"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

APRIL 2019

Monthly meeting This month's meeting will take place on **Monday 15 April** at the **Catholic Church Hall** starting at **19.00.** The presenter is Dr Shazrene Mohamed from the UCT and the SAAO in Cape Town. The title of her presentation is 'Another one bites the dust' Prof Patricia Whitelock, a fellow astronomer at SAAO, has stated the following about Shazrene: "She is a gifted scientist and a brilliant communicator who delights in making her work accessible to colleagues, students and the public. She is particularly good with smart young people and is a fantastic mentor." See below for details.

Important notice **2018 membership renewal window closed**
If you have not already renewed your membership, from this month, your details will be removed from the Centre's membership list. The implications of this are that you will no longer receive the monthly sky maps or Southern Cross newsletter, no longer be eligible to join Centre trips, and, if you wish to attend monthly or interest group meetings, on each occasion, you will have to pay the R25 visitor's fee. All is not lost, however. You are welcome to rejoin the Centre at any time by contacting Laura Norris, the Treasurer, at meetings, on 028 3164453 or at dunorris@whalemail.co.za

WHAT'S UP?

Diamond cross This asterism can be found towards the south, between the Southern Cross and the False cross (to the left of Canopus). It is formed by four of the stars in the constellation Carinae (the keel of the older composite constellation Argo Navis, named for the Greek mythological ship in which Jason and the Argonauts sailed).. The four bright stars form an almost perfect diamond shape which is visible south of 20°N latitude. It is an interesting formation to located in its own right, but is also a useful guide to locating Carina's two most impressive objects. Just beyond the apex of the long axis of the diamond cross tilted towards the southern Cross, is the Southern Pleiades (IC 2602). This open cluster includes several stars visible to the naked eye, but it is best viewed through binoculars. Its features have similarities to those of the northern Pleiades found in Taurus, hence its name.. A little further away in the same direction is the Eta Carina nebula (NGC 3372). This bright, diffuse patch of glowing gas is divided into two parts by a dark V-shaped lane. Best viewed with binoculars or a telescope, the nebula contains numerous stars and clusters. These include both the Homunculus and Keyhole nebulae and the variable star Eta Carinae.

LAST MONTH'S ACTIVITIES

Monthly centre meeting This took place on 18 March. The presenter was Case Rijsdijk, President of the ASSA. Before he started his fascinating talk on 'the New Horizons mission', he gave a low-tech, but very helpful practical demonstration on how the Higgs boson confers mass onto different particles.

Case's main message about the very successful ongoing New Horizon's mission was how much has been achieved using 2006 technology. In addition, the mission was not to a nearby object, like Mars, but to reach, study and travel beyond an object about half the size of Mercury, almost 6 billion km away from Earth. It took over 6 hours for a communication to reach the spacecraft and another 6 hours to receive the reply. A plutonium reactor was installed as solar power as an energy source was impossible at that distance from the Sun. When the spacecraft flew past Pluto it was travelling at around 14 km/second. This means that the cameras which took the detailed images we now have of Pluto had to be able to pan effectively, at great speeds. The pixel capacity of the cameras was also much lower than would be used if the mission was being launched today. This achievement itself showed great forethought and planning with limited technology. The images have enabled scientists to identity that Pluto is a rocky body, with an atmosphere, and an intriguing surface.

The amazing achievements relating to Pluto and its five moons proved to be only part of what the mission has achieved. Case outlined how the location of the tiny rock labelled MU69 (now named Ultima Thule) was confirmed form Earth. This involved the Hubble telescope and several attempts to observe occultations (the passing of one astronomical object in front of another) from a number of locations on Earth, including South Africa. The resulting data enabled scientists to confirm that New Horizons would be able to fly past it closely enough to obtain clear images of a tiny object 6.6 billion km away from Earth. Case's enthralling talk made the audience realise that any tendency to regard space missions, particularly those like New Horizons, as almost routine as a grave mistake. They are great achievements of human intelligence and ingenuity which push the limits of current technology.

Interest groups

Cosmology At the meeting on 11 March, Pierre Hugo presented the seventh part in the current series on 'Natural philosophy: science for non-scientists'. The topic was 'Fabric of space - inertia'.

Astro-photography No meeting was held in March.

