"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

MAY 2017

We would like to welcome the following new members who joined the Centre during recent months: Richard Ketteringham, Max Michaelis, Pam and John Millbank, and Dirk van Niekerk.

This month's Centre meeting
This will take place on **Monday 15 May** at the **Scout Hall** starting at **19.00**. Centre member, Johan Retief, will be talking on 'Asteroids, comets and dwarf planets'. See below for more details.

WHAT'S UP?

Another icy visitor Night owls also will also have the opportunity observe a comet this year. Throughout May and June Comet Johnson (C/2015 V2) can be observed with binoculars. During May it rises before midnight and is visible throughout the night while, in June, it will be visible from nightfall until after midnight. Like PanSTARRS, it was discovered in 2015. It is named after its discoverer. Like other comets with originated in the Oort cloud, it is a long period comet ie it has an orbital period of more than 200 years. These comets are ejected from the Oort Cloud and directed towards the Sun by the gravitational effects of passing stars and general galactic motion. The name 'comet' is derived from the Greek for 'long-haired star'. The shape of a comet's orbit is important in deciding its fate. Those who pass too close to the Sun are likely to be destroyed. Those with very eccentric orbits could eventually leave the solar system and travel into interstellar space. Others have an orbit which leaves them travelling repeatedly through the solar system on a certain timescale eg Halley's comet, which passes Earth every 75 years. The fate of Comet Johnson is unknown. Its current orbit is known, but this can be affected by the gravitational effects of large objects like Jupiter and the Sun.

LAST MONTH'S ACTIVITIES

Monthly centre meeting On 17 April, Kate Storey-Fisher, a master's research fellow at University of the Western Cape, gave a very interesting and informative presentation on 'Physics in the dark: the missing matter and energy in the Universe'. For the topics of both dark matter and dark energy, she gave useful summaries of their discovery and historic backgrounds before outlining the approaches which are currently being used to understand and, hopefully, detect the elusive and only indirectly known components which make up over 95% of the matter in the Universe.

The search for dark matter involves direct detection experiments (mostly deep underground), attempts to create dark matter in the Large Hadron Collider, and computer simulations, modelling showing that dark matter is central to the formation and evolution of visible matter, including galaxies. The nature of even more elusive dark energy, the force which is causing the accelerating expansion of the Universe, is being investigated through observation of weak gravitational lensing, and analysis of the characteristics of the Cosmic Microwave Background. Kate completed her fascinating overview with an outline of the possible fate these dark components may have for the future of the Universe. From the possibilities of the 'Big Rip', the 'Big Crunch' and the in-between 'Knife Edge', she proposed that current knowledge supports the latter, in which the effects of dark matter and dark energy balance each other out.

Interest groups

Cosmology 14 people (12 members, 2 visitors) attended the meeting on 3 April. Unfortunately, technical problems meant they were unable to watch the scheduled DVD episodes pf the DVD series Particle Physics for Non-Physicists: a Tour of the Microcosmos' presented by Prof Steven Pollock, Professor of physics at the University of Colorado at Boulder. Instead, Pierre Hugo outlined the ideas of two theorists, Henry Lindner's concept of 'flowing space' and Paul Klevgard's novel interpretations of relativity.

Astro-photography No meeting took place in April.

Other activities

Educational outreach

Hawston Secondary School Astronomy Group No meetings were held during school holidays in April, but recommenced in the new term.

Lukhanyo Youth Club No meetings took place in April.

Catchup on a previous observation event Bennie Kotze reports on the event which took place in Hawston during the partial solar eclipse on 26 February: "It is Sunday, 26 February, and I am on my way back from Leeuwenboschfontein (Southern Star Party) after experiencing three fulfilling days of stargazing. My commitment for the weekend is not yet done as Johan Retief and I have a further appointment at the Hawston harbour at 5pm, and that's where I'm heading. We will entertain two school groups in order to view the solar eclipse through our telescopes.

