"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

JUNE 2017

We would like to welcome the following new members: Rossouw van der Walt and Norval Geldenhuys

This month's Centre meeting
This will take place on **Monday 19 June** at the **Scout Hall** starting at **19.00**. Daniel Groenewald from the SAAO in Cape Town will talking about 'The monsters of deep space See below for more details.

WHAT'S UP?

A celestial trio On the 3rd and 4th, a satellite (Moon), planet (Jupiter) and star (Spica) will form a close triangle. Jupiter is the third brightest object in the night sky, after the Moon and Venus. It is visible at some period during darkness throughout this year. With binoculars, it is possible to see the planets four brightest moons. These Galilean moons (disocvered in 1610 by Galileo with one of the earliest telescopes) are, from innermost to outermost, Io, Europa, Ganymede and Callisto. How many are visible depends on their positions at the time of viewing. Spica (Alpha Virginis) is the brightest star in the Virgo constellation (the virgin). Actually a binary pair, is is much brighter than other stars in the constellation and appears to be solitary, rather than part of an identifiable grouping. Located about 250 ly away, it is the 13th brightest star in the night sky. Virgo (named for the Greek goddess of justice) is the second largest of the 88 named constellations. It contains several members of the Virgo Cluster of galaxies. Over 55 million ly away, the Virgo Cluster is the nearest large cluster of galaxies and the centre of the local supercluster (containing at least 10,000 galaxies). The Virgo Cluster's irregular elliptical shape includes over 2,000 galaxies, some of which can be seen through small telescopes.

LAST MONTH'S ACTIVITIES

Monthly centre meeting On 15 May, Centre member, Johan Retief, gave an excellent presentation on 'Asteroids, comets and dwarf planets'. The talk focussed on the many small celestial objects located in the Solar System, and the nature, location and characteristics of which have led to the need for clearer definitions over time. He defined minor planets (asteroids), dwarf planets (object with enough mass to make it round, but too small to have removed material around its orbit) and comets, and gave a brief history of discovery of the first, larger, non-planetary objects eg Ceres.

For each of the three groups, he then outlined their characteristics and classifications and explained the sometimes complex methods of confirming the existence and labelling and/or naming methods used to record them. So many asteroids and comets have been, and continue to be, found that the Minor Planet Centre in the USA was formed in 1947 to record the details of each object.

Then, Johan described the areas in which these objects are located, including the asteroid belt, Kuiper belt and Oort cloud. In addition, he talked about the Trojan asteroids, groups which share the orbits of some planets at some of their Lagrangian points, particularly Jupiter and Neptune. Finally, he introduced the concept of binary or double planets, a concept in which two orbiting objects both have similar mass ratios. Although some have been proposed in the Solar System eg, Pluto and its moon Charon, the International Astronomical Union does not recognise this concept among recognised types of objects.

Interest groups

Cosmology 22 people (20 members, 2 visitors) attended the meeting on 1 May. They watched another two episodes in the DVD series: Particle Physics for Non-Physicists: a Tour of the Microcosmos' by Prof Steven Pollock, Professor of physics at the University of Colorado at Boulder. These episodes were Lecture 7 'Weak interactions and the neutrino' and Lecture 8 'Accelerators and the particle explosion'.'

Astro-photography At the meeting on 9 May, members continued to work on processing their own astro-images.

Other activities

Educational outreach

Hawston Secondary School Astronomy Group Weekly meetings continued during May, following the start of the new term

Lukhanyo Youth Club No meetings are being arranged while members are attending a series of workshops being run by SANSA staff during 2017

Stargazing Although some committee members set up their telescopes and binoculars at Gearing's Point on 26 May, clouds prevented any meaningful viewing. The cloudy weather also deterred any members of the public from attending the event.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting will take place on **Monday 19 June** at the **Scout Hall** starting at **19.00**. Daniel Groenewald from the SAAO in Cape Town will be talking on 'The monsters of deep space'. He explains: 'In the depth of space, monster galaxies are lurking. Luckily for astronomers, these galaxies are easily observed. However they are rare in numbers. These monster galaxies are found at the heart of galaxy clusters and can be dozens of times the mass of our own galaxy, the Milky Way. During this talk we will explore these massive galaxies and also take a look at the intricate relationship these massive galaxies have with their close neighbours.'

