **18.30.** Access details will be circulated to members closer to the time. The presenter is **Case Rijsdijk.** His talk is titled '**The very early Universe**'. See below for further details.

2021 meeting dates For your diaries. The remaining dates of the monthly meetings for 2021 are as follows: 20 September, 18 October and 15 November.

WHAT'S UP?

Venus, then Mercury near Spica (Virgo) From 1 – 4 September, towards the West after sunset, Venus moves ever closer to Virgo's brightest star Spica ((Alpha (ɑ) Virginis). After its closest position, on 5 September, the evening star then moves further and further away. At the same time, Mercury moves ever closer to the star, remaining close to it for the latter third of the month. Although Virgo i(the Virgin) s the largest of the zodiac constellations and the second largest of all 88 named constellations, it has only one bright star. The faintness of Virgo's other stars makes Spica appear solitary rather than part of a constellation. Its name is derived from the Latin *spica virginis* meaning ' the virgin's ear of wheat', reflecting the mythological link between the female and fertility. Located about 250 ly away, the 15th brightest star in the night sky appears blue-white. Like many stars, it is actually a binary system. The two stars are so close that their gravitational interactions mean they are both egg-shaped, rather than spherical. They orbit each other every 4 days and can only be identified separately through a large telescope.

LAST MONTH'S ACTIVITIES

Monthly centre meeting At the Zoom meeting on 16 August, Dr Pieter Kotzé ,Centre member and retired researcher at SANSA, gave a compelling presentation on 'Cosmo-climatology: Does solar variability affect Earth's climate? Pieter addressed the claim, by some, that the Sun, not human activity, is responsible for global warming and climate change. He noted that the Sun is the greatest energy supplier to Earth and powers it climate system. This has been the basis for claims that solar output is responsible for climate change, with sunspot activity proposed as the visible link between the two. The correlation between low sunspot numbers and the Maunder Minimum (Little Ice Age) in the late 17th century is an event used to support this claim. Pieter explained that, while the Sun does drive climate, its effects on Earth are modulated by other short and long term processes incl orbital variations, volcanic eruptions, El Nino and human-created sources eg greenhouse gases, aerosols. Overall, the evidence shows that, over the recent years of global warming, solar irradiance has actually fallen, demonstrating that the Sun is not the main driver, as claimed by some.

Pieter then looked at a rare source of data on historic climate patterns specifically in South Africa. He outlined work done recently on the tree rings of a 1,000 year old dead baobab tree. Analysis of a particular carbon isotope, whose levels identify periods of higher and lower rainfall, identified the climate variations experienced from 1600 – 2000. More specifically, it identified that South Africa experienced severe drought during the period of the Maunder Minimum. Overall, Pieter's data-driven presentation demonstrated that, while the Sun can influence climate, it only does to some extent, and is not responsible for recent global warming.

Interest groups

Cosmology At the Zoom meeting, held on 2 August, Derek Duckitt presented the video 'Why is the universe the same everywhere?'.

Astro-photography Imaging and processing were discussed at the Zoom meeting held on 9 August.

Other activities

Educational outreach No activities took place during August

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's **Zoom meeting**, will take place on the evening of **Monday 20 September** starting at **18.30**. Access details will be circulated to members. The presenter is **Case Rijsdijk.** His talk is titled '**The very early Universe**'.
Synopsis "Cosmology today has become a Physical Science in that much of it, going back to the CMB, and a little beyond, is falsifiable. However the origins of the Universe are still speculative and there are many models trying to account for current observations. It has become clear that in the past it was possible to "do Cosmology" with Physics; today it is possible to "do Physics" with Cosmology!*
I will be looking at possible new approaches to, or consequences of, speculative models, from the Planck era onwards; using Particle Physics beyond the Standard Model (SM), to try and explain the origins of the Universe. This will need a short look at the SM, some details of a proposed model and some potential falsifiable experiments from this model."
* Robert Sanders "Deconstructing Cosmology" 2016
Biography Case Rijsdijk's life has been moulded by two passions – physics and astronomy. His enthusiasm for these subjects, and his dedication and commitment to sharing them with colleagues, teachers and the public, across South Africa and the world, has led to him being made the recipient of several awards, including the first and only Special Award from the National Science and Technology Forum recognising an outstanding contribution to Science, Engineering, Technology and Innovation, and ASSA's Gill Medal..
Born in the Netherlands in 1945, Rijsdijk was educated at Kabulonga Boys High School in Lusaka, Zambia. He attended the UCT and graduated from there in 1969 with a BSc in Physics. During this time he also studied astronomy at the (then) Royal Observatory at the Cape (now SAAO) by Prof R H Stoy, the last Astronomer Royal at the Cape. He continued his postgraduate studies in physics and astronomy there after graduating before ill health curtailed his formal research. He taught Physics, Mathematics and Statistics from 1971 at St Georges College in Zimbabwe and then from 1977/93 at Bishops in South Africa. During this time he published papers on Physics, Astronomy and Education. He went on to