Upon arrival at Hawston harbour, teacher Zuki and her 15 science class pupils from Lukhanyo Primary School) and the Hawston Space Cadets (Gr 12's from Hawston Secondary School) were already there waiting, in anticipation. The pupils were absolutely amazed to see how the Sun is cannibalised by the Moon. Active and repeated viewing continued during the entire progress of the eclipse. Our viewers extended beyond only the scholars, as it was evident that the Hawston harbour is a favorite gathering place for the local community to socialise on a Sunday afternoon. It was a first experience for the scholars and for most of the adults who showed interest. We calculated that 50+ viewed this natural phenomenon. Johan and I both agreed that it was a highly successful and worthwhile venture."

Photo taken through my 5" Celestron

THIS MONTH'S ACTIVITIES

Monthly centre meeting

This month's meeting will take place on **Monday 15 May** at the **Scout Hall** starting at **19.00**. Centre member, Johan Retief, will be talking on 'Asteroids, comets and dwarf planets'. Johan is the Centre's most prolific presenter and, as in the past, Johan's presentation will be well-researched and presented in his amusing, enjoyable and informative style.

There is an entrance fee of R10 per person for members, R20 per person for non-members, and R10 for children, students and U3A members.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month at 19.00. This month's meeting will take place on **1 May** at the Scout Hall. Attendees will watch the postponed two episodes in the DVD series: Particle Physics for Non-Physicists: a Tour of the Microcosmos'. The content will be Lecture 7 'Weak interactions and the neutrino' and Lecture 8 'Accelerators and the particle explosion'.'

There is an entrance fee of R10 per person for members, R20 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 third Monday of each month. The next meeting is on **7 May**. Members will continue work on processing their own astro-images.

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 Organisers continue to work towards accessing a telescope or images which learners can start using this year.

For further information on both the MONET and Las Cumbres projects, please contact Deon Krige at deonk@telkomsa.net

FUTURE ACTIVITIES

Possible trips for 2017 are being considered. Details will be circulated to members when arrangements have been made.

2017 MONTHLY MEETINGS

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

15 May	'Asteroids, comets and dwarf planets' Presenter: Johan Retief, Centre member
19 June	'The monsters of deep space' Presenter David Groenewald, SAAO, CT
17 July	'Deep sky stargazing' Presenter: Auke Slotegraaf, psychohisotiran and editor of the Sky Guide
21 Aug	Topic to be confirmed. Presenter: Dr Amanda Sickafoose, SAAO, CT
18 Sept	'Hidden features: discovering space in a reluctant Universe' Presenter: Dr Michelle Cluver, UCT

16 Oct 'Jupiter: the neighbourhood bully' Presenter: Jenny Morris, Committee member

20 Nov 'Mars, the Red Planet. Cna mankind go there? ' Presenter: Johan Retief, Centre member

11 Dec Xmas party

ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

A decision on the planning application by the Council of Overstrand Municipality continues to be awaited. This was scheduled for consideration at the end of April, but the outcome is not yet known. The Friends of the Observatory pledge fund continues to be an important source of funds to cover associated costs.

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, something which is still awaited.

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

New Horizons hit a milestone 4 April: The New Horizons spacecraft is getting closer to its new mission every day, and at midnight (UTC) on 3 April it hit a new milestone. It has travelled 782.45 million km, which is the halfway point between Pluto and its next mission.

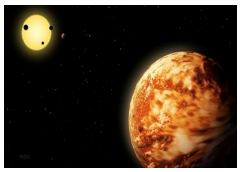
An artist's rendering of New Horizons' next mission: Kuiper Belt object 2014 MU69. NASA/JHUAPL/SwRI/Alex Parker

New Horizons is scheduled to fly by Kuiper Belt object 2014 MU69 on 1 January 2019, which will set the record for "most distant world ever explored in the history of civilization," according to Alan Stern, the New Horizons principal investigator. MU69 is a classical Kuiper Belt object, which means it is low-eccentricty and it orbits beyond Neptune without any orbital resonance with the planet. It was discovered by the Hubble Space Telescope in June of 2014 and was selected as the team target by the New Horizons team in August of 2015. Details of MU69 are hard to see, even with the Hubble, but it is estimated that the object is less than 45 km across.

