"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

APRIL 2017

This month's Centre meeting
This will take place on **Monday 20 March** at the **Scout Hall** starting at **19.00**. Dr Kate Storey-Fisher, astrophysics research fellow at the University of the Western Cape will be talking on 'Physics in the dark: the missing matter and energy in the Universe'. See below for more details.

WHAT'S UP?

A frozen visitor from afar Throughout April and May, Comet PanSTARRS (C/2015 ER_{61}) will be visible through binoculars towards the east, before sunrise. It was discovered in March 2015 and was initially identified as an asteroid. However, a few months later, observations showed that it had a coma (an envelope of gas and dust surrounding the solid nucleus) and it was reclassified as a comet. Like most of the other comets in the solar system, PanSTARRS originated in the Oort Cloud, the extensive, roughly spherical halo which fills a large part of space beyond the Kuiper belt (which, itself is located beyond Neptune). Composed of ice and dust, the small bodies of comets are believed to be remnants of the formation of the solar system. There are estimated to be around 10 billion comets forming the Oort cloud. PanSTARRS has become increasingly bright over time as it moves closer to the Sun. Like other comets, it has a very eccentric orbit. This was affected by the large gravitational influence of Jupiter when it passed that planet during 2016. Its altered orbit means that on 4 April, it will reach its closest point to Earth.

LAST MONTH'S ACTIVITIES

Monthly centre meeting On 20 March, Centre chairman, Pierre de Villiers gave a talk on 'How we have learned science from space telescopes and missions'. The material was a repeat of the talk he gave at U3A earlier in the month, although he took the opportunity to expand on some of the more technical and cosmological content for Centre members. The focus of Pierre's fascinating and informative presentation was on how multi-wavelength observations have provided rich information on celestial objects and the cosmos. Over the past few decades, NASA, in particular, has launched a series of satellites which have, or are, observing the skies across the electro-magnetic spectrum, including gamma-rays, X-rays, ultraviolet, infra-red and radio, in addition to optic wavelengths. Using the images and data which these missions have provided, Pierre described how this multi-wavelength approach has advanced science in astronomy and cosmology. He focussed on four areas: galactic and cosmic structure, timeline and features of the Big

Bang, the discovery and nature of dark matter, and the search for exoplanets as part of the desire to know whether there is other life out there.

Interest groups

Cosmology 25 people (23 members, 2 visitors) attended the meeting on 6 March. They viewed the next two pf a 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. The lectures were L5: 'Quantum mechanics gets serious' and L: 'New particles and new technologies'.

Astro-photography At the meeting on 13 March, members continued to discuss processing of their own astro-images.

Other activities

Joint U3A/HAC presentations The last two of four presentations at U3A, jointly co-hosted by HAC, took place this month. On 7 March, Centre chairman Pierre de Villiers talked on 'How we have learned science from space telescopes and missions ' and, on 14 March, Prof Johann du Preez, from University of the Free State, talked on 'The Vredefort impact crater.'

Stargazing A stargazing event formed part of the OnVerWag Neighbourhood Watch's Earth Hour evening held at Davies Pool in Onrus on 25 March. Early cloud and a chilly wind disappeared and an excellent evening's viewing took place. Approximately 50 members of the public joined Centre members to view a number of objects with the naked eye, and through binoculars and telescopes. These included Orion, Canis Major and Minor, Gemini, Leo and Southern Cross constellations, Orion and Coalsack nebulae, Omega Centauri and Tuc 47 globular clusters, Hyades, southern Pleiades and Jewel box open clusters, and Jupiter and the Galilean moons. The Large and Small Magellanic Clouds were also clearly visible. Some people also spotted orbiting satellites and shooting stars.

Educational outreach
Hawston Secondary School Astronomy Group Weekly meetings continued during March.
Lukhanyo Youth Club No meetings took place in March.