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 **5 June** at the Scout Hall, **starting at 19.30**. Attendees will watch the next two episodes in the DVD series: Particle Physics for Non-Physicists: a Tour of the Microcosmos' by by Prof Steven Pollock, Professor of physics at the University of

Colorado at Boulder. The content will be Lecture 9 'The particle zoo' and Lecture 10 'Fields and forces'.

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 **12 June**. 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.

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, as municipal staff requested some additional information. Hopefully, a decision will be made 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.

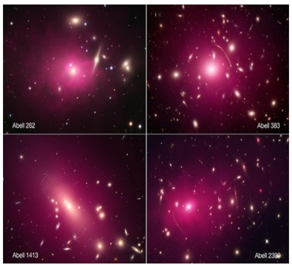
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer, 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

Dark matter may be fuzzier than we thought 1 May: Dark matter has a profound effect on our universe, shaping galaxies and even leaving its fingerprints on the energy left over from the Big Bang. Despite its relevance, dark matter is also extremely hard to detect - rather than observe it directly, astronomers instead look for clues based on its gravitational interaction with normal matter (the protons, electrons, and neutrons that make up everything we see and touch). Recent observations made with NASA's Chandra X-ray Observatory have hinted that dark matter may be 'fuzzier' than previously thought.



Four of the 13 galaxy clusters used in the recent Chandra study, all of which indicate that dark matter could be fuzzier than previously envisioned. X-ray: NASA/CXC/Cinestav/T.Bernal et al.; Optical: Adam Block/Mt. Lemmon SkyCenter/U. Arizona

The study focused on X-ray observations of 13 galaxy clusters. The authors used observations of the hot gas that permeates galaxy clusters to estimate the amount and distribution of dark matter within the clusters and test its properties against current leading models, looking for the model that best fits the data. The current standard cosmological model includes 'cold dark matter' as a major component. In this case, 'cold' simply means that dark matter travels slowly when compared to the speed of light. However, cold dark matter models indicate that dark matter - and normal matter, which is drawn to the dark matter via gravity - should clump together in the centres of galaxies. However, no such increase in matter, normal or dark, is seen. Additionally, cold dark matter models predict that the Milky Way should have many more small satellite galaxies than we currently see. Even accounting for the fact that some satellites may be challenging to find, the cold dark matter models still over-predict our satellites by a considerable amount.

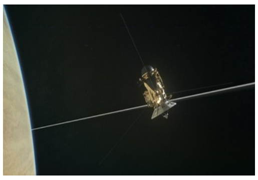
However, cold dark matter is only one of several dark matter theories. By contrast, 'fuzzy dark matter' is a model in which dark matter has a mass about 10 thousand trillion trillion times smaller than an electron. In quantum mechanics, all particles have both a mass and a corresponding wavelength. Such a tiny mass would actually cause the wavelength of dark matter to stretch 3,000 light-years between peaks. (The longest wavelength of light, which is radio, stretches just a few miles between peaks.) With a wavelength this long, dark matter would not clump in the centres of galaxies, which could explain the reason this is not observed. However, while simple fuzzy dark matter models fit observations of small galaxies, larger galaxies may require a slightly more complex explanation. Galaxy clusters are larger test beds still, which is why researchers turned Chandra to several massive galaxy clusters for observations.

The results show that, while a simple fuzzy dark matter model still did not explain the cluster observations well, a more complex and 'fuzzier' model did. In this model, dark matter occupying several quantum states at once (think an atom with many electrons, some of which are at higher energy levels) creates overlapping wavelengths that further spread out the effect, which changes the distribution of dark matter expected throughout the galaxy cluster as a whole.

The predictions from this model match the observations of the 13 galaxy clusters much more closely, indicating that fuzzier dark matter may be the best model to incorporate into cosmological models. However, further study and more precise measurements are needed to better test this theory and ensure it truly reflect what we see throughout the cosmos.

By: Alision Klesman

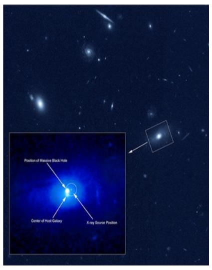
Cassini encounters the 'Big Empty' during its first dive 3 May: Yesterday, NASA's Cassini spacecraft entered its second of the 22 dives and scientists are excitedly waiting for the data to get a second look at the rings after the surprising information from the first dive: there appears to be no dust in the area.