New Horizons project scientist Hal Weaver from APL, in Laurel, Maryland, said this next fly by will be the next big thing. "The January 2019 MU69 flyby is the next big event for us, but New Horizons is truly a mission to more broadly explore the Kuiper Belt. In addition to MU69, we plan to study more than two-dozen other KBOs in the distance and measure the charged particle and dust environment all the way across the Kuiper Belt."

After two and a half years of constant data collection, the spacecraft will be getting a much-needed break later this week as it enters into a 157-day hibernation on 7 April. The hibernation will begin just two hours before another milestone for New Horizons: reaching the halfway point between closest approaches to Pluto and MU69. By: Nicole Kiefert

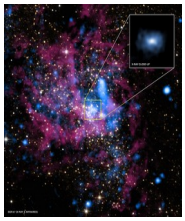
An exoplanet the size of Neptune has been found 6 April: NASA recently confirmed that 3,472 exoplanets have been discovered, but until recent years, very few of those exoplanets have been smaller than Jupiter. A team of astronomers at Yale found an exoplanet, called Kepler-150 f, about 3,000 light years from Earth in the Kepler-150 system. Scientists have known about the system since 2014, but computers had somehow missed the Neptune-sized exoplanet.


Michael S. Helfenbein via Yale

The computer programs used to detect exoplanets look for planetary transit signals when the planet will cross in front of the Sun's path. Considering Kepler-150f's orbit is 637 days, it makes sense that a computer may have missed that or written it off as an artefact. Kepler scientists need multiple transits to confirm a planet. As the original mission was four years long, Kepler biases short-period planets. Kepler only had the chance to see -150f transit twice.

However, students at Yale used a mathematical approach that has since been to find the hidden exoplanet. Joseph Schmitt, a graduate student at Yale and lead author of the paper, said that Kepler-150 f was simply "hiding in plain sight. Only by using our new technique of modeling and subtracting out the transit signals of known planets could we then actually see it for what it really was," Schmitt said. By: Nicole Kiefert

Get ready for our first image of a black hole 6 April: Astronomers have just brought a telescope online that is (virtually) the size of Earth. Dubbed the Event Horizon Telescope, it is aiming to achieve something that has never been done before: imaging the space around a black hole all the way down to its event horizon.


X-ray: NASA/UMass/D.Wang et al.; IR: NASA/STScI

One of its targets is Sagittarius A*, or Sgr A* for short. Sgr A* is the supermassive black hole in the centre of the Milky Way, with a mass of approximately 4 million Suns. Because it is so massive and so (relatively) close at a distance of 25,600 light-years, it is the largest black hole visible in our sky. But large is a relative term as well — current estimates place the size of the black hole at 100 Astronomical Units (AU) or less. One AU is the average distance between Earth and the Sun, 150 million km. Some estimates even indicate that the black hole could be as small as the distance between Mercury and the Sun, just 46 million km.

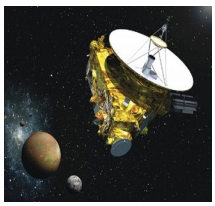
When astronomers 'see' black holes, they are actually seeing light from a disk of material around the black hole, which is sitting beyond the event horizon. Anything within the event horizon itself is truly invisible, as that marks the point at which even light cannot travel fast enough to break free of the black hole's gravity and escape. However, currently, astronomical instruments do not have the resolution to really see the disk closely or image its structure.