Southern star party Bennie Kotze reports on the event which some HAC members attended from 23-26 February: 'The destination was Leeuwenboschfontein Guest Farm - approximately 65km beyond Montagu. A three hour drive brought me to the venue situated in a barren and arid landscape. I was, however, totally stunned by the beautiful leaf-green environment and green lawns. The main buildings are not modern, but the facilities and accommodation were close to five star rating. I

Upon my arrival on the Thursday afternoon, the lawn in front of the main building was already scattered with telescopes of all shape and sizes. Of them all, a 14"*Celestron Cassegrain*, with a superb high quality mount, really impressed me the most. The next three nights were absolutely ideal for stargazing and were used productively by all, and some until the early hours of the morning. I gave my *Celestron* 5" a good run and it served me well. Pierre de Villiers, positioned next to me, managed to fine-tune his recently acquired instrument. As no white light was permitted at the site designated for telescopes, I had to find a secluded spot behind the main building to test my astro-photography skills.

During the afternoons of the next few days lectures of various topics were presented. The highlight of these was that of Jim Adams, ex Chief Technologist at NASA. He served NASA for 40 years and had managed a number of NASA's space projects as part of his portfolio. It was a real privilege to have him as a speaker. His lectures dealt with spin-offs, whether technical or medical, which emanated from space research since the inception of NASA. At present he maintains a website at *spinoffs.nasa.gov*

All in all, the visit to the SSP was, as the CNN presenter Richard Quest would say, a very profitable venture. My only wish is that more of our HAC members attend the SSP in future.'

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting will take place on **Monday 17 April** at the **Scout Hall** starting at **19.00**. Dr Kate Storey-Fisher, astrophysics research fellow at the University of the Western Cape will be talking on 'Physics in the dark: the missing matter and energy in the Universe'.

About the talk: Everything we can see - from Table Mountain to the Andromeda galaxy, to us - makes up only a tiny fraction of the matter in the Universe. A whopping 95% of the Universe is dark, made of stuff that is invisible to us, which we call dark matter and dark energy. Physicists first stumbled upon the mystery of dark matter in the 1930s; they noticed that galaxies were moving too fast for the amount of visible mass in them. More recently, astronomers were astonished to discover that the Universe is expanding at an accelerating rate. They realised that this acceleration must be caused by an unseen source of energy, now known as dark energy. Today, the dark Universe continues to be probed using a plethora of techniques, including gravitational lensing and modifications to Einstein's theory of gravity. This talk will discuss the discovery of dark matter and dark energy as well as modern efforts of physicists to determine the nature of these 'missing' components, the implications for the evolution and fate of the Universe.

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 **3 April** at the Scout Hall. Attendees will watch the next 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 **10 April**. 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.

17 April	'Physics in the dark: the missing matter and energy in the Universe'. Presenter: Kate Storey-Fisher, UWC
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. Hopefully, this will take place at their meeting this month. 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:

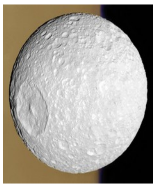
Account name – Hermanus Astronomy Centre

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

There's now one less ocean world in the solar system 1 March: There are plenty of oceans in the Saturn system - including Enceladus, Titan, and possibly Dione. That used to include Mimas, but new research suggests we need to reconsider this.


NASA / JPL / Space Science Institute

Research published in 2014 suggested that one of Saturn's tiny moons, Mimas, could have an ocean … or just a football shaped core. This uncertainty resulted from weird discrepancies in Mima's orbit around Saturn. It seemed to wobble in its interactions, something that usually indicates that an ocean is sloshing around in the interior. Even at the time, there was a bit of scepticism. While Enceladus and Jupiter's moon Europa both have cracks in the surface and geyser activity, Mimas' surface seemed relatively inert, with a giant crater giving it the appearance of a Star Wars Death Star. It would also need a heat source to drive this interior sea world, which would be 24-32km below the surface.

The research debunking the ocean was led by Alyssa Rose Rhoden of Arizona State University. She and her co-authors put forth what an ocean on Mimas would need to look like to explain its wobble by comparing it to Europa and Enceladus' surface cracks and crevices. They found that any ocean would have created massive cracks across the surface, rivalling those of Europa instead of the serene surface seen today. By: John Wenz

Asteroids are splitting in half and growing tails 2 March: A big difference between an asteroid and a comet has usually been that icy comets can develop tails while rocky asteroids generally do not. That is, until this recent discovery of some very unique asteroids came to light. Astronomers are interested in these particular asteroids not just because they split in two, but some are also sprouting tails.