An artist's rendering of Cassini diving through Saturn's rings. NASA/JPL-Caltech

With this revelation, the Cassini team is continuing on with their original plan for further observations. Now, the team can ignore their 'plan B' and will nothave to worry about dust affecting the instruments. "The region between the rings and Saturn is 'the big empty,' apparently," Cassini Project Manager Earl Maize of NASA's Jet Propulsion Laboratory said. "Cassini will stay the course, while the scientists work on the mystery of why the dust level is much lower than expected."

Having no other spacecraft pass through Saturn's rings before, the team had prepared for a dusty environment in the 2,000-kilometre area, planning to have Cassini use its round antenna as a shield. When Cassini's Radio Plasma Wave Science (RPWS), the instruments in the shield that detect dust, detected a very small amount, scientists switched the data to audio format. Expecting to hear the pops and cracks of dust hitting the RPWS, the team was surprised to only hear the squeaks of Cassini diving through the rings."It was a bit disorienting -- we weren't hearing what we expected to hear," said William Kurth, RPWS team lead at the University of Iowa, Iowa City. "I've listened to our data from the first dive several times and I can probably count on my hands the number of dust particle impacts I hear." After assessing the data, the team believes Cassini only encountered a handful of dust particles no bigger than 1 micron across. Cassini is scheduled to reconnect today after its second dive yesterday. By: Nicole Kiefert

Chandra spots a recoiling black hole 12 May: You would think a black hole with a mass of 160 million times that our Sun would be difficult to move — and you would be right. Nonetheless, astronomers have spotted a potentially 'renegade black hole' offset from the centre of an elliptical galaxy about 3.9 billion light-years away.


The bright X-ray source CXO J101527.2+625911 is visibly offset from the center of its elliptical host galaxy. Because this object shows other signatures of a growing supermassive black hole, astronomers think it's a black hole experiencing the recoil of a previous merger or other interaction. X-ray: NASA/CXC/NRAO/D.-C.Kim; Optical: NASA/STScI

Dongchan Kim of the National Radio Astronomy Observatory in Charlottesville, Virginia, and his colleagues discovered a supermassive black hole whose X-ray emission - a sign of growth due to the influx of new material onto the black hole - is offset from the centre of its host galaxy by roughly 3,000 light-years. The black hole, labelled CXO J101527.2+625911, was not easy to find. First, the researchers had to examine data from thousands of X-ray images from the Chandra X-ray Observatory to find a galaxy showing signs of an accreting supermassive black hole. They examined those candidates with the Hubble Space Telescope to look for two 'peaks' of brightness in the optical images, which would indicate one of two scenarios: either a pair of accreting supermassive black holes, or a single renegade black hole ousted from the centre of its galaxy. Finally, they looked at Sloan Digital Sky Survey spectra of any galaxies that matched the previous two criteria. Spectra are observations that break light into its constituent parts, allowing astronomers to easily identify certain types of processes - such as accretion - and clearly identify motion.

Supermassive black holes preferentially lie in the centre of their host galaxy, where they do not move much. When one is clearly offset from the centre, then, it likely means something interesting is going on. Astronomers are searching for cases such as these because they can shed further light on the formation and behaviour of supermassive black holes and the galaxies in which they reside.

CXO J101527.2+625911 does indeed show both an offset and distinct motion. Its velocity does not match the overall motion of its host galaxy, leading researchers to believe that it is experiencing the recoil of a previous black hole merger. When two black holes merge, they must first spiral in toward each other, each losing angular momentum before they finally collide. Because the black holes are so massive, this process generates gravitational waves. Differences in mass, spin, and orientation of the two merging black holes cause asymmetry in the gravitational waves produced, which at the final moment of merging can give the object that results a massive kick in one preferred direction. This is called recoil, and it results in a single supermassive black hole moving in a distinct direction away from the center of its galaxy.