become national chair of the SA Association of Teachers of Physical Science.
He returned to the SAAO in 1993 where he started the Science Education Initiative, SEI, to promote Astronomy as a vehicle for Science Education among South Africa's previously disadvantaged people. In 1998 he created and managed the Friends with the Universe project during South Africa's first Year of Science and Technology to promote SALT. Perhaps the most enduring aspect this project was its mobile facility – a mini-bus known as the "Starbus", which was equipped with SEI materials to run workshops in rural areas, similar vehicles are now active in several countries.
Other initiatives that Rijsdijk was involved with, and attended annually, were SciFest Africa – the National Science Festival held in Grahamstown each year, running w/s, the Science Olympics and giving lectures, in 2001 he co-founded an international Astronomy Educational Collaboration of all the major Observatories in the world, STARTEC, after which he was involved in developing the Frank Bash Visitors Centre at McDonald Observatory in Texas, USA. He has attended over 90 Conferences where he presented papers/talks on physics, astronomy and education, both in SA and overseas, is an Honorary member of the SA Institute of Physics, the Royal Society of SA and ASSA.
His retirement has been hectic. He maintains that retiring is merely the cessation of formal employment. He is still involved in teacher training, the SA Physics Olympiad, the ASSA and his research in Particle Physics. "I am still working… but the difference is I don't get paid!" He values the contribution he has bean able to make to education. "There is nothing in the world that gives me greater satisfaction than to share some of my knowledge and experience with others."

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. The next meeting, on the evening of **Monday 6 September** will be shown **via Zoom,** starting at **18.30**. Details of the topic and access details will be circulated to members, in due course.

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 Zoom meting will take place on **Monday 13 September**.

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**, starting at **18.30**. The remaining dates for this year are as follows: 20 September, 18 October and 15 November.

Remaining external speakers are Case Rijsdijk (September) and Petri Vaisänen (October). The remaining Centre member presenter is Jenny Morris (November). Details will be circulated closer to the time, each month.

ASTRONOMY GEARING'S POINT ASTRONOMY EDUCATION CENTRE (GPAED)

Municipal agreement has been obtained for this project, which is to be located within the existing whale-watching area at Gearing's Point.. Work is underway to obtain the necessary quotes and other budgetary requirements in order to submit an amended proposal to the National Lottery Commission.

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

Galileo Project to search for alien artefacts hiding in the solar system 3 August: Make way, SETI (aka the Search for Extraterrestrial Intelligence). There is a new game in town, which might be called SETA (the Search for Extraterrestrial Artefacts), though it is officially known as the Galileo Project. SETI began in 1960 and has, in the intervening six decades, been almost exclusively limited to the search for radio and laser signals from potential alien civilisations. The Galileo Project, which was launched this month, will instead embark on a systematic search of the skies above Earth and outer space for artificial objects of extraterrestrial origin - possible space probes, active sensors, or long-defunct "astro-archaeological artefacts."


Loeb suggested that 'Oumuamua could be alien technology. shutterstock

Serendipity played a role in the start of this venture, according to Harvard astronomer Avi Loeb, who heads the Galileo Project. In early July, Loeb said, "an administrator in Harvard's Astronomy Department told me they'd just received $200,000 for my research fund, which someone had donated without even telling me." A day or so later, Loeb was able to contact the generous individual (whom he did not know beforehand), and after their conversation he was given even more money. Since then, other individuals have sent money to support this research effort, no strings attached. In a couple of weeks, Loeb accumulated $1.75 million. "They basically told me: 'Here is the money. Do with it whatever you think is right,'" he said. "In all my decades in academia, that kind of thing never happens."

Loeb had gained some notoriety from the January 2021 publication of his book, Extraterrestrial, which argued that 'Oumuamua - the first known object passing by Earth to come from outside the solar system - had peculiar features unlike those of any asteroid or comet seen before. 'Oumuamua is now headed toward Neptune on its way out of the solar system, and we will never know exactly where it came from or what it is made of. Loeb issued a controversial suggestion in his book, and in a 2018 Astrophysical Journal Letters paper, that 'Oumuamua could be the product of an alien civilization - a possibility, he stressed, that should not be dismissed out of hand. Extraterrestrial s now a bestseller that has been translated into 25 languages, and Loeb has submitted to more than 1,000 interviews, averaging six per day for six months. He has been effective, as well as tireless, in getting the word out, and that message has apparently resonated with some people - including a few well-heeled donors.Without engaging in any fundraising, Loeb has already secured enough seed money to get the Galileo Project started, and hehas assembled a research team that includes scientists (presently working on a voluntary basis) from Caltech, Cambridge University, Harvard, Princeton, Stockholm University, the University of Tokyo, and other institutions.