This image from the Hubble Space Telescope shows asteroid P/2013 P5, an example of an activated asteroid with a glowing tail of dust. NASA/ESA

The asteroid pair the astronomers have become most interested in is P/2016 J1. Fernando Moreno, a researcher at the Institute of Astrophysics and Andalusia (IAA-CSIC), said, "The results derived from the evolution of the orbit show that the asteroid fragmented approximately six years ago, which makes it the youngest known asteroid pair in the solar system to date." Besides being the youngest asteroid pair, P2016 J1 has another feature that makes it interesting to astronomers. "Both fragments are activated, ie they display dust structures similar to comets. This is the first time we observed an asteroid pair with simultaneous activity." Studies showed that the asteroid pairs were activated at the point on the orbit closest to the Sun and remained that way for somewhere between six to nine months. Moreno thinks the dust is likely caused by "sublimation of ice that was left exposed after the fragmentation."

Asteroid pairs are a common occurrence in the main asteroid belt. The pairs form when an asteroid breaks in two pieces, either from an impact, excess rotational speed, or, in some cases, two asteroids destabilizing each other's initial orbits. Though the pairs are not gravitationally linked, they do have similar orbits around the Sun. The pairs move in quasi-circular orbits between Mars and Jupiter, so they do not experience the temperature change that causes tails on comets. There have been about 20 documented cases of these asteroid pairs with an increased glow and a dust tail, and the asteroids have sometimes been called 'main belt comets' as a result. By: Nicole Keifert

This is where stardust comes from 8 March: The Atacama Large Millimetre/submillimetre Array (ALMA) in the Chilean Andes has made several groundbreaking discoveries since it was brought online in 2011. Able to image the sky in millimetre and millimetre wavelengths, ALMA can spot emission associated with molecular gas and dust, which are cold and can be difficult or impossible to see at other wavelengths. Using this ability, ALMA has identified dust and gas in a galaxy that formed when the Universe was only about 4% of its current age.


Artist's impression of ALMA observations have uncovered an extremely young, dusty galaxy already polluted with the products of supernovae, ESO/M. Kornmesser

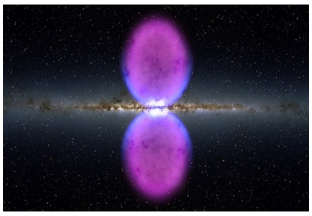
The galaxy is called A2744_YD4, and it's the most distant galaxy ever found by ALMA. It sits at a redshift of 8.38, which is associated with a time when the universe was just 600 million years old. Redshift measures the amount by which a distant object's light is stretched by the expansion of the universe. Objects with a higher redshift are farther away, and thus we are looking at them as they appeared in the past. In the very nearby universe, objects have a redshift of nearly zero; high-redshift objects, such as A2744_YD4 with its redshift of 8.38, are extremely far away (the exact distance depends on the expansion history of the universe). It is also important to note that redshift is not linear - redshifts of 0-1 are considered relatively nearby, while redshifts of 8-9 are some of the farthest objects we can currently see as we look back to the very early universe. The cosmic microwave background was produced at a redshift of about 1,000.

A2744_YD4's cosmological 'timestamp', as given by its redshift, falls within the estimated age range for the Epoch of Reionisation, which occurred somewhere around a redshift of 10, when the Universe was about 400 million years old. The Epoch of Reionisation is when the universe's first luminous sources - stars, quasars, and galaxies - turned on and ionised neutral hydrogen atoms (that is, knocked their electrons away). Neutral hydrogen is opaque to short wavelengths of light, which means that it absorbs these wavelengths easily so the light cannot pass through. As neutral hydrogen throughout the Universe was ionised, however, light could finally travel vast distances.

The detection of A2744_YD4 and its properties, which was made by an international team of astronomers led by Nicolas Laporte of University College London, is remarkable for several reasons. A2744_YD4 is full of dust. Laporte explained that "the detection of so much dust indicates early supernovae must have already polluted this galaxy." Supernovae are the end result of massive stars, which blow away much of their interiors explosively as they die. Among the material blown away is dust, which is made up of elements such as aluminium, silicon, and carbon, and is spread across galaxies by these explosions. This dust is an integral component of today's stars (like our Sun) and the planets surrounding them. In the very early Universe, however, this dust was scarce, simply because the process of its creation and dispersion via supernovae had not had much time to complete.