Kim's group does acknowledge that the alternate scenario is still possible: The galaxy may have two supermassive black holes, one of which (in the centre) is either not growing as quickly or whose emission is shrouded. However, they still favour the recoiling black hole scenario, as the host galaxy also shows signs of disruption in its outer regions and rapid new star formation, both hallmarks of a recent merger with another galaxy that increases the likelihood of a recoiling black hole. By: Alison Klesman

Astronomers create the largest map of the universe 19 May: Quasars are extremely bright, extremely distant objects. They are the disks of material around supermassive black holes, which heat up and glow as material streams inward toward the event horizon. And now, the Sloan Digital Sky Survey (SDSS) has identified more than 147,000 of these objects in the distant Universe to create a first-of-its-kind 3-dimensional map of the early Universe that is also the largest such map available to date.


This artist's impression shows a quasar — the hot disk of material around the supermassive black hole that resides in the center of a galaxy. ESO/M. Kornmesser

The observations were taken over the course of two years as part of the SDSS Extended Baryon Oscillation Spectroscopic Survey, abbreviated eBOSS, which uses the Sloan Foundation 2.5m Telescope at Apache Point Observatory. EBOSS aims to more accurately measure the expansion history of the Universe. The quasars in the study were spotted shining at a time when the Universe was between 3 and 7 billion years old.

This new, more complete map of the universe and its expansion history agrees with the standard cosmology astronomers have developed over the past two decades and are currently using today, which includes properties such as Einstein's general theory of relativity and the existence of dark matter and dark energy. Studying this time frame is particularly important because its the epoch leading up to when the Universe's expansion changed from a decelerating to an accelerating expansion. That happened when the Universe was roughly 7.8 billion years old, or about 6 billion years ago. Today, that acceleration continues - in short, objects farther away from us are receding faster, and continue to do so because of a cosmological component called dark energy. Characterising the exact nature of this transition from a decelerating to accelerating Universe can place further constraints on the nature of dark energy, which is the dominant component in the Universe at the present time.

Will Percival, a professor of cosmology at the University of Portsmouth and the eBOSS survey scientist, explains, "Even though we understand how gravity works, we still do not understand everything – there is still the question of what exactly dark energy is. We would like to understand dark energy further." eBOSS is looking into the nature of dark energy by studying 'baryonic acoustic oscillations', or BAOs. BAOs are the remnant signature of sound waves traveling through the very early Universe; when the Universe was about 380,000 years old, these sound waves were essentially frozen in place by changing conditions. Since then, their signature has been stretched by the expansion of the Universe. However, astronomers have a good idea of what the BAOs should have looked like at the time they were frozen, making the changes seen in BAOs over time a clear record of the Universe's expansion over time.

Thus, BAOs can be used as a sort of 'standard ruler' by cosmologists. The size of the oscillations corresponds to the most likely distance between galaxies, including the quasars that reside within them. According to Pauline Zarrouk, a PhD student at the University Paris-Saclay, "You have metres for small units of length, kilometres or miles for distances between cities, and we have the BAO for distances between galaxies and quasars in cosmology." Today, the distribution of galaxies (and their quasars) is a reflection of the frozen-in BAOs, so the better we can map the Universe, the better we can understand how its expansion has changed over time, independent of other ways of measuring that expansion, such as using supernovae or lensed quasars.

Thus far, "Our results are consistent with Einstein's theory of general relativity" says Hector Gil-Marin of the Laboratoire de Physique Nucléaire et de hautes Énergies in Paris. Gil-Marin is one of the astronomers who contributed to the analysis of the quasars and the creation of the map. "We now have BAO measurements covering a range of cosmological distances, and they all point to the same thing: the simple model matches the observations very well." Even as eBOSS continues through 2020, there are plans for future sky surveys to increase the detail of such maps by a factor of ten, helping to paint an ever-clearer picture of our universe's past. By: Alison Klesman

Merging white dwarfs may create most of our galaxy's antimatter 22 May: More than four decades ago, astronomers discovered the first gamma-ray emission coming from outside the solar system. This high-energy signal is associated with the destruction of roughly 1043 ositrons - a type of antimatter - each second. Despite extensive follow-up, astronomers today are still looking for the exact source (or sources) of this emission, which could run the gamut from mundane (natural processes in a stars life) to exotic (dark matter) origins. Recently, a group of astronomers has determined that positrons resulting from white dwarf mergers could contribute significantly to the signal we see.