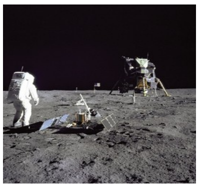
One of the Galileo Project's main focuses will be to look at UFOs, also called Unidentified Aerial Phenomena (UAP) in a 2021 report by the US Office of the Director of National Intelligence, which concluded that "a handful of UAP appear to demonstrate advanced technology" and that "limited data leaves most UAP unexplained." "That was a novel admission," Loeb commented, "a government report that concluded there are objects in the sky we don't know the nature of. I say, let's move this debate to the realm of science so that we can finally clear up the question using standard research procedur"You wouldn't ask a plumber to bake a cake," he added. "Similarly, people in the military or in politics are not trained as scientists, and should not be asked to interpret what they see in the sky." Accordingly, the Galileo team is already designing a network of small, ground-based telescopes, around 25 centimetres in diameter, that will be connected to cameras and computer systems. "We'll use these telescopes and process the data in the same way astronomers always do," Loeb explained, "but instead of looking at distant objects, we'll look at nearby objects, moving fast across the sky." Within a year, he and his colleague hope to start collecting data that will be open to the public and science community so that anyone can analyse it. A Harvard official recently questioned Loeb as to whether this research falls under his job description. "I analyse and interpret data from telescopes," he replied. "That's what astrophysicists do."

Another Galileo Project objective is to develop software and algorithms that can pick out other interstellar objects like 'Oumuamua from data collected by the Legacy Survey of Space and Time (LSST) telescope, which is due to begin operations in 2023. If an object is detected early enough, on its way into the solar system, a space mission could be initiated to get close enough to the ET visitor to obtain a high-resolution picture that would be worth more than 1000 words in Loeb's estimation. These days, he wouldn't necessarily have to convince a giant bureaucracy like NASA to back such a mission. "Instead, we might have to convince just Elon Musk or Jeff Bezos."

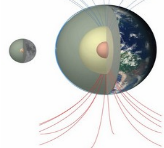
There is a major stigma associated with UFOs, Loeb noted, which makes many scientists think they are not worth studying - or even looking at. He is not sympathetic to that view, as it reminds him of the treatment Galileo Galilei received from philosophers of his era who, in the early 1600s, disputed his discoveries of the moons around Jupiter, or the rings around Saturn, and even refused to look through Galileo's telescopes to see for themselves. The same kind of resistance comes up whenever the possibility is raised that some things we see in the sky could have been made by other intelligent beings. Some sceptics subscribe to the dictum, first articulated by Carl Sagan, that "extraordinary claims require extraordinary evidence," carrying that tenet a step further by insisting that extraordinary evidence is required before one should even begin studying UFOs or consider the prospect that strange 'Oumuamua-like objects may be artificial. Attitudes like that have prompted Loeb to modify Sagan's statement into a kind of cri de coeur for the Galileo Project: "Extraordinary conservatism leads to extraordinary ignorance."

By: Steve Nadis

Did the Moon once have a long-lived magnetic field? New research resolves the mystery. 5 August: Surrounding Earth is a powerful magnetic field created by swirling liquid iron in the planet's core. Earth's magnetic field may be nearly as old as the Earth itself – and stands in stark contrast to the Moon, which completely lacks a magnetic field today. The question is - Did the Moon's core generate a magnetic field in the past? In the 1980s, geophysicists studying rocks brought back by Apollo astronauts concluded the Moon once had a magnetic field that was as strong as Earth's. However, a robust magnetic field requires a power source, and the Moon's core is relatively small. For decades, scientists have struggled to resolve this conundrum: how could such a small core create a strong magnetic field?

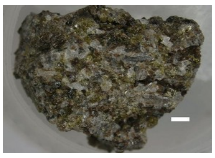

Scientists have been studying lunar samples brought back from Apollo missions to understand the geologic history of the Moon. NASA

I am a professor of geophysics and have been studying Earth's magnetic field for more than 30 years. I recently assembled a team to use new scientific techniques to re-examine the evidence for lunar magnetization. We found that the Moon did not, in fact, have a long-lived magnetic field. Not only does this finding change the modern understanding of the Moon's geologic history, it also has major implications for the presence of resources on the Moon that could be critical to future human exploration.


Relative to the Earth, the Moon has a small core, and it is not obvious how it could have created a strong magnetic field. Rory Cottrell/U. Rochester, CC BY-ND

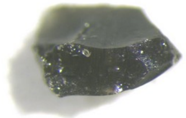
Certain rocks have the extraordinary ability to preserve records of past magnetic fields when they contain minerals with iron atoms that align with a magnetic field as the rock cools and solidifies. The best magnetic minerals at preserving evidence of a field are tiny - a thousand times smaller than the width of a human hair - because it takes a lot of energy to rearrange their atoms. Geophysicists who study ancient magnetism recreate this process, reheating rock samples in the presence of known magnetic fields and comparing the new alignment of the iron atoms with the orientation of iron atoms before the rock was reheated. This allows researchers to learn about past magnetic fields.