Other activities

Educational outreach

Hawston Secondary School Space Cadets Weekly meetings stopped for exams towards the end of March. They will resume in April.

Lukhanyo Youth Club Work continues on the construction of analemmatic sundials here and other schools in the Overstrand.

Stargazing Excellent viewing awaited the 8 members and 8 members of the public who attended the public event on 1 March. Objects observed included Omega Centauri, the Jewel Box and the Orion nebula. Two events also took place in February for Creation Wine staff. The first took place at the farm on the 20th and the other on the 27th, at the open area behind Dutchies restaurant. The weather was better on the 27th, but both events were enjoyed by those who attended.

THIS MONTH'S ACTIVITIES

Monthly centre meeting

This month's meeting, will take place on **Monday 15 April** at the **Catholic Hall** starting **19.00**. The presenter, Dr Shazrene Mohamed is an adjunct senior lecturer, a joint SAAO/UCT position. Shazrene is a computational astrophysicist working at the SAAO. She completed her undergraduate studies in Astronomy, Astrophysics and Mathematics at Harvard University and, on a Rhodes Scholarship, obtained her PhD in Astrophysics from Oxford University. After two years as an Argelander Fellow in Bonn, Germany, she moved to Cape Town where she is currently an NRF Research Career Advancement (RCA) fellow. She is a Rhodes Scholar, a NRF P-rated researcher and recipient of the South African Institute of Physics (SAIP) Silver Jubilee Medal. She serves on the International Astronomical Union (IAU) South African National Committee and is an Associate Member of the National Institute for Theoretical Physics (NITheP).

Her research interests in computational astrophysics include modelling outflows from single and binary stars, and dust formation in stellar winds. Her research primarily focuses on supercomputer simulations of evolved binary stars to investigate how they interact with their surroundings and with each other, particularly, how mass is transferred from one star to another. These systems are important as they are thought to be the progenitors of novae and supernovae explosions.

Shazrene's presentation is titled 'Another one bites the dust'. The following summary was given by the Cape Centre prior to her giving this talk in 2018: 'What is stardust and where does it come from? In this talk, Dr. Mohamed will present our current understanding of one of the most important components of our Universe. Some of the recent discoveries about stardust, also some outstanding mysteries and puzzles will be highlighted. Come along to hear how you could capture your very own particles from space.'

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. The next meeting is on **Monday 1 April** at the **Catholic Hall**, starting at **19.00.** Pierre Hugo will lead the eighth session in the series 'Natural philosophy: science for the non-scientist'. This will be the second part of the topic will be "Fabric of space - inertia '.

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

Astro-photography This group meets on the second Monday of each month. The next meeting will be on **Monday 8 April.**

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

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

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

Other activities

Stargazing No events are planned for April.

FUTURE TRIPS

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

2018 MONTHLY MEETINGS

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

15 April	'Another one bites the dust'. Presenter. Dr Shazrene Mohamed, UCT/ SAAO, CT
20 May	'The upgraded HESS facility in Namibia'. Presenter, Herbert Pioller, Centre member
24 June	'Star formation and the gas cycle in galaxies'. Presenter: Dr Moses Mogotsi, SAAO., CT
15 July	'Near-Earth asteroids: monitoring close approaches and mitigating objects'. Presenter: Dr Nicolaus Ersamus, SAAO, CT
19 August	'More unusual curvaceous geographical wonders of Earth'. Presenter: Jenny Morris, Centre member
16 September	Topic TBA. Presenter: Pierre de Villiers, Centre chairman
21 October	TBA
18 November	'The Cassini family dynasty and their Saturnian legacy'. Presenter: Jenny Morris, centre member
9 December	Xmas party

ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

Work continues on planning and administrative requirements for work to begin on the proposed Astronomy Self-guided Education Centre, to be located within the existing whale-watching area at Gearing's Point.

The **Friends of the Observatory campaign** was launched several years ago when preliminary work began on plans to construct an astronomical observatory in Hermanus. Over the years, members have been very generous, for which we are deeply grateful. It may seem logical to assume that, now money has been awarded by the National Lotteries Board, pledge monies are no longer needed. Unfortunately, that is not the case. NLC funds can only be used once the plans have been formally approved by the Municipality.