Two white dwarfs in a binary system can spiral toward each other and merge, setting off a supernova event that triggers the creation of material that will decay into antimatter over time. ESO/L. Calçada

The emission associated with galactic positron annihilation occurs when a positron meets its counterpart, an electron, destroying both particles in the process. Thus, this emission requires a ready source of antimatter, which has remained mysterious ever since its initial detection. Measurements suggest that the signal is nearly one and a half times higher in the bulge, or central regions of the Milky Way, than in the arms. This particular aspect of the emission has led to the development of several models that speculate an overabundance of positrons in this area could be due to processes related to dark matter or our galaxy's central supermassive black hole. However, many astronomers are still searching for less exotic ways the positrons we're seeing undergo annihilation could be produced.

Roland M. Crocker of the Research School of Astronomy and Astrophysics at Australian National University and his co-researchers examined a possible stellar source of galactic positrons that could be responsible for the signal: white dwarf mergers. White dwarfs are the remnant cores of Sun-like stars, left behind after the star runs out of fuel and dies. If two low-mass stars (between about 1.4 and 2 times the mass of the Sun) circle each other closely in a binary system, they can interact via a process called mass transfer, where gas from the stars is exchanged. The end result is two white dwarfs that may eventually merge, and that merger can result in the production of radioactive isotopes that decay into positrons.

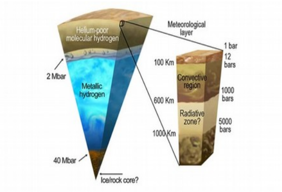
There are several clues that have led Crocker and his co-authors to this conclusion. The ratio of the signals strength in the bulge and arms is similar to the ratio of the stellar mass (essentially the number of stars) in these two structures as well. This led the astronomers to consider that the positron production could be related to an older stellar population, such as white dwarfs. Additionally, by looking at the processes that produce positrons through radioactive decay, they determined that the decay of 44Ti into positrons is the most likely source. However, this material is not produced in sufficient amounts in most core collapse supernovae, which occur when a massive star reaches the end of its life. While supernovae triggered by the merger of two white dwarfs are much rarer, these events should produce more 44Ti per merger, which would then decay and produce the number of positrons required to create the emission line from their subsequent annihilation.

The current resolution of instruments used to study this emission is not high enough to find point sources, such as individual supernova remnants, in the bulge. Thus, more precise measurements and computer simulations will be needed to determine the positron production rates from such events. The authors also state that white dwarf mergers are likely not the only source of antimatter in our galaxy, which still includes contributions from massive stars and black holes, even if dark matter is eventually ruled out as a viable source for this emission. By: Alison Klesman

Juno results offer tantalizing hints of Jupiter's secrets 24 May: The first results from Juno's brush with Jupiter reveal swarms of cyclones, massive ammonia plumes and complex interactions between a turbulent magnetic field and powerful streams of electrons. The Juno team is still sifting through the massive piles of data the probe is sending back from the gas giant. Since arriving last year, the probe has begun to study the composition and internal structure of Jupiter. We are also learning more more about its super powerful magnetic field, information that will yield insights into how our solar system formed and how gas giants around other stars may behave.

Juno is armed with an array of instruments that allow researchers to gather information from both the outer layers and deep below the clouds. Visible and infrared cameras capture outermost details, while magnetometers and a microwave radiometer (along with detectors tuned for various types of energetic particles) gather information on the flurry of electromagnetic activity infusing the planet. Also on board is equipment to measure the world's gravitational field, which could offer important clues about Jupiter's interior composition.

The first and most visually striking data Juno returned were images of the north and south poles, both spotted with dozens of cyclones, some reaching almost 1,440 km in diameter. Even more strikingly, microwave readings at the equator detected a huge plume of hot ammonia gas emanating from deep within the planet. This column seems to bring ammonia to the outer layers, where it crystallizes into ice particles and rains down at higher latitudes near the poles. The feature is in some ways similar to Hadley cells on Earth, which fuel hurricanes and the jet stream while distributing moisture throughout the tropics. The plume stems surprised researchers, who had assumed that the ammonia clouds were relatively uniform all the down, and could help illuminate how weather systems on the planet form.