Early researchers studying the first rocks brought back from the Moon by US astronauts wanted to use this method to study the Moon's magnetism. However, they faced problems. Lunar rocks contain a certain type of iron – called native iron – that is easily altered by heat. Additionally, the native iron grains in lunar rocks are sometimes relatively large, making them less likely to reliably record past magnetic fields. From the 1970s onward, geophysicists used alternative, non heating methods to study the Moon's magnetism. They found that some lunar samples had recorded strong magnetic fields, suggesting that the Moon had a magnetic field for over 2 billion years. However, this result only deepened the conundrum. The question of how the Moon's core could produce a strong magnetic field remained unsolved.

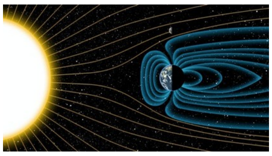

Samples from the Moon, like this lunar basalt, are a complex mix of many minerals, and only some can record signals of past magnetic fields. The white scale bar is 1 mm.

In the experiments, some Apollo samples showed evidence of strong magnetic fields but other samples did not. Some researchers attributed the missing magnetisation to the presence of large native iron grains that were poor magnetic recorders. However, many of the samples also contained small iron grains that should have recorded a field. There have been long-standing doubts about the non-heating techniques researchers used on the Apollo samples. Some scientists have called them methods of "last resort" and conclude that the uncertainties in data collected in this way were so large that any interpretation must be viewed as speculation. Alternatively, another group of scientists has suggested for decades that when meteorites strike the Moon, they create a dusty plasma – a gas of ions and electrons – that could generate a strong magnetic field and magnetise lunar rocks near the impact zone.

In 2008, geophysicist Klristin Lawrence decided to revisit the question of lunar magnetisation using an improved reheating technique. In contrast to the researchers who originally studied the samples, she was unable to detect any definitive evidence for a past magnetic field. The approach Lawrence and her team used was better than the non heating tests, but her results were still not conclusive. She felt she was on to something, though, and that is when she turned to me and my lab for help. In 2011, Lawrence brought us a collection of lunar samples to test. We had been developing techniques to identify individual millimetre-size silicate crystals that contain only very small iron grains and have ideal recording properties. We then used an ultrasensitive superconducting magnetometer and a special carbon dioxide laser to rapidly heat those samples in a way that avoids altering their iron minerals. We found that nearly all the rocks had profoundly weak magnetic signals. At the time of this first test we were still improving the method, so we could not say with certainty whether the samples had formed on a Moon without a magnetic field. We have been improving our testing methods, and last year we decided to revisit the Apollo samples. We definitively found that some of the samples did indeed contain magnetic minerals capable of preserving high-fidelity signals of ancient magnetic field - but the rocks had recorded no such signals. This suggests that the Moon lacked a magnetic field for nearly all of its history.


This small piece of lunar glass was formed and magnetised by a meteorite impact and could explain the strong magnetic readings from the past. Rory Cottrell/U. Rochester, CC BY-ND

So, what explains the previous findings of a magnetic Moon? The answer was in one of the samples: a small, dark piece of glass containing tiny iron-nickel particles.The glass was made by a meteorite impact and showed clear evidence of a strong magnetic field, but was formed only about 2 million years ago. Nearly all geophysicists agree the Moon did not have a magnetic field at that time, because after 4.5 billion years of cooling there was not enough heat left to power the churning of iron in the Moon's core to generate a field. The magnetic signature of the glass matched simulations of magnetic fields that can be generated by meteor impacts. This showed that meteorite impacts alone can create strong magnetic fields that magnetise rocks nearby. This could explain the high values previously reported from some Apollo rocks. Taken together, I believe these findings resolve the mystery of a seemingly magnetic Moon.


Earth's magnetic shield blocks solar wind, whereas the lack of a magnetic field on the Moon allows the solar wind to directly hit its surface and deposit elements. Michael Osadciw/U. Rochester, CC BY-ND

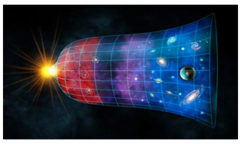
This new view of lunar magnetism has huge implications for the potential presence of valuable resources as well as information about the ancient Sun and Earth that may be buried in lunar soils. Magnetic fields act as shields that prevent solar particles from reaching a planet or moon. Without a magnetic field, solar wind can hit the surface of the Moon directly and implant elements like helium-3 and hydrogen into the soil. Helium-3 has many applications, but importantly, it could be a fuel source for nuclear fusion and future planetary exploration. The value of hydrogen comes from the fact that it can combine with oxygen to form water, another crucial resource in space. Since the Moon did not have a long-lived magnetic field, these elements could have been accumulating in soils for billions of years longer than previously thought.