However, in A2744_YD4, this process has apparently had enough time to progress. A2744_YD4 produces stars at a rate of 20 solar masses per year, which is a full 20 times the rate of the Milky Way's comparatively paltry star formation rate of 1 solar mass per year. Based upon this rate, the group estimated that only about 200 million years were needed to form the dust seen in A2744_YD4. As a result, "we are witnessing this galaxy shortly after its formation," according to co-author Richard Ellis of the European Southern Observatory and University College London. This detection, coupled with the age of A2744_YD4, helps astronomers to better pin down the life cycle - including the formation i of the Universe's first stars, called Population III stars. By: Alison Klesman

Hubble solves the mystery bulge at the centrer of the Milky Way 9 March: The Milky Way appears as a relatively flat structure when viewed along its plane in visible light. Gamma-ray emission, however, paints a different picture: two huge structures billowing outward from the galaxy's bulge like an enormous hourglass. Named the Fermi Bubbles, these structures are the result of the Milky Way's supermassive black hole gorging itself on interstellar gas in the past. Using the Hubble Space Telescope (HST), astronomers have now determined just when these structured formed.


The Fermi Bubbles NASA's Goddard Space Flight Centre

A team of astronomers led by Rongmon Bordoloi of the Massachusetts Institute of Technology has used distant quasars to trace the structure and motion of the northern Fermi Bubble, which rises 23,000 light-years above the plane of the Milky Way and contains enough cool gas to create 2 million Sun-size stars. By observing the ultraviolet light from 46 quasars with the Cosmic Origins Spectrograph (COS) on HST, the team mapped out the motions of cool gas within the bubble down to an age: 6-9 million years.

Most galaxies contain a supermassive black hole at the centre, and the Milky Way is no exception. Sgr A* resides in the Milky Way's bulge and has a mass equivalent to 4.5 million solar masses. Today, Sgr A* is relatively quiet, accreting slowly as the galaxy ages. By contrast, quasars are young, massive supermassive black holes at the centres of galaxies in the early Universe, sucking down huge amounts of gas and dust that shine brightly as the material is funnelled into an accretion disk before finally passing into the black hole. Like these younger black holes, astronomers believe that our own supermassive black hole was once more active, at a time when the galaxy was still forming and material was more plentiful for accretion.

Sometimes, though, material does not actually make it all the way into the black hole. Matter can escape along the black hole's spin axis, exiting the area - and often the galaxy altogether - as huge outflows that span tens or hundreds of thousands of light-years. The Milky Way's Fermi Bubbles are such an outflow. They were discovered in 2015 and named after NASA's Fermi Gamma-Ray Telescope, which spotted them.

Learning more about the origins of these outflows requires information about their motion. "We have traced the outflows of other galaxies, but we have never been able to actually map the motion of the gas," said Bordoloi. "The only reason we could do it here is because we are inside the Milky Way. This vantage point gives us a front-row seat to map out the kinematic structure of the Milky Way outflow." As the quasars' light travels through the bubble to reach Earth, it highlights the gas in bubble itself, allowing astronomers to determine information such as its chemical composition, temperature, and motion. The 'cool' gas in the northern Fermi Bubble, which contains elements such as silicon and carbon, was clocked at 3 million kph and reaches temperatures of 9,800 degrees C. Such cool gas is actually likely gas from the disk of the galaxy that has been swept up by and integrated into the outflow itself, which has temperatures of up to nearly 10 million degrees C). It is these high temperatures that cause the gas to shine in energetic light, such as gamma rays.

Once the gas' motion - its direction of movement and velocity - was measured, astronomers used this data to turn back the clock and pinpoint when the gas started moving. This origin is also the last known 'big meal' enjoyed by Sgr A*, which has not managed to suck down such a significant amount of matter ever since. "What we find is that a very strong, energetic event happened 6 million to 9 million years ago," Bordoloi explained. "It may have been a cloud of gas flowing into the black hole, which fired off jets of matter, forming the twin lobes of hot gas seen in X-ray and gamma-ray observations. Ever since then, the black hole has just been eating snacks."