This is why every 'image' ever shown of a black hole in a news article or textbook is an artist's rendering, rather than an actual picture. However, that is all about to change. The Event Horizon Telescope makes use of a technique called Very Long Baseline Interferometry (VLBI) that requires several telescopes observing the same object from different locations to create highly detailed images of very, very small sections of the sky. The farther apart the telescopes are located, the greater the detail they can achieve. The Event Horizon Telescope will link eight radio telescopes around the world, including the Atacama Large Millimetre/submillimetre Array in Chile, the Caltech Submillimetre Observatory in Hawaii, the Large Millimetre Telescope Alfonso Serrano in Mexico, the South Pole Telescope in Antarctica, and other facilities in France and Spain to utilize the longest baselines possible. By creating a truly Earth-sized telescope, the project should be capable of imaging the space around a black hole in exquisite detail.

This will allow astronomers to study not only the structure of the disk around the black hole, but also to test general relativity, get a better look at how the black hole actually feeds on material, and maybe even determine how the outflows and jets that are so common among black holes are actually created.

The giant telescope came online on 5 April and will observe for about a week and a half, gathering data until 14 April. In addition to imaging our relatively quiescent Sgr A*, it will also look at the more active supermassive black hole residing in Messier 87, a huge elliptical galaxy in the nearby Virgo Cluster. The amount of information obtained will be so immense that it is too large to transfer digitally - it will be stored physically and taken to the Max Planck Institute in Germany, and the Haystack Observatory in Massachusetts for processing. That will take time, but, in a few months, we may finally have our first picture of the region immediately around a supermassive black hole. By: Alison Klesman

New Horizons enters hibernation 11 April: After getting halfway to its next target, New Horizons entered a well-deserved hibernation on 7 April. After two and a half years of being 'awake', the spacecraft is finally getting a break.


An artist's rendering of New Horizons from the Launch Press Kit. NASA

New Horizons was launched in January 2006 and headed to explore Pluto. Between the last hibernation and entering its current hibernation, New Horizons had been 'awake' for 852 days for the Pluto flyby and the 16 months following to send data back to Earth. Now the spacecraft is on its way to the Kuiper Belt to study Kuiper Belt Object 2014 MU69 in January 2019. While New Horizons is in hibernation, which is scheduled to end on 11 September 11, the science and mission operations teams will be busy planning the MU69 flyby and deciding on flyby altitudes.

Most of New Horizons will be unpowered during its 157-day hibernation, but the onboard flight computer will continue checking in on the craft's health and safety and send reports back to Earth once a month. By: Nicole Kiefert

Enceladus' sea floor has hydrothermal vents like ours 13 April: In 1977, a group of marine researchers discovered something they had only before theorised: cracks in the ocean floor releasing heat, warming up (and often boiling) the ocean around it. They also found molluscs in them, and subsequent vents have yielded heat resistant microbes, giant tube worms, and more fantastic creatures living in what are essentially small, underwater volcanoes.

Now, NASA has announced that they have indirect evidence for hydrothermal vents beyond Earth. In its encounters with Saturn's moon Enceladus, the Cassini craft found chemicals associated with these events. It adds to the body of evidence that Enceladus could be ripe for life.


Cassini Imaging Team, SSI, JPL, ESA, NASA

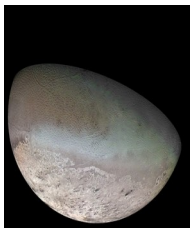
"Enceladus is too small to have retained the hydrogen from when it formed, so the hydrogen we see today is coming from inside Enceladus**,**" Linda Spilker, project scientist on the Cassini mission, said in a press conference. Enceladus, which is a tiny moon, took Cassini researchers by surprise when they discovered what seemed to be geysers of water emitting from the south pole in 2005. Subsequent investigations built a picture of the origin: liquid water under the surface of Enceladus, which led to the idea of an entire ocean under the surface. The heating mechanism, to date, has not been discovered.