There is also scientific value. Elements embedded by solar wind could shed light on the evolution of the Sun. As the Moon passes through Earth's magnetic field, elements from Earth's atmosphere can be deposited on the lunar surface, and these may hold clues about the earliest Earth. The absence of a long-lived magnetic field on the Moon might strike some as a loss, but I believe it may unlock a scientific bonanza and a valuable stash of potential resources. By: John Tarduno, The Conversation

What would this cyclic model of the universe mean for the Big Bang? 20 August: In Paul Steinhardt's corners of the cosmology world, to say that history repeats itself would be a laughable understatement. That is because, according to him and a handful of peers, the universe's form may be hurtling into a new cycle every trillion years or so."One hundred million years sounds like a long time, but cosmically it's like tomorrow," Steinhardt says. The professor of physics and director of the Princeton Centre for

Theoretical Science co-wrote a paper on this topic, A Cyclic Model of the Universe, with Neil Turok. The cyclic model of the universe he helped pioneer is just that: a theory that the universe forms itself again and again in cycles. Proponents of this model are asking us to rethink the Big Bang and the rapid inflation of the universe. They contend that doing so could fill in some of the biggest gaps in our common understanding of the way space and time work.

The generally accepted understanding of the universe is this: About 14 billion years ago, the Big Bang happened. In its early seconds, the laws of physics as we understand them did not apply. All that would eventually become matter burst forth in a matter of seconds - first particles, like electrons and photons, and eventually neutrons and protons, the building blocks of our atoms. Early seeds of stars, planets, and galaxies expanded out from that momentous point in time and space. It spread in such a way that the universe became highly smooth. Smoothness, on an enormous scale, just means that things within the universe are relatively evenly distributed. That is, if you were to put a cube around one section of the universe, it would not be much more dense than another randomly placed cube. On a smaller scale, like between galaxies or within a solar system, matter is 'lumpy' and filled with clusters.


Andrea Danti/Shutterstock

Physicists theorise that shortly after the Big Bang, something called 'inflation' occurred. Essentially, what was once a tiny, packed-together universe expanded out rapidly in a fraction of a second, and it continues to expand today. Inflation is part of the current standard model of the universe, called the Lambda Cold Dark Matter (LCDM) model. In LCDM, the shape of the universe's trajectory looks, in some depictions, like a funnel, its wide top growing and spreading further out over time.

That is one interpretation. There are others that have arisen out of the same bits of information that scientists can actually observe and measure in real life - that is, observational astronomy. The real life information is crucial if scientists are to use models to make actual predictions about the future of our cosmos. "Cosmology is kind of teamwork, you need some people focusing on really pragmatical and observational stuff and you need people to go sci-fi," says Leonardo Giani, a postdoctoral research fellow at the University of Queensland in Australia, whose studies focus on alternate models of the universe besides the standard model. "That's how it goes."

Theoretical astrophysics is all about educated guesses that are shaped by the few things we do know for certain. Something called the Cosmic Microwave Background (CMB) contributes to a big part of that observable information. The CMB is made up of the traces of radiation left over from an early phase of the universe. Radio telescopes can pick it up, and then translate the waves into a heat-map image of sorts. This image actually shows us how the contents of the universe were distributed about 400,000 years after the Big Bang — the earliest observable snapshot of a universe devoid of stars, solar systems and galaxies. Everything was closer together and almost uniform, except for tiny fluctuations that became the matter forming stars and galaxies. This image serves as evidence that the universe started packed together, and has expanded to where it is today. We also know that the universe continues to expand, and can even measure, to some degree, how fast it is doing so. The CMB also serves to confirm that an earlier version of the universe was very hot, and our era is much colder.

Steinhardt says a number of problems arise with the inflation model, which itself expanded and corrected previous models that arose from Big Bang theory. The inflation model was supposed to explain why, for example, the universe appears so homogenous on a huge scale without the same initial conditions. However, Steinhardt says, there are so many possibilities that arise from an inflationary model that it makes the model itself less useful. Previous models, he says, do not rule out predictions about the cosmos that are wrong. "It's like I came to explain to you why the sky is blue, but then when you look at my theory more closely, 'Oh! My theory could have also predicted red, green, polka dot, striped, random [colors],'" Steinhardt says. "And then you say 'Okay, what good is that theory?'"