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

Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

If you make an online donation, please include the word 'pledge', and your name, unless you wish to remain anonymous.

ASTRONOMY NEWS\

Hubble and Gaia revise the weight of the Milky Way 7 March: Measuring the total mass of our home galaxy is a tough puzzle. It is difficult to see it all at once, buried as we are within one of its spiral arms. Also, there is a huge portion of the Milky Way we can never see, since it is made up of dark matter, which does not emit light at all. So, to get

an accurate number, researchers need to weigh both the visible and invisible material that makes up the galaxy. Now scientists have done just that, using new data from the Hubble Space Telescope combined with the Gaia spacecraft. This latest mass measurement of the Milky Way weighs in at 1.5 trillion times heavier than our Sun.


The Milky Way is surrounded by globular clusters, dense groups of stars that appear as yellow dots in this illustration. ESA/Hubble, NASA, L. Calçada

Gravity dictates that the more massive an object is, the faster its satellites will orbit around it. So, the new data from the two spacecraft looked at our galaxy's brightest satellites: globular clusters. These are dense groups of stars that orbit in the halo, or outer portion of a galaxy. Most large galaxies have such hangers-on, and the Milky Way is no exception. Many spacecraft can spot these globular clusters, and they are even popular targets for backyard astronomers. However, to accurately judge their motions in three dimensions takes high precision and careful analysis. Gaia and Hubble are both up to such work. Gaia specialises in the very precise measurements of objects across the Milky Way, and returned measurements of 34 clusters out to 65,000 light-years. Hubble can see farther at higher resolution, but has a smaller field of view than Gaia. It found 12 clusters out to 130,000 light-years. Together, the spacecraft made a comprehensive map that let astronomers estimate the Milky Way's mass out to 1 million light-years.

Earlier findings ranged from only 500 million times our Sun's mass up to 3 trillion times. The new finding of 1.5 trillion solar masses puts the Milky Way among the universe's larger galaxies. It also has a normal amount of dark matter, given the number of stars that astronomers measure. Understanding the total mass of our galaxy, and how its stars' mass stack up against its dark matter, can help astronomers answer important cosmological questions about how galaxies like ours evolve. By: Korey Haynes

This speeding star is escaping our galaxy - and it is not like the others 13 March: The Milky Way Galaxy contains billions of stars. Though the vast majority of these are bound to the galaxy by gravity, astronomers have found a few tens of stars that are not orbiting but instead fleeing our galaxy at extreme speeds. These hypervelocity stars have intrigued researchers for years, and now a new mysterious player has entered the game. LAMOST-HVS, the closest of these fast-moving stars to our Sun, has an origin story markedly different from the way we believed these stars are kicked out of the Milky Way.

In a study led by researchers from the University of Michigan, astronomers used data from the Magellan telescope in Chile and the European Space Agency's Gaia satellite to wind back the clock and trace the trajectory of LAMOST-HVS, an 8.3-solar-mass star zipping away from the galaxy at more than 568 kilometres per second. LAMOST-HVS is the closest hypervelocity star to the Sun, and researchers estimate it was sent on its way by an event that occurred 33 million years ago. However, that event, it seems, was different from the single origin astronomers have developed for how hypervelocity stars are ejected from the galaxy, suggesting there may be more than one way to kick a star out of the Milky Way.

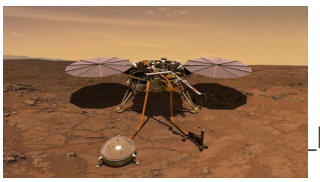
Gravity is a force that pulls things together. However, it can also, under the right circumstances, boost them to high speeds, sending them sailing away instead via a slingshot effect. The traditional picture of how hypervelocity stars are made begins with a binary star system. If that system passes too close to the supermassive black hole in the Milky Way's centre, which contains 4 million solar masses, the immense gravity can tear the binary apart. One star is nabbed by the black hole, while the other is shot out at incredible speeds. It takes a massive black hole to accomplish this, which is why astronomers believed the Milky Way's central black hole was the only explanation.