The Ion Neutral Mass Spectrometer on the craft made the observation of molecular hydrogen in the ejecta from these geysers. According to principal investigator Hunter Waite of the Southwest Research Institute and his co-investigators, the source almost certainly has to be hydrothermal vents at Enceladus' sea floor. This means there is plenty of geological activity, increasing the chances for life. Indeed, researchers published a paper last year suggesting that hydrothermal vents were the source of life on Earth, where

chemical reactions fed these early microbes. If that is the case on Enceladus, the ocean may have microbial life at the very least. "The hydrogen could be a potential source of chemical energy for any microbes living in Enceladus' ocean," Spilker says.

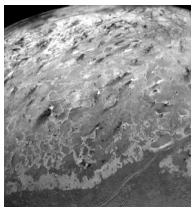
It may be years or even decades until we know for sure - in September, NASA will intentionally crash Cassini into Saturn to make sure it does not crash land into Titan or Enceladus and accidentally contaminate either potentially habitable moon with Earth bacteria. By: John Wenz

Should we reconsider our view on Neptune's largest moon? 18 April: Before it was eclipsed by Jupiter and Saturn's ice-rich moons, Neptune's largest moon Triton made a play to be recognised as one of the most interesting satellites in the solar system. However, new research reveals Triton as a potential water-world. Large fractures on the surface hint towards a liquid ocean beneath the icy crust.


Neptune's largest moon Triton, which is slightly larger than Pluto, is considered to be a captured Kuiper Belt Object. NASA / Jet Propulsion Lab / U.S. Geological Survey

When Voyager 2 visited Neptune in 1989, it snapped the first images of Triton, revealing towering dark plumes and a tenuous nitrogen atmosphere. Few craters mar the crust, suggesting that something is resurfacing the young exterior. Triton's density suggests a layer of ice or water only a few hundred kilometres thick. "Triton is an interesting satellite. It was the first active satellite ever imaged," says Terry Hurford, a planetary scientist at NASA Goddard Space Flight Centre in Greenbelt, Maryland. Hurford examined the geyser-rich moon and found evidence that it may still have an ocean today.

Today, ocean worlds abound in the solar system. Jupiter's moon Europa hides an ocean beneath a thick icy crust. Two other Jupiter satellites, Ganymede and Callisto, are also considered ocean worlds. Saturn's moon Enceladus not only carries an ocean but vents it through geysers at its southern pole, while another moon, Titan, boasts not only lakes and seas on the surface but a water-rich layer beneath the crust. Even tiny Pluto may hold a liquid ocean, while the subsurface water on its largest moon Charon has long since frozen. After studying fractures on the surface and modelling how they may have evolved, Hurford thinks it is time to add Triton to the club.


This image shows possible geyser activity on Triton, indicating the presence of an ocean below. NASA-JPL

On Europa, fractures in the surface come from tidal stresses. As the moon orbits the planet, it is slowly squeezed and released, breaking apart the surface. However, Triton's orbit is nearly circular, one of the roundest of any moon, so Neptune's kneading today is limited. In the past, however, Triton probably was not quite as well-rounded. The moon holds the dubious fame of being the largest object to travel around its planet backwards,

in what is known as a retrograde orbit. Its backward orbit suggests that Triton did not form around Neptune but is instead a captured object, an icy Kuiper Belt Object from the outer solar system. Its original eccentric orbit would have allowed Neptune to squeeze it more frequently, heating the interior and melting the ice.

"We definitely know Triton had an ocean in its past," Hurford says. "It's not clear whether or not that ocean stuck around." All that squeezing by Neptune would have caused the crust to split, creating fractures. Over time, as Triton's orbit became more circular, the tidal stress would have decreased. With a circular orbit, tidal heating would decrease and the ocean would eventually freeze, leaving ancient fractures across the surface.