Then there is the singularity problem. The inflation theory, Steinhardt argues, also gets stuck at the point 'before' the Big Bang, because according to it, there is nothing before it. "The fundamental philosophical problem with the Big Bang is, there's an after but there's not a before," Steinhardt says. "In a similar way, we don't know 'one time only' things that happened in history." Mathematically, the Big Bang looks like it came from an undefined state - something that is not explained by the laws of physics under Einstein's theory of general relativity. This is also called a 'singularity'. To Steinhardt - but not to everyone – that is the mathematical equivalent of a red flag. "We all learned in school, when you get one over zero for an answer, you're in trouble, because that's a nonsense answer. You made a mistake." In a related problem, there is also some difficulty in reconciling the inflation theory with string theory and quantum mechanics, says Steinhardt. If the model correctly described the universe, other accepted frameworks of physics would agree with it. Instead, Steinhardt says they are at odds. "When one's thinking about cosmology, you're often reaching across fields of thinking, which are quite distant, either on the astro side or on the fundamental physics side and seeing, do they fit together?" The cyclic model, he says, helps do this.

A cyclic model of the universe is designed to solve some of the seemingly unsolvable problems of the Big Bang and inflation models. "It allows us to go beyond the Big Bang, but without any kind of magical philosophical issues," says Stephon Alexander, a professor of physics at Brown University, and the co-inventor of an inflation model of the universe based on string theory. "Because time has always existed in the past." Scientists have proposed a cyclic model that could work mathematically in a few ways. Steinhardt and Turok's model of a cyclic universe is one of them. Its core principles are these: The Big Bang was not the beginning of time; there was a previous phase leading up to it, with multiple cycles of contraction and expansion that repeat indefinitely; and the key period defining the shape of our universe was right before the so-called bang. There you would find a period of slow contraction called the Big Crunch. So, instead of a beginning of time arising out of nothing, the cyclic model allows for a long period of time in the lead-up. It claims to fix the same problems as the inflationary theory did, but builds even further. For one thing, the existence of time before the Big Crunch removes the singularity problem - that undefined number. It also utilizss string theory and quantum fluctuations.

Like the LCDM, a cyclic model would also account for dark energy, an unobservable force that scientists believe is behind the accelerating expansion of the universe. But in

Stenhardt and Turok’s model, things get a little more like science fiction: Two identical planes, or ‘branes’, (in string theory, an object that can have any number of dimensions) come together and expand apart. We can observe the three dimensions of our plane, but not the extra dimensions of the other. Dark energy is both the force leading the branes into a collision, with separation between them. Expansion of the branes themselves follows, and dark energy draws them together again once they’re as flat and smooth as they can become.

Giani, the researcher, is not so sure, because of some of the assumptions this model brings in from string theory. He likes another cyclic model from Roger Penrose, a theoretical physicist at Oxford who came up with what Penrose himself called “an outrageous new perspective” on the universe. “I was completely amazed by it,” Giani said. It’s hard to wrap your head around: In the distant, distant future, our solar system and galaxy will be engulfed by black holes, which eat up all the other mass in the universe, and then after an unimaginable amount of time, only black holes will exist. Eventually, only photons exist, which have no mass and therefore no energy or frequency, according to our accepted laws of physics. Measurements of scale, Penrose explains, no longer apply at this stage, but the shape of the universe remains. At the moment of the Big Bang, he argues, when particles are so hot and close together that they also move at almost the speed of light, they also lose their mass. This creates the same conditions at the Big Bang as the cold, distant future universe. Their scale is no longer relevant, and one can beget the other. The remote future and the Big Bang become one and the same.

Ultimately, what humans can observe of our universe is limited. That is why theories of the universe are never complete. They balance the small sliver of the universe we can observe with mathematical models and theory to fill in the rest. So, in cosmology, scientists search for observable phenomena that disprove their models, and reshape their theories again to suit the problem. However, as our technology rapidly advances, observations that support or detract from one model or another come more often. “It's completely worth making all this speculation in this work, because we are getting to the point in which this data will arrive,” Giani says. One such observation could produce compelling support for either a cyclic model or confirm the more accepted inflationary theory. Because of how matter is distributed in our view of the oldest part of the universe (seen in the CMB), gravitational waves that reach us may be polarised, like light, at a particular frequency. Soon - within a few years, in fact - scientists may be able to determine whether this polarization exists. If it does, it will support the inflationary model. If this polarisation does not exist, it will undermine ’slow contraction’, a hallmark of the cyclic model.

By: Sophie Putka

Why cosmic radiation could foil plans for farming on Mars 23 August: What would it take for humans to live on Mars? The first step is to successfully get people to the red planet, of course. Once there, the astronauts would face a task that could be even more difficult: figuring out how to survive in an environment that is vastly different from Earth's. A new study demonstrates one of the challenges -- Earth's plants do not grow as well when exposed to the level of radiation expected on Mars.