After tracing LAMOST-HVS's motion back through time, the researchers discovered that its journey began in the Milky Way's disk, not anywhere near the central bulge where the supermassive black hole is located. That rules out the supermassive black hole as the object responsible for its boost… so what else could it be? Because high gravity is needed to kick a star out at such high speeds, a stellar-mass black hole left over from a supernova or a few encounters with even reasonably massive stars just won't do it. But, the authors suggest, a massive star cluster that houses several very massive stars of at least 30 solar masses each could generate enough kick if LAMOST-HVS swung too close to them. Alternatively - and even more exotic - an encounter with an intermediate-mass black hole with about 100 solar masses would also do the trick.

Intermediate-mass black holes have been theorised for years and while some observational evidence points to their existence, they have yet to be unequivocally confirmed. They are believed, however, to form in massive star clusters such as the one that ejected LAMOST-HVS, so the idea that one may be responsible for the star's current state is not impossible.

The crux of this discovery comes back to LAMOST-HVS's point of origin, which the team traced back to a position in the Milky Way's Norma spiral arm. However, there is no massive star cluster known at that location. This does not entirely throw a wrench in their results, however - such a cluster could easily be hidden from view by dust in the Milky Way between Earth and the Norma arm, making it difficult to observe. If the cluster can be found, the team says, it may provide additional evidence to prove the existence of intermediate-mass black holes. Additionally, if a massive cluster is to blame, it would reveal further clues about how such clusters influence the environments of the galaxies in which they reside. By: Alison Klesman

The Mars InSight lander is stuck. NASA's hacking a fix with Earthly clones 15 March: Last month, NASA's Mars InSight lander started digging into the Red Planet. Its HP3 (Heat Flow and Physical Properties Package) instrument was designed to burrow and measure Mars from underground, uncovering new geological evidence about how heat flows through the martian soil. The part of this instrument that actually burrows into the ground is known as the mole. It was meant to penetrate up to 4.8m. However, it stopped just hours after it starting digging. The mole only made it about 30cm deep.



_NASA's Mars InSight lander for launch to the Red Planet. NASA

Since then, mission scientists have been hard at work trying to figure out how to get it going again. Their current best guess, according to Tilman Spohn, the HP3 instrument's principal investigator, is that the mole hit a rock or a gravel layer. He admits that is partly speculation. It is also possible the drill is snagged on its own support structure somehow. The team needs to investigate all the possibilities before acting. To find out, the NASA team has turned to a suite of diagnostic tools, like InSight's camera and other sensors. They are also trying to recreate the problem with engineering models here on Earth. InSight has a twin, currently located in Berlin, and many more copies of its various instruments, including the mole. And engineers have been practising with these clone landers ever since the failure, trying to recreate the problem they're seeing on Mars, and then devise a way to get the earthbound moles digging again. Only then will they try those fixes them on the real InSight.

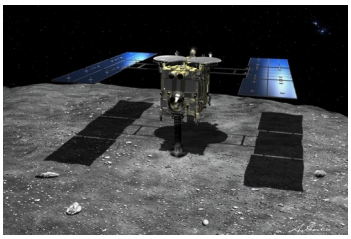
Spohn points out that the whole process is slow, and it may be another month before the team is ready to try any fix-it attempts on Mars. Even once they devise a solution, it may require writing new software, testing it on the models on Earth, and then sending it to the real InSight before any action happens. So, for the moment, the teams at both the German Aerospace Center, which provided the HP3 instrument, and at NASA's Jet Propulsion Laboratory, which runs the larger InSight mission, are working together to find both the cause and possible solutions to InSight's digging problem. By: Korey Haynes

There are scenarios that may stop the mission where it stands. "If it's a 1 metre block of rock at the spot," Spohn says, "There's no way we can handle that situation. The hope is that what we're hammering against is a small rock, say half the size of the mole's length. We could push that aside by continuing to hammer." Spohn calls this the "brute force" approach. One way scientists are considering to help the mole hammer down would be to press down on the mole or its support structure, probably with InSight's arm, to lend it more force and limit any recoil. Right now, part of the problem might be that the mole is bouncing off the rock instead of driving through, so adding more pressure could help it dig down. However, pushing down is not what the arm was designed for, which is why testing with the models on Earth would be so important before they try them on the $800 million craft on Mars.