An illustration of Jupiter’s interior. A possible inner “rock” core is shown, surrounded by a metallic hydrogen envelope (shown in blue) and outer envelope of molecular hydrogen (shown in brown), all hidden beneath the visible cloud deck. Juno’s gravity field data will reveal new clues about Jupiter’s core. NASA/JPL-Caltech/SwRI

Researchers also studied the planets immense magnetic field and found that, close to the planet, it was much stronger than expected, clocking in at 7.766 Gauss — about ten times stronger than Earths. Their measurements also found lots of magnetic complexity near Jupiter’s outermost layers, which supports the hypothesis that the world’s magnetic field is being driven by the swirling liquid hydrogen layer beneath the clouds. A full mapping of the magnetic field awaits data from further Juno orbits.

“Juno is giving us a view of the magnetic field close to Jupiter that we’ve never had before,” said Jack Connerney, Juno’s deputy principal investigator. “Already, we see that the magnetic field looks lumpy: It is stronger in some places and weaker in others. This uneven distribution suggests that the field might be generated by dynamo action closer to the surface, above the layer of metallic hydrogen. Every flyby we execute gets us closer to determining where and how Jupiter’s dynamo works.”

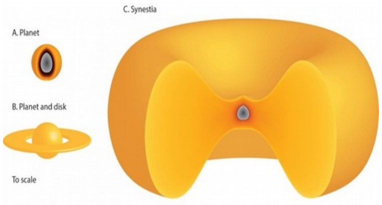
Understanding its magnetic field will add another piece to the puzzle of Jupiter’s interior. While planetary scientists assume it to be mostly hydrogen, the true composition, density and structure remain unknown. Scientists assume that the crushing pressures create a large layer of metallic hydrogen in the planets interior with a rocky core beneath, but definitive evidence is still lacking. Juno is also taking gravitational measurements as it orbits, which should give us more information about the interior as additional data becomes available.

In addition to looking below Jupiter’s clouds, the researchers wanted to see what happens above them, where charged particles from both the sun and within Jupiter interact with its magnetic field, creating huge auroras. Juno first encountered the shroud of particles last summer when it passed through the bow shock, a sort of shock wave created when Jupiter’s magnetic field shunts particles from the solar wind aside. The bow shock seems to have been moving outward as Juno passed through it, the researchers say.

As it moved closer, Juno also measured the density of the particles it encountered on its trip around Jupiter, and took readings of the streams of aurora-generating electrons flowing toward the planet as the probe flew over its poles. These particles moved in different ways than the streams of electrons that create auroras on Earth, revealing that Jupiter’s magnetic field must behave in ways that ours does not. By studying how the particles behave in the grip of the gas giant's magnetic field lines, researchers can better map the field itself — providing its own clues about what's going on beneath Jupiter's clouds.

The probe itself has suffered little damage as a result of the planet's intense radiation belts and repeated dives near the surface, the researchers say, indicating that the 'suit of armour' protecting the spacecraft is holding. This is good news for the remainder of the mission, according to Scott Bolton, Juno's principal investigator. "We need the rest of our mission to really figure out how Jupiter works," Bolton said. "We've also confirmed that Juno is the right tool to do this … We're actually going to win over this beast and learn how it works." Juno will continue to orbit Jupiter until 2018, completing a total of 37 orbits, each time building a more complete picture of the planet. While these initial results are promising, much more is still to come. By: Nathaniel Scharping

Earth may have been shaped like a doughnut at one point in time 26 May: Scientists proposed a new type of planetary object they are calling synestia, where a celestial body violently collides with another body, resulting in a doughnut-shaped disk of vaporised rock. After some time, the body will cool down and turn into the solid, round planets we currently know.



A to scale illustration of the synestia process. Simon Lock, Harvard University

Sarah Stewart, a planetary scientist at the University of California Davis, and Simon Lock, a graduate student at Harvard University in Cambridge, co-authored the study The name synestia combines the prefix 'syn-' meaning 'together' and Estia, the Greek goddess of architecture and structures. The idea was modelled after ice skaters doing a spin - when they put their arms out to the side they slow down but when they tuck their arms in, their momentum stays constant.