SergeyDV via Shutterstock

Wieger Wamelink, an ecologist at Wageningen University in the Netherlands who describes himself as a space farmer, has been frustrated by sci-fi depictions of growing plants on Mars. "What you often see is that they do it in a greenhouse," he said, "but that doesn't block the cosmic radiation," which consists of high-energy particles that may alter the plants' DNA. Mars lacks the same degree of protection from cosmic radiation that the Earth's atmosphere and magnetic field provide. To prove his suspicion that cosmic radiation could be dangerous to plants, Wamelink decided to test the hypothesis himself.

First, Wamelink and his team had to recreate the cosmic radiation. The team settled on using gamma rays generated by radioactive cobalt, even though the actual cosmic radiation that bombards Mars' surface consists of various types of radiation, including alpha and beta particles. But, generating alpha and beta rays on Earth is much more difficult, Wamelink said. It would require a particle accelerator, which Wamelink would love to use, "but I would have to put some plants in the collider for, let's say, two or three months." Considering the high demand for the equipment, "I think it's not ever going to happen," he said. Once Wamelink and his team secured radioactive cobalt, the team grew rye and garden cress in two groups: one with typical growing conditions and the other had similar conditions but added gamma radiation. Four weeks after germination, the scientists compared the two groups and saw that the leaves of the group exposed to gamma rays had abnormal shapes and colours. The weights of the plants also differed; the rye plants in the gamma-ray group weighed 48% less than the regular group, and the weight of the garden cress exposed to gamma rays was 32% lower than their unblasted counterparts. Wamelink suspects the weight difference is due to the gamma rays damaging the plants' proteins and DNA.

Michael Dixon, who studies agriculture at the University of Guelph in Canada and was not involved in the study, said this research did a reasonable job replicating the cosmic radiation considering that it's impossible to copy it perfectly. Ultimately, researchers would need to study plants on the Martian surface to get a full understanding of the impacts. Dixon is a part of a team that is planning to attempt to grow barley on the Moon, which should happen in the next ten years, he said. One of the first questions that Dixon and his co-workers plan to study is whether or not plants can survive the exposure to lunar radiation. Wamelink said space agencies should step up their research into crops to improve the quality of the food that astronauts eat. "People at ISS [International Space Station] still eat astronaut food. And that's not very nice," Wamelink said. "I don't know if you ever tasted it, but, well, you don't get happy from it." Researching space farming and food production is "way more important than some people think," he said. "Radiation is a problem, but it's solvable, I think." By: Karen Kwon, Inside Science

'Tiger Stripes' on Enceladus could be even more unique than previously thought

25 August: Enceladus, Saturn's sixth largest moon, is awash with liquid water beneath its icy shell. At the moon's south pole, the subsurface ocean erupts from one hundred geysers located along four parallel fractures known as 'tiger stripes'. The towering jets of ice particles form a plume that snows back down to the surface. Some of the ice even escapes the moon's gravity and forms Saturn's E-ring. Icy moons that have (or are thought to have) sub-surface oceans are common in the outer solar system. For example, Jupiter has several of them. These form when gravity from the planet they orbit stretches and squeezes their interior. Scientists think that these tidal stresses generate enough heat to sustain the liquid water. Tidal stresses can crack the ice shell, but it may be difficult for these fractures to travel all the way through. Enceladus' tiger stripes are unusual because

they extend down to the ocean - and they present an enticing opportunity to search for evidence of life outside Earth.


Saturn's moon Enceladus sports several vast rifts (often called "tiger stripes") near its south pole, as seen in this false-color image from the Cassini spacecraft. NASA/JPL/Space Science Institute/CICLOPS

The famous stripe features are surrounded by 300-meter-high margins that form a valley-like trough up to several kilometers wide at the moon’s surface. To understand exactly how they formed, researchers model ice shell fractures based on various thicknesses. “Our models show that tidal stresses can fracture the ice shell all the way through, but indirectly limit how thick the ice can be,” says Catherine Walker, a glaciologist from the Woods Hole Oceanographic Institution. This new research shows that fractures originating at the surface are unlikely to reach the subsurface ocean, even for thinner ice depths. However, fractures that begin at the base of the ice shell have a better chance of piercing the surface, especially if they connect with cracks that originate from the top of the ice shell. “The ocean is under pressure, so water is forced into tiny cracks at the base of the ice shell, which widens and propagates the cracks all the way up to the surface,” says Carolyn Porco, a planetary scientist and visiting scholar at the University of California, Berkeley, and former leader of the Cassini Imaging Team, who suggested this possibility with colleagues in 2014.

The recent study also found that it is more difficult to form fractures through the entire ice shell than previously thought. Existing fractures reduce the overall amount of stress, and when this is accounted for, new ones do not propagate as deep or as high, says Walker. “The exact ice shell thicknesses are not known - but it could just be that Enceladus’ ice shell is thinner than we think at the south pole.”