Population III (Pop III) stars theoretically contain only hydrogen, helium, and very little if any 'heavier' elements, such as lithium. This chemistry makes Pop III stars extremely metal-poor, if not devoid of metals altogether (astronomers typically refer to any elements heavier than helium as 'metals', regardless of their classification on the periodic table.) Pop III stars probably began developing about 100 million years after the Big Bang. The metals created inside these massive stars began to spread via supernovae, and as the metal content of the universe increased, Pop II stars began to form about 13 billion years ago. Today, these stars are found in the bulges and haloes of galaxies, and while they're still considered metal-poor, they contain metal abundances much greater than the very early universe. The cycle of stellar birth and recycling continued, until, about 10 billion years ago, Pop I stars began to form. The Sun is a Pop I star, and the metals found inside it and the solar system can all be traced back to the same type of supernovae that spread dust (and metals) throughout A2744_YD4. By: Alison Klesman

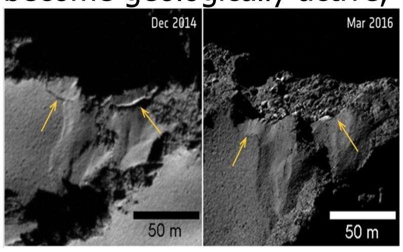
New theory suggests Mars had rings in the past 20 March: A recent theory by NASA-funded scientists at Purdue University in Lafayette, Indiana suggests that space debris may have previously become rings around Mars.


Mars' moon Phobos, NASA/JPL-Caltech/University of Arizona

David Minton and Andrew Hesselbrock developed a model that claims debris resulting from objects such as asteroids slamming into Mars alternates between becoming rings and becoming a moon. Such a collision 4.3 billion years ago formed Mars' North Polar Basin and would have resulted in debris that became rings. According to the model, the debris in the rings eventually moved away from Mars and spread, where it then came together to form a moon. After the moon was formed, the gravitational pull between Mars and the moon would have come into play and pulled it inward toward the Roche limit, which is the distance where a self-gravitating celestial body such as an asteroid or moon is torn apart by interactions with a larger planet. This cycle could have repeated itself up to seven times in the past several billion years.

The model suggests Phobos is about 70 million years from reaching the Roche limit, breaking apart, and becoming a new set of rings. This theory could also explain the mysterious sediment on Mars' equator as pieces of past moons breaking apart as they formed the rings. "You could have had kilometre-thick piles of moon sediment raining down on Mars in the early parts of the planet's history, and there are enigmatic sedimentary deposits on Mars with no explanation as to how they got there," Minton said. "And now it's possible to study that material." By: Nicole Kiefert

Rosetta spots major changes on comet 67P 22 March: Planets and moons are not the only geologically active places to be found in the solar system - recent data returned from the European Space Agency's Rosetta mission highlight the fact that comets can become geologically active, too.



Comet 67P has undergone significant changes in the past few years ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

Comets are icy, rocky bodies that spend most of their time in the outer solar system on highly elliptical orbits that take tens, hundreds, or thousands of years to complete. Far from the Sun, temperatures are too cold for water to exist as a liquid or gas, so comets carry their water (and other volatiles, such as carbon dioxide and methanol) as ices. When a comet's orbit brings it close to the Sun, the temperature rises and these ices begin to sublimate, transforming from a solid directly into a gas and helping to form the comet's signature tail.

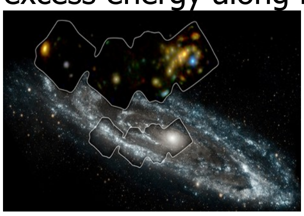
However, the formation of this breathtaking feature can spell big changes for the surface of the comet. "This is something we were not able to really appreciate before the Rosetta mission, which gave us the chance to look at a comet in ultra-high resolution for more than two years," says Ramy El-Maarry of the University of Colorado, Boulder, a member of the U.S. Rosetta science team and the first author of the paper, which is based on data taken while Rosetta orbited comet 67P/Churyumov-Gerasimenko from August 2014 through September 2016.

During this time, comet 67P made its way through the inner solar system; as the comet warmed, Rosetta recorded substantial changes occurring on the surface. "We saw a massive cliff collapse and a large crack in the neck of the comet get bigger and bigger," says El-Maarry. The crack, which occurred in the slimmest part of the dog bone-shaped comet, was identified in August 2014 and initially extended about 500 metres. By December of the same year, the crack had widened by about 30m; by June 2016, a new fracture had appeared, running parallel to the first and spanning between 150-300m. Because of its location at the comet's smaller, structurally weaker neck, El-Maarry believes it may one day split the comet in two. The crack is believed to have occurred as the comet's rotational rate around its axis sped up due to heating by the Sun.