If they keep hammering and bend or break part of the lander, there are no fixes on the Red Planet. "If you make a mistake, it's gone," Spohn says. However, he also points out that if the mole starts to dig freely again, it could reach its target depth within about four hours, and it has plenty of energy left to do so. InSight itself runs on solar power, and was designed for two Earth years of duty. InSight only arrived on Mars in November, so it has lots of time left. If the worst case arises and the mole can't continue, Spohn admits, "We would lose a significant amount of science." The mole needs to descend at least 3 metres to accomplish its goal of measuring heat flow from Mars' interior. "But there are still things to be done," he says. InSight's other instruments are working as planned, and they would still get information from the foot of Mars dirt that InSight has been able to dig through. "It would still be stuff that hasn't been done before," Spohn says. "Not as bold as originally planned, but still good science." By: Korey Haynes

Hayabusa2 results hint asteroid Ryugu was broken off larger space rock 19 March: The Japanese Space Agency's (JAXA) Hayabusa2 spacecraft swooped down and collected a first sample from the asteroid Ryugu on 22 February. Now JAXA is ready to make an even more dramatic sample collection in April when it uses explosives to shoot an

impactor at the space rock to create an artificial crater. Hayabusa2 will not leave Ryugu until the end of 2019, and it is expected to make it home to Earth with the samples at the end of 2020. In the meantime, scientists are learning plenty from Hayabusa2's other explorations, which have already started to yield results, mission scientists announced Tuesday. That includes new evidence that Ryugu's was once part of a much larger asteroid.


Artist's impression of Hayabusa2 collecting material on Ryugu

Hayabusa2's cameras and instruments are constantly sending back information about Ryugu. Scientists knew before arriving that it was a stony, carbonaceous chondrite asteroid. However, orbiting closely around Ryugu has taught them much more. For one, Ryugu is much more rugged than scientists expected, something which pushed back their first touchdown manoeuvre. Instead of collecting their first sample in October, they stayed in orbit, trying to find a spot to touch down that was free of large boulders that might harm the spacecraft. While scientists eventually found a spot, the landing area was much smaller than they had originally hoped, meaning they had to be much more careful about touchdown. The February collection went smoothly, and the team is now confident in their ability to navigate around Ryugu.

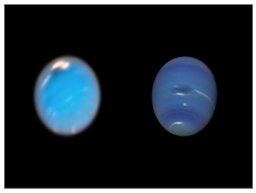
Scientists also found that Ryugu is darker than most asteroids of its type, reflecting less than 2% of the sunlight it receives. When they compare it to meteorite samples in labs, scientists found it looks like materials that have undergone 'thermal metamorphosis' – in other words, they have been changed by exposure to heat. Seconding this theory, Ryugu also shows signs of being covered in hydroxyl, a material made up of hydrogen and oxygen. Seeing this is a good indication that Ryugu once contained water that has since been baked away, leaving behind only some of the components.

Seiji Sugita said all the evidence points to Ryugu being a fragment of a larger, older asteroid parent body. The complex history of its surface does not make sense for a body as small as it is, and the size itself points toward its origin – Sugita says it could not have survived 4.6 billion years of solar system history on its own. In short, Ryugu's parent would have had water on it, which was later baked away. Then, some impact broke off fragments and sent Ryugu off on its own, sometime in the last few hundred million years. He says that when the samples Hayabusa2 collected are returned to Earth, they may be able to date that collision and point to a specific parent asteroid body.

Hayabusa2's next big manoeuvre will be delivering an impactor to Ryugu's surface on 5 April 5. Instead of the small bullet it used to collect its first sample, this will be a 4.5-pound impactor that the spacecraft will send crashing into Ryugu's surface to stir up material from well underneath the surface. The spacecraft will descend about two weeks later into what researchers expect will be a 9m crater in order to investigate and collect more samples that will tell researchers about the asteroid's still-mysterious interior.

By: Korey Haynes

Hubble catches Neptune forming new, massive storms 25 March: Neptune has a new storm, in the form of a large dark spot that appeared in late 2018. By analysing Hubble images dating back to 2015, astronomers have discovered high-altitude clouds that formed years ahead of the visible storm, indicating it was already forming there, swirling beneath the clouds and haze. The telltale clouds are teaching astronomers more about how such storms form and evolve on all the giant outer planets.