However, the old fractions do not fit well with the otherwise young outer layer suggested by cratering. "There's a disconnect between the age of the fractures and the age of the surface," Hurford says. In an effort to bridge the gap, he began to examine how fractures could have formed more recently. Voyager 2 was only able to capture fractures on the Neptune side of the tidally locked moon, which keeps one face permanently turned towards its planet. The fractures, which run for hundreds of kilometres, bear a strong similarity to those found on the icy world Europa, which has an icy crust slowly squeezed by Jupiter.

Rather than focusing on how circular Triton's orbit is, Hurford turned his attention to its gradual decay. The active moon isn't staying put. Instead, it is slowly spiralling inward. In about 3.5 billion years, the moon will collide with its planet. Hurford found that the inward spiral would also create tidal stresses on the moon. With an ocean beneath its surface, the crust would continue to form fractures today. While ancient fractures from the original orbit may have been filled by active surface processes, new fractures would have continued to form.

Triton's status as the first active moon might have kept scientists from recognising that it could still host an ocean today. "When we first saw activity on the satellite, we weren't thinking about ocean worlds," Hurford says. "Now that we're starting to see oceans, we're starting to rethink the method of eruptions on Triton."

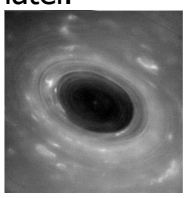

This was Voyager 2's parting image of Neptune and Triton as it continued its long journey out of the solar system. NASA-JPL

With their liquid-water oceans and hints of hydrothermal activity, Europa and Enceladus are considered two of the most promising sites in the solar system for life to have evolved. Because water is a key ingredient for life as we know it, all of the ocean worlds hold the hope of potential habitability. "Anywhere you have an ocean, you have the possibility of life," Hurford says. For Triton, habitability depends in part on the thickness of the icy shell, as well as what is going on in the rocky layer interacting with the water. "We're so new to thinking about this, we just don't know," Hurford says.

So far, Triton observations have been limited to Earth-bound instruments and a single Voyager 2 flyby. However, that could change. In 2013, the National Research Council's Planetary Science Decadal Survey, which helps determine NASA's upcoming missions, set as its third highest priority a mission to Uranus, after closely considering Neptune. Known as ice giants, the two worlds have different compositions from Jupiter and Saturn. Hurford

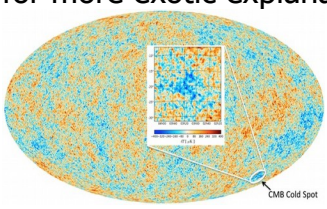
thinks that Neptune could be a contender for the next decadal survey, which is already under study. "Maybe we'll have a chance to go back," he says. By: Nola Taylor Redd

Cassini reconnects after first dive through Saturn's rings 27 April: After successfully surfing through Saturn's rings on 26 April 26, NASA's Cassini spacecraft is back in contact with Earth. NASA's Deep Space Network (DSN) found Cassini's signal at 11:56 pm. PDT April 26, and the craft started sending back data from the dive just five minutes later.


This image from Cassini shows Saturn's atmosphere closer than we've ever seen it before. NASA/JPL-Caltech/Space Science Institute

Researchers were confident Cassini would make it through the rings without issue, but still took extra care with the dive since it was the first time the area was ever explored. Cassini was about 3,000 km from Saturn's cloud tops where the air pressure is similar to Earth's at sea level, and about 300 km from the innermost edge of the rings. "No spacecraft has ever been this close to Saturn before. We could only rely on predictions, based on our experience with Saturn's other rings, of what we thought this gap between the rings and Saturn would be like," Cassini Project Manager Earl Maize of NASA's Jet Propulsion Laboratory, said. "I am delighted to report that Cassini shot through the gap just as we planned and has come out the other side in excellent shape." For extra care, Cassini used its dish-shaped antenna as a shield, which put it out of contact with Earth during the crossing, but it reconnected 20 hours later. On 2 May 2, Cassini is scheduled for its second of 22 dives through the rings before its death plunge into Saturn's atmosphere on 15 September. By: Nicole Kiefert