Over a decade ago, the Cassini spacecraft flew through the plume and detected a composition of mostly water, but also salts and organic molecules that hinted at the subsurface ocean. The spacecraft detected tiny grains of silica, too, which suggests the presence of hydrothermal vents. Temperatures may reach close to 100 degrees Celsius within these vents, which would allow organisms to survive without sunlight, says Morgan Cable, a chemist who heads NASA’s Astrobiology and Oceans Worlds Group. Like hydrothermal vents on Earth, those on Enceladus sit on the seafloor. There, heat from the moon’s rocky interior may erupt hot mineral-rich water in chimney-like ocean currents - and organisms could take advantage of the different concentrations of dissolved minerals in these streams. “We are conservative in our estimate of life due to the limited energy budget, but you could certainly have multicellular organisms such as crabs,” Cable says.

All in all, Enceladus’ tiger stripes offer a unique opportunity to collect and analyse fresh material from a sub-surface ocean without the need to dig or drill. A future mission would include repeat fly-throughs of the plume, and a possible landing on the south polar terrain to sample freshly falling material that erupts from the geysers. Touching down on Enceladus would enable the most comprehensive search for evidence of life and allow for easier collection of materials, including repeat and varied measurements to increase scientists’ confidence levels in any discoveries, Porco explains. A landing could also offer detailed insights into Enceladus' geophysical workings and help resolve open questions; for example, the ice shell thickness and the width of the fractures. However, of all the burning questions, discovering whether life exists outside of Earth is the most alluring."It's only in the outer reaches of our solar system that we could be assured any life found there would represent a genesis of life that is independent of life on Earth," Porco says."And whether or not life has arisen independently elsewhere is the most beguiling question that we could hope to answer in exploring the solar system."

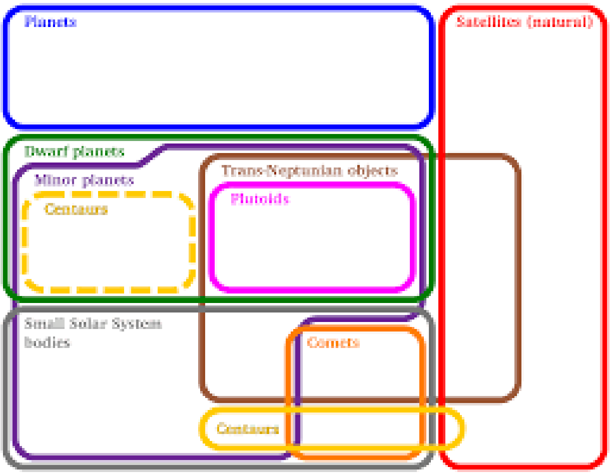
By: Theo Nicitopoulos

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

DID YOU KNOW?

Solar system objects Part 2: Overview (2)

Natural satellites (moons)



These do not orbit the Sun. They orbit other objects in the solar system, usually planets, but also some dwarf planets, minor planets and other small objects.

The word 'moon' comes from the Old English Germanic word 'mōna', which was derived from an earlier word for 'month'. The adjective used in relation to a moon is 'lunar', derived from the Latin word for moon, 'luna'. Since 1919, Earth's own moon has officially been called the Moon, to differentiate if from other moons and address the confusion caused by the many names then inu se for Earth's natural satellite. For clarity, the moons of other planets and celestial objects are given their own names eg Saturn's Titan.

For may centuries, Earth's Moon was considered to be a planet. It was only in the early 17^{th} century, when Galileo discovered that Jupiter has natural satellites, that it became known that a celestial body could orbit around objects other than the Sun. In 1610, Kepler was the first to use the work 'satellite' to describe such objects. The word is derived from the Latin word for 'attendant', 'companion' or 'guard'.

Natural satellites are not uncommon in the solar system. There are six planetary satellite systems, with he number of orbiting moons varying from 1 (Earth) to over 60 (Jupiter, Saturn). Of other larger objects, at least four dwarf planets have moons. Also, there are several hundred smaller objects which have orbiting moons.

The Earth-Moon system is unique among the planetary systems in that the ratio of the Moon's diameter to that of Earth's is much greater than any other moon-planet ratios. The ratio is 5 times greater than the next one, that between Neptune and Triton. Among smaller objects, the ratio between Pluto and its moon Charon is the greatest.

There is no formal lower limit to the size of a moon, as long as they orbit an object other than the Sun. Objects with diameters even under a kilometre are called moons. However, objects of only a hundred metre's diameter or so, like those found in Saturn's rings and orbiting some asteroids, have become known as moonlets. There is also no upper limit, which is problematic when a body and its moon are of similar size. These are sometimes described as a double planet, or double asteroid.

Sources: Ridpath, I (Ed) 2012 Oxford dictionary of astronomy 2nd rev ed,, Slotegraaf, A and Glass, I (Eds) 2020 Sky guide: Africa south, britannica.com, en.wikipedia.org,

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