Neptune's dark storms were first captured by Voyager 2 in 1989 (right). NASA/ESA/GSFC/JPL

Neptune, like all the outer solar system planets, forms large and durable storms. While Jupiter's Great Red Spot is infamous, Neptune's dark blue spots were unknown until Voyager 2 flew past in 1989, sending back pictures of two large storms on its surface. Jupiter's Great Red Spot has been visible for at least 190 years, and possibly since the 1600s. When Hubble peered at Neptune in 1994, its storms had already vanished.

Since then, Hubble has spotted dark storms appearing and disappearing on Neptune, lasting only two years or so – though maybe up to six years – before dissipating again. Like hurricanes on steroids, Neptune's storms are dark vortexes of clouds racing at high speeds, each roughly the size of planet Earth. However, Earth storms rarely last more than a few weeks, and form around low-pressure areas. On the giant planets, they instead form around regions of high-pressure. "That makes them more stable to start," says Amy Simon of NASA's Goddard Space Flight Centre. "And there are no land masses. That's what breaks storms up on Earth." On Jupiter, the planet's jet streams lock its massive storm in place near the equator, where it has safely churned for centuries. On Neptune, wind patterns push the storms north or south where they get shredded by opposing wind currents within a few years."

Hubble also often sees white methane clouds floating at the top of Neptune's atmosphere. These are pushed aloft by the high-pressure storm systems, says Simon, but, she adds, "Sometimes we see high clouds that don't have a dark spot associated." So while astronomers cannot predict for sure where a storm will form, they can look back and trace its history, even before the dark spot itself became visible. This became obvious when Simon and her colleagues were looking at images of Neptune's clouds from 2015 through 2017, and realised that they hovered just where the dark storm eventually appeared in late 2018. This tells astronomers that the storms form over long periods of time, deeper down in the atmosphere than Hubble can spy.

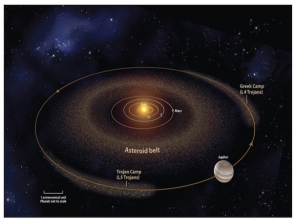
By having new evidence of the storms to observe, Simon and her colleagues hope they can better understand how storms form on all the major planets. "The computer models have a hard time forming these storms," Simon says. And with no dedicated missions to the ice giants yet, (Voyager 2's flyby was the closest approach to either Neptune or Uranus), computer models are vital to understanding the stormy worlds. By: Korey Haynes

Trojan asteroids reveal Jupiter's great migration 27 March: If thereis one thing we know from the slew of exoplanets detected over the past few decades, it is that giant

planets are not afraid to cozy up to their stars. However, because the region near an active young star is not the ideal place to build large planets, astronomers tend to think oversized exoplanets first form far from their host stars before migrating inward as they age. Now, new research suggests the biggest planet in our solar system, Jupiter, likely underwent its own great migration early in its life, and it turns out it was quite the trip.

According to the study, although Jupiter now sits an average distance of 5.2 astronomical units from the Sun (1 AU is the average Earth-Sun distance), the core of the gas giant likely formed some 18 AU away. That is about twice as far as present-day Saturn is from the Sun. Furthermore, Jupiter apparently made the entire journey in less than about a million years, which is just a blink of the eye in astronomical terms. Although the idea of a wandering Jupiter is not new, "This is the first time we have proof that Jupiter was formed a long way from the Sun and then migrated to its current orbit," said lead author Simona Pirani, a doctoral student at Lund University. "We found evidence of the migration in the Trojan asteroids orbiting close to Jupiter."

Jupiter's Trojan asteroids are a mysterious bunch of objects. Sharing an orbit with the giant planet, these dark and reddish bodies are divided into two main groups: the 'Greek Camp', which leads Jupiter, and the 'Trojan Camp', which trails behind.



Jupiter's 'Greek Camp' of asteroids hang out ahead of the planet at L4, while Jupiter's 'Trojan Camp' trails behind at L5. Astronomy: Roen Kelly after NASA/WMAP Science Team; Jupiter above: NASA/ESA/A. Simon (GSFC)

Though the Minor Planet Centre database currently lists 7,190 known Jupiter Trojans, they are not divided equally between the two camps. Instead, the leading Greek Camp has anywhere between 40 and 100 percent more asteroids than the trailing Trojan Camp (the imbalance is more pronounced for smaller asteroids). "The asymmetry has always been a mystery in the solar system," said Anders Johansen, a professor of astronomy at Lund University.