Other changes that Rosetta recorded include the relocation of a 130 million kg boulder to a new spot 140m away. The study speculates that the boulder's movement is likely due to the several outburst events the spacecraft recorded as originating near the massive rock's original location. The collapse of a cliff on the comet's nucleus, which occurred in July 2015 was also likely due to an outburst of gas and dust that encompassed the area. In the wake of the collapse, Rosetta was able to peer briefly beneath the dusty surface of the comet to spot the pristine water ice preserved below.

These observations are the first such high-quality records of the processes that take place on comets as they approach the Sun. According to El-Maarry, such observations allow astronomers to better understand the processes that shape comets and the timescales over which they occur. This makes it possible to work backwards and make better inferences about the conditions in the early solar nebula, which are preserved within the interiors of such icy, distant objects. By: Alison Klesman

NASA's NuSTAR solves the mystery of the Andromeda galaxy's high-energy X-rays 24 March: The Andromeda galaxy (M31) is the Milky Way's largest neighbour, as well as the largest member of the Local Group. A spiral galaxy much like our own, astronomers often use Andromeda as a proxy to study the Milky Way, since we cannot simply step outside our own galaxy to take a look back. Now, the mystery of high-energy X-ray emission emanating from the centre of the Andromeda galaxy has finally been solved. NASA's Nuclear Spectroscopic Telescope Array (NuSTAR) has uncovered the source of the X-ray emission as a likely pulsar - a swiftly spinning stellar remnant that beams out excess energy along its magnetic poles.


Central region of the Andromeda galaxy, NASA/JPL-Caltech/GSFC

The object, known as Swift J0042.6+4112, has been seen in lower-energy X-rays for decades. NASA's Einstein Observatory first spotted the source in low-energy X-rays in the 1970s. The Swift satellite also saw it in 2013, but the object's nature was still difficult to tease out among the many other low-energy X-ray sources nearby. Swift J0042.6+4112 has also been observed with the Chandra X-ray Observatory and the European Space

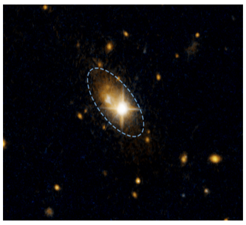
Agency’s X-ray Multi-Mirror Mission (XMM-Newton).

Now, NuSTAR’s capabilities have finally allowed astronomers to make an educated guess as to the source’s nature. Mihoko Yukita of Johns Hopkins University and her co-authors present a detailed study of the object, concluding that it is most likely a pulsar residing in a binary star system. As it pulls material off its close neighbour, the pulsar spits out X-rays. The nature of these X-rays closely matches the X-rays given off by pulsars in the Milky Way, leading the researchers to conclude that Swift J0042.6+4112 is the same type of object. “We didn't know what it was until we looked at it with NuSTAR,” said Yukita. “That’s because NuSTAR provided the final piece of the puzzle - the nature of Swift J0042.6+4112’s high-energy X-ray emission, not observable with other telescopes.

The identification of Swift J0042.6+4112 as a pulsar is strange, however, because astronomers would expect emission from the infall of matter onto a central supermassive black hole to dominate the high-energy X-rays emerging from the galaxy. That is because supermassive black holes are millions of times more massive than pulsars. Andromeda’s supermassive black hole tips the scales at 100 million solar masses (1 solar mass is the mass of our Sun). By comparison, the Milky Way’s central supermassive black hole is only about 4 million solar masses. And a pulsar, by nature, cannot grow to more than about three solar masses before it collapses and eventually forms a stellar-sized black hole.

That is why this result is so intriguing, but also so important for the study of pulsars in our own galaxy and beyond. Ann Hornschemeier of NASA's Goddard Space Flight Centre, one of the paper’s co-authors, explained, “NuSTAR has made us realise the general importance of pulsar systems as X-ray-emitting components of galaxies, and the possibility that the high energy X-ray light of Andromeda is dominated by a single pulsar system only adds to this emerging picture.”   By: Alison Klesman

Astronomers spot a runaway quasar 24 March: Supermassive black holes reside at the centres of most galaxies - or do they? A new detection by the Hubble Space Telescope (HST) points to an active supermassive black hole in the process of fleeing its galaxy. The astronomers who spotted it say the data present a strong case for a gravitational wave event that knocked the black hole for a loop and sent it rocketing away in one direction.