The team was interested in how that idea would apply to rapidly spinning planets colliding with each other and how it would impact the angular momentum. The people doing the study believe the collision that formed Earth likely caused a synestia before it cooled back down and formed into the solid, round object it is today. The researchers said those days probably did not last more than 100 years, tough. On top of a theory for planets how planets have formed, the study also lends to the idea of the formation of the Moon since its composition is similar to that of Earth's. By: Nicole Kiefert

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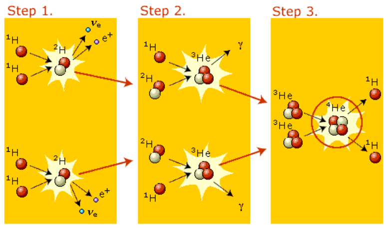
DID YOU KNOW?

The Sun Part 15: **Sun – energy production 2**

Fred Hoyle



Proton-proton chain reaction

Hans Bethe

A decade after Gamow's work, in 1938, Hans Bethe, a German-American physicist, published an analysis of different possibilities for reactions by which hydrogen is fused into helium. In it, he described the first of two processes proposed to be the source of energy in stars. What he and his colleague Charles Critchfield derived was the proton-proton chain reaction, the dominant energy source in stars with low masses up to about a solar mass. A year later, he independently developed the carbon-nitrogen-oxygen (CNO) cycle, positing that, in larger, hotter stars, this was the means by which hydrogen was converted to helium, with the associated release of large amounts of energy. These two nuclear reaction routes were, at first, speculative, but other physicists checked the equations and confirmed that they were viable. Bethe was awarded the Nobel prize for physics in 1967 for his work on stellar nucleosynthesis.

Bethe did not address creation of heavier nuclei. The original work on this was undertaken by the English astrophysicist Fred Hoyle. In 1946, he argued that a collection of very hot nuclei would assemble into iron. He explained the production of all heavier elements, starting from hydrogen in 1954, describing how advanced fusion stages within stars would synthesise elements between carbon and iron in mass. As part of his work, he proposed that hydrogen is continuously created in the Universe from vacuum and energy without need for a universal beginning. Hoyle derided the Big Bang theory and Big Bang nucleosynthesis, not realising that Lemaitre's Big Bang model was needed to explain the existence of deuterium and neuclides between helium and carbon, as well as the fundamentally high amount of helium present both in stars and the interstellar medium.

The first proof that nucleosynthesis occurs in stars was observations that interstellar gas has become enriched with heavy elements as time has passed. Stars born later in the Milky Way formed with much higher initial heavy element abundances than those which formed earlier. It was the 1952 detection by spectroscopy of the element technetium in the atmosphere of a red giant star which provided first direct evidence of nuclear activity within stars. Because technetium is radioactive, with a half life much less than the age of the star, its abundance must reflect its recent creation within the star.

In 1957, a review paper by Eleanor and Ronald Burbridge, William Fowler and Hoyle (B2FH) collected and refined earlier research into processes for transformation of one heavy nucleus into others within stars. It gave promise of accounting for the observed relative abundances of the elements, but did not enlarge on Hoyle's 1954 picture for the origin of primary nuclei as much as was often assumed, except in the understanding of nucleosynthesis of those elements heavier than iron. Empiric evidence for the processes described by Bethe and Hoyle could be, and was, documented by astronomers. During the 1960s, Fowler, Alastair Cameron and Donald Clayton expanded Hoyle's explanations, followed by many others.

Processes The prime energy producer in the Sun is fusion of hydrogen to form helium in the core at temperatures around 14 million K. Later in the stars life, fusion reactions will also move into the shells surrounding the core. The initial reaction involved in the chain reactions involved in nuclear fusion is hydrogen burning. It occurs via the proton-proton (p-p) chain or the CNO cycle. Processes following hydrogen burning are helium burning (via the triple-alpha process), carbon burning, neon burning, oxygen burning and silicon burning. These processes are able to create elements up to and including iron and nickel.

In smaller stars with core temperatures under 18 million K, the p-p chain reaction dominates. Essentially, the process involves fusion of four hydrogen protons into a helium-4 nucleus. This occurs through a sequence of chain reactions that begins with fusion of two hydrogen atom (protons) to form a nucleus of deuterium. Isotopes of lithium, beryllium and boron are also produced during the intermediate stages.

The subsequent process of deuterium burning consumes any pre-existing deuterium found at the core. Energy is released at different stages of the p-p chain process. The process is relatively insensitive to temperature, so the hydrogen burning process can occur in up to a third of the stars radius and occupy half its mass.

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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