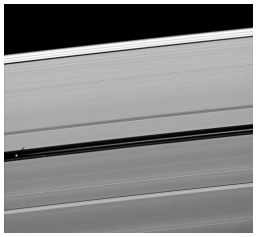
In order to investigate why Jupiter has more Trojans in its vanguard than at its flank, the researchers ran advanced computer simulations that marched the early solar system through millions of years of evolution by 50-day increments. Based on numerous simulations, the researchers say the inward migration of the giant planets always resulted in a larger swarm of Trojans in front of Jupiter instead of behind it. This is due to the fact that as Jupiter travels inward, it creates a wider zone of gravitational stability ahead of the planet, leading to a surplus of Greek Camp asteroids. Other evolutionary models that rely on Jupiter forming in its current position, however, result in equal numbers of Trojans in both camps.

Additionally, the study shows that Jupiter's great migration occurred pretty quickly in cosmic terms. Within just a few million years of Jupiter beginning as a small, icy asteroid, the planet grew large enough to capture the majority of its Trojans. Then, over the next roughly 700,000 years, Jupiter and its tag-along Trojans made their push closer to the

Sun, propelled by gravitational interactions between the fledgling gas giant and the young Sun's protoplanetary disk.

The Trojans aren't just interesting because they drifted inward with Jupiter. According to the paper, "In our scenario explored here, the Jupiter Trojans are a primordial population in which Jupiter's core formed. Therefore, they hold precious information about the building blocks of our giant planets' cores." This means, Johansen said, "We can learn a lot about Jupiter's core and formation from studying the Trojans." That is exactly what NASA's Lucy mission, scheduled to launch in 2021, plans to do. Named after a famed 3.2-million-year-old hominin fossil that helped us explore human evolution, Lucy is a Discovery-class robotic spacecraft that aims to shed light on how our solar system came to be. Over the course of more than a decade, Lucy will venture out to the orbit of Jupiter to explore six different Trojans — targeting asteroids in both the Greek and Trojan camps — along with a main-belt asteroid. By: Jake Parks

Saturn's small moons formed from the dust of its rings 28 March: NASA's Cassini mission to Saturn may have ended in 2017, but researchers are still analysing the vast amount of data it sent back over its final spectacular months. Astronomers most recent findings centre on five of Saturn's small ring moons: Pan, Daphnis, Atlas, Pandora and Epimetheus. During six close flybys near the end of its mission, Cassini uncovered new insights into how the moons formed, and what gives them their different colours. Astronomers say they now have strong evidence that these tiny moons formed from the dust of Saturn's rings. That is interesting because the rings themselves likely formed from shredded moons.


Pan, one of the moons seen during Cassini's close flybys, orbits in the Encke gap of Saturn's rings. NASA/JPL/Space Science Institute

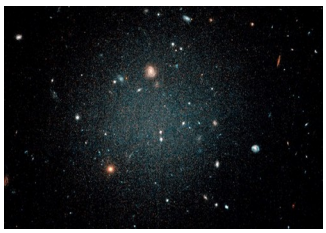
Saturn has more than 60 moons, including giants like Titan and Enceladus, whole worlds with complex geologies and atmospheres. However, embedded in its rings are smaller, rocky bodies that are just as mysterious in their own ways. One of the persistent questions is whether the rings themselves are the shattered remnants of past moons. Perhaps instead, these small moons could be built up from the material in the rings.

Cassini's new evidence hints that the ring moons it studied have low densities, meaning they likely formed from gently colliding ring material, which is now loosely stuck together. Since coming together, the moons have suffered complex histories. Small as they are, these ring moons show grooves and cracks from tidal stresses. They are caught between Saturn's massive tug and the smaller but more complicated gravitational pull from many larger moons. All this pulling means they're being heated and pulled apart by the forces surrounding them.