Quasar 3C 186 encircled by the dashed line, the bright star-like object to the lower right of the dimmer, blob-like galaxy. NASA, ESA, and M. Chiaberge (STScI and JHU)

While this is not the first such suspected ‘rogue black hole’, it is currently the most compelling evidence for one. Astronomers have now assembled data from not only HST, but the Chandra X-ray Observatory and the Sloan Digital Sky Survey as well. “The amount of data we collected, from X-rays to ultraviolet to near-infrared light, is definitely larger than for any of the other candidate rogue black holes,” said Marco Chiaberge of the Space Telescope Science Institute (STScI) and Johns Hopkins University.

A quasar is really the disk of dust, gas, and other matter that surrounds a supermassive black hole. As this material clumps and rubs together on its way into the black hole itself, it heats up and shines brightly, allowing astronomers to spot it. (This is because the material is located outside the black hole's event horizon, inside of which even light cannot escape.) This quasar, named 3C 186, is associated with a distant galaxy that sits about 8 billion light-years away.

How exactly did astronomers conclude that the object they spotted is a runaway quasar? Using observations from HST in both visible and near-infrared light, the team originally identified the galaxy as an object of interest while completing a survey of galaxies currently undergoing mergers. Chiaberge explained that "I was anticipating seeing a lot of merging galaxies, and I was expecting to see messy host galaxies around the quasars, but I wasn't really expecting to see a quasar that was clearly offset from the core of a regularly shaped galaxy. Black holes reside in the centre of galaxies, so it's unusual to see a quasar not in the centre."

Once the object had been spotted, the team was able to determine the black hole's mass and speed based on spectroscopy, which breaks light into many components and allows for the measurement of quantities such as composition and velocity. The black hole's mass is more than 1 billion Suns, making it the largest such black hole to ever have been detected fleeing the center of its galaxy. Based on their measurements, "we discovered that the gas around the black hole was flying away from the galaxy's centre at 7.6 million kph)," said Justin Ely of STScI, a co-author on the paper. Because the black hole itself cannot be seen, this gas can be used as a proxy for the black hole's velocity. For a little perspective, an object launched from Earth travelling at that speed could reach the Moon in about three minutes. And if it continues at that speed, in another 20 million years or so, 3C 186 will be free of its galaxy's gravitational pull, sailing off into intergalactic space.

The team also modelled the starlight in the galaxy to determine how far 3C 186 had travelled thus far, only to find that the black hole is now more than 35,000 light-years from the centre of the galaxy (the Sun is about 26,100 ly from the centre of our galaxy).

How does such a massive object get ejected from its galaxy's centre? It takes a lot of energy: the equivalent of 100 million supernovas going off simultaneously. That exact scenario, of course, is not very likely, but such a blow could be delivered by the gravitational waves resulting from the collision of two large black holes. Gravitational waves, originally predicted by Albert Einstein and confirmed via the Laser Interferometer Gravitational-Wave Observatory in 2016, are 'ripples' in the fabric of space-time that occur when two massive objects, such as neutron stars or black holes, circle each other and merge.

3C 186's host galaxy actually sports faint arcs of material, called tidal tails, that speak to the possibility of a past merger with another galaxy. And when galaxies merge, so too should their central supermassive black holes However, if the two supermassive black holes are not precisely matched in mass or rotation, the gravitational waves emitted as they swirl ever closer to each other will be unbalanced, stronger in one direction than any other. When the objects finally merge, the imbalance can give the resulting black hole a kick, sending it off in one particular direction. "This asymmetry depends on properties such as the mass and the relative orientation of the back holes' rotation axes before the merger," explained team member Colin Norman of STScI and Johns Hopkins University. "That's why these objects are so rare."

If 3C 186 is truly what it appears, it would provide additional proof that such supermassive black hole mergers can occur. There is a second possible explanation, though it is less plausible in this scenario. Images taken with telescopes give no sense of depth. Thus, the quasar could be associated with a foreground or background galaxy, and not the galaxy it appears to be escaping. If this was true, however, the team argues that the host galaxy of the quasar should be detected, and no such galaxy was seen. By: Alision Klesman

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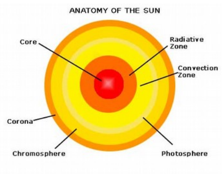
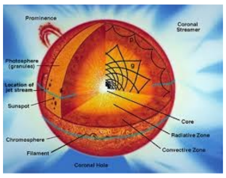
DID YOU KNOW?