This cosmic Cold Spot challenges our current cosmological model 27 April: The cosmic microwave background (CMB) is the fingerprint of the Big Bang. This remnant radiation occurs throughout the sky, with a temperature 2.73 degrees above absolute zero (about -270 Celsius). While the CMB is fairly uniform, it does have some (very small) fluctuations. These fluctuations hold the key to details about both the Big Bang and the very early lifetime of the universe. Now, researchers have determined that a Cold Spot, an area of the CMB 0.00015 degrees below its surroundings, is not due to a lack of matter in the area, as previously thought. Ruling out this mundane possibility leaves open the door for more exotic explanations of the Cold Spot.



The Cold Spot is an area of the cosmic microwave background with a lower temperature than its surroundings. On this map from the Planck craft , warmer CMB temperatures appear redder and cooler temperatures appear bluer. ESA and Durham University

In a study led by Ruari Mackenzi and Tom Shanks at Durham University's Centre for Extragalactic Astronomy the group explored the possibility that a 'supervoid' of space - an area lacking a significant number of galaxies and other matter - is responsible for the Cold Spot. Both regular matter and dark matter tend to clump together in space, forming structures such as clusters and walls in some areas, while leaving voids without much

material in others. This effect is exacerbated by the expansion of the universe, and causes the CMB coming from the direction of a void to look different than CMB radiation that must travel through areas of space more densely populated on its way to Earth.

Previous studies used a technique called photometric redshift to measure the distance of galaxies in the direction of the Cold Spot. This technique uses a galaxy's perceived colours to estimate how far away it is, because more distant galaxies appear redder than their nearby counterparts. However, photometric redshifts often have significant uncertainties. Mackenzi and Shanks' team instead used spectroscopic redshifts, which break apart the light from an object and are much more accurate, to determine the distance to 7,000 galaxies in the direction of the Cold Spot with data from the Anglo-Australian Telescope.

The more accurate data revealed, however, that there is no supervoid in the direction of the Cold Spot. Instead, that area of the sky looks much like the rest, with clusters of galaxies and smaller voids between them. When the sky in the direction of the Cold Spot was compared with another area of the sky without a cooler CMB behind it, no significant difference was found. "The voids we have detected cannot explain the Cold Spot under standard cosmology," said MacKenzie in a press release detailing the results.

What does this mean? Standard cosmology is the model we currently use to describe the universe around us. Observations that challenge this model must be examined carefully, but can be used to further refine our model to ensure it is correct. Even without a supervoid in the way, the team estimates a likelihood that the Cold Spot appeared by random chance as 1 in 50. According to Shanks, "This means we can't entirely rule out that the Spot is caused by an unlikely fluctuation explained by the standard model. But if that isn't the answer, then there are more exotic explanations."

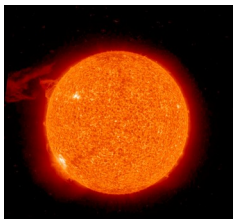
Such exotic explanations, he says, include "a collision between our universe and another bubble universe. If further, more detailed, analysis of CMB data proves this to be the case then the Cold Spot might be taken as the first evidence for the multiverse – and billions of other universes may exist like our own." The multiverse describes a set of infinite universes, which includes the one in which we live. To date, no evidence has been found that the multiverse is more than science fiction, but researchers are continually pushing the boundaries of the observable universe to determine whether this concept is fact or fiction. While at the moment the Cold Spot is certainly not definitive evidence of a multiverse, it does indicate a problem in our standard cosmological model that may need addressing if the cause of the temperature fluctuation in this area remains unclear.

By: Alision Klesman

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

DID YOU KNOW?