The Sun Part 13: **Sun – structure 2**





Solar structure

Solar atmosphere Normally overwhelmed by sunlight, this is visible during totality of a solar eclipse. Illogically, it is much hotter than the Sun's surface, with temperatures increasing with increasing distance. These high temperatures, particularly in the corona, show that the solar atmosphere is heated by something other than direct heat conduction from the photosphere.

One possible explanation is the presence of Alfvén waves, transverse waves that occur in regions containing a magnetic field and a plasma. The ionised, highly conducting plasma material is 'frozen' into the magnetic field and forced to take part in its wave motion. However, Alfvén waves do not easily dissipate in the corona and cannot fully explain its very high temperatures. Heating by flares and other large scale solar emission phenomena is perhaps a stronger possibility, but is still being investigated.

Chromosphere About 9,000 km thick, this forms the lowest of the three parts of the solar atmosphere. Its name, meaning 'colour', reflects its visibility as a coloured flash at the start and end of a solar eclipse. Temperatures increase with altitude, from around 5,500 K at the upper photosphere, to around 20,000 K near the top.

Transition region Temperatures rise rapidly from around 20,000 K to close to 1,000,000 K in this thin region, which is about 200 km in depth. The increase is facilitated by full ionisation of helium ions in the transition region, which significantly reduces radiative cooling of the plasma. This region does no occur at a defined altitude. It forms a nimbus around chromopsheric features eg spicules, filaments, and is in constant, chaotic motion. The region is not easily visible from Earth, but is easily observed in space by instruments sensitive to the ultraviolet part of the spectrum.

Corona The average temperatures in the corona, the outer part of the solar atmosphere, and the origin of the solar wind, is 1-2 million K, but it can reach 8-20 million K in the hottest regions. Explanation for these temperatures is incomplete, but at least some is known to be from magnetic reconnection.

Coronal streamers are tapered patterns visible in corona when the Sun is covered. They are formed by outward flow of plasma which is shaped by the Sun's magnetic field lines and extend millions of kilometres into space. This extended solar atmosphere has a volume much greater than that of the Sun itself. Waves at the outer surface of corona with randomly blow away from the Sun are the origins of the solar wind. This continuous outflow of ionised gas energy from the corona consists of electrons, protons and, to a lesser extent, nuclei of elements like helium

Heliosphere This is the tenuous outermost part of the solar atmosphere. Filled with solar wind plasma, it is defined to begin at the distance where the flow of the solar wind becomes superalfvénic ie where flow becomes faster than the speed of Alfvén waves. This occurs at approximately 20 solar radii (0.1 AU).

Temperatures and dynamic forces in the heliosphere cannot affect the shape of the corona because information can only travel at the speed of Alfvén waves. The solar wind travels continuously outwards through this region, forming the solar magnetic field into a spiral shape until it impacts the heliopause**.** more than 50 AU from the Sun. In December 2004, Voyager 1 passed through a shock front thought to be part of the heliopause. Both Voyagers recorded higher levels of energetic particles as they approached this boundary.

Links between solar surface and atmosphere Solar prominences are large, bright gaseous features which reach outwards from the Sun's surface, often in a loop shape. Anchored in the photosphere, they extend out into corona. First described in the 14th century Laurentian Codex in a description of the May 1185 solar eclipse as 'flame like tongues of live embers', they typically extend over many 1,000s of kilometres. The largest on record is estimated to have been around 800,000 km long (over half the Sun's diameter). Some are so powerful that they throw out matter from the Sun into space at speeds of 600->1,000 km/s.

While the corona consists of extremely hot ionised gases (plasma) which do not emit much visible light, prominence plasma is typically 100 times cooler and denser than coronal plasma, and more visible. They form over timescales of about 1 day and may last a few days or persist in the corona for several weeks or months. Some break apart and may give rise solar flares or coronal mass ejections. Ongoing, intensive research is still being undertaken in order to identify how and why solar prominences and other solar emission features form.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed, www.en.wikipedia.org,

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