The Sun Part 14: **Sun – energy production 1**



Arthur Eddington Solar energy George Gamow

Stars like the Sun are thermonuclear furnaces. The process of nucleosynthesis which occurs in stars creates new atomic nuclei (elements) from pre-existing nucleons by nuclear reactions. Apart from hydrogen and helium, which were created soon after the Big Bang, it is the means by which the natural abundances of chemical elements in stars are both created and vary due to nuclear fusion reactions in the cores and overlying stellar mantles.

The life cycle of stars is inextricably linked with changes in the relative abundances of their elements. Changes in nucleosynthetic processes initiate the stages which occur during the latter stages of a stars life. The younger Sun consists almost entirely of hydrogen (73%) and helium (24%) and it is the conversion of hydrogen to helium which is the primary energy source of the star for billions of years. Core fusion of lighter hydrogen to heavier helium increases the atomic weight of gaseous elements, causing pressure loss and contraction of the core, accompanied by temperature increases.

Later in their lives, in low-mass stars like the Sun, as temperatures increase progressively as the composition of the core evolves, the nuclear reactor will produce elements up to and including iron, elements which are released into the interstellar medium when the dying star ejects matter as its outer layers blow away. It is this stellar nucleosynthesis which is responsible for the galactic abundance of elements from carbon to iron and nickel (The elements heavier than these are released when larger stars die in extremely hot supernova explosions).

History of nucleosynthesis theory The goal of this theory is to explain the vastly differing abundances of chemical elements and their isotopes in the Universe. Those abundances, when plotted on a graph as a function of atomic number of elements, have a jagged sawtooth shape that varies by factors of tens of millions. This suggested a natural process other than random distribution. The first ideas were simply that chemical elements were created at the beginning of the Universe, but no rational physical scenario for this assumption could be identified. It gradually became clear that hydrogen and helium are much more abundant than any other elements. In fact, all the rest form less than 2% of the mass in the cosmos. In addition, it was found that oxygen and carbon were the next two most common elements. Also, there was a general trend towards high abundances of the light elements, esp those composed of whole numbers of helium-4 nuclei.

The predominance of hydrogen and helium in the Universe, and stars like the Sun is a result of events which occurred within three minutes of the beginning of the Universe. Although helium continues to be produced by stellar fusion and alpha decays, and trace amounts of hydrogen continue to be produced by spallation (the process which reduces the atomic weight of interstellar mater by impact with cosmic rays, to produce some of the lightest elements present in the Universe) and certain types of radioactive decay, most of the hydrogen and helium in the Universe is accepted to have been produced by the Big Bang via so-called Big Bang nucleosynthesis, Because only about twenty minutes passed before this process was stopped by expansion and cooling, no elements heavier than beryllium, or possibly boron, could be formed. Elements formed in this time were in the plasma state and did not cool to the state of neutral atoms until much later.

Another stimulus to the development of a coherent nucleosynthesis theory was development was realisation that the energy released from nuclear fusion reactions accounts for the longevity of the Sun as a source of heat and light. It was also realised that the process of fusion of nuclei in a star, starting from its initial hydrogen and helium

abundance, also synthesises new nuclei as a by-product of that fusion process. Furthermore, fusion product nuclei are restricted to those only slightly heavier that the fusing nuclei, meaning that they do not contribute heavily to the natural abundances of the heavier elements.

It was the English astrophysicist Arthur Eddington who, in 1920, on basis of Aston's precise measurements of atomic masses, proposed that stars obtain their energy through nuclear fusion of hydrogen into helium. He also raised the possibility that the heavier elements may also form in stars, but his ideas were not generally accepted, as the nuclear mechanism was unknown.

In the 1920s, the Russian-American George Gamow applied his early training in nuclear physics to astrophysics. In 1928, he derived the Gamow factor, a quantum-mechanical formula that gave the probability of bringing two nuclei sufficiently close for the strong nuclear force to overcome the Coulomb barrier. He and other scientists used this factor to derive the rate at which nuclear reactions should proceed a the high temperatures s believed to exist inside stars.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, Singh, S (2004) Big Bang, www.en.wikipedia.org

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