Cassini also observed the moons' colours. Some of them are reddish, while others are tinged more blue. The moons location in orbit seems to determine their colour. Moons circling in the main ring pick up a red colour from material there. For other moons,

Saturn's fuzzy and diffuse E-ring contributes water ice or vapour, giving them a bluish tint. Pan, orbiting in the Encke gap between Saturn's rings, is the reddest in colour. Epimetheus, on the outer edge of the main ring and closer to the E-ring, is the bluest of the moons studied. By: Korey Haynes

Second ghostly galaxy without dark matter discovered, first confirmed 29 March: A year ago, astronomers were flabbergasted when they discovered a galaxy almost entirely devoid of dark matter. As the first galaxy ever found lacking the elusive substance - which is thought to account for 85% of the universe's mass - the news rippled through the astronomical community. This left some researchers delightfully intrigued, and others understandably sceptical. "If there's [only] one object, you always have a little voice in the back of your mind saying, 'but what if you're wrong?'" astronomer Pieter van Dokkum of Yale University, who led last year's ground-breakling study, said "Even though we did all the checks we could think of, we were worried that nature had thrown us for a loop and had conspired to make something look really special whereas it was really something more mundane." Now, a new study shows van Dokkum and his team had it right all along.


NGC1052-DF2 is a large, but very diffuse galaxy located some 60 million light-years away. NASA/ESA/P. van Dokkum (Yale University)

Researchers state they have confirmed a ghostly galaxy located some 60 million light-years away named NGC 1052-DF2 (DF2 for short) has virtually no discernible dark matter. Furthermore, a second recent study found yet another dim and diffuse galaxy with a dearth of dark matter, nicknamed DF4. Taken together, the new findings show DF2 is not alone, but instead part of a larger and previously unknown population of galaxies that have seemingly freed themselves from the bonds of dark matter. This new research may have dramatic implications for prevailing theories about the formation and evolution of galaxies, as well as the true nature of dark matter itself. "The fact that we're seeing something that's just completely new is what's so fascinating," said Shany Danieli, a graduate student at Yale University. "No one knew that such galaxies existed, and the best thing in the world for an astronomy student is to discover an object - whether it's a planet, a star, or a galaxy - that no one knew about or even thought about."

The strange galaxy DF2 is a member of a relatively new class of galaxies called ultra-diffuse galaxies (UDGs). Though UDGs can grow as large as the Milky Way in size, these faint spectres contain hundreds to thousands of times fewer stars. This means you can basically see right through them, which makes UDGs very difficult to observe in detail. DF2 is a hazy galaxy that is part of a larger group dominated by the massive elliptical galaxy NGC 1052. Initially, the researchers were drawn to the innocuous galaxy because it did not appear the same in images captured by the Dragonfly Telephoto Array and those obtained by the Sloan Digital Sky Survey (SDSS). Dragonfly saw DF2 as a blob of dim light, while SDSS saw a group of point-like sources.

Upon closer examination using Hubble's Advanced Camera for Surveys and the 10-meter Keck Observatory, the researchers determined DF2 is a transparent UDG that rivals the

Milky Way in size but contains roughly 200 times fewer stars. "I spent an hour just staring at the Hubble image," van Dokkum said last year. "It's so rare, particularly these days after so many years of Hubble, that you get an image of something and you say, 'I've never seen that before.' This thing is astonishing: a gigantic blob that you can look through. It's so sparse that you see all of the galaxies behind it."

With the new views of DF2, van Dokkum and his team identified 10 globular clusters (large groups of old stars) inside the galaxy and found they are moving three times slower than expected. This suggests that DF2 only contains, at most, a miniscule amount of dark matter. After all, if it had more mass than what's visible, the clusters would orbit much faster. Because one of the major tenets of good science is reproducibility, van Dokkum and his team have spent the past year using the Keck Cosmic Web Imager (KCWI) to improve the precision of their previous measurements. "KCWI is unique because of the combination of its large survey area," said Danieli. "The instrument not only allows us to see the whole galaxy at once, its high spectral resolution also enables us to measure the mass accurately. There is no other instrument in the world that has those two properties." Armed with even more precise measurements for the speeds of globular clusters inside DF2, the researchers again calculated the galaxy's mass. As before, their results show the amount of dark matter in DF2 is basically nil.

While working to confirm DF2 is truly a galaxy deficient in dark matter, the researchers simultaneously searched for a second example of a galaxy made exclusively out of normal matter. They found it in DF4. "Discovering a second galaxy with very little to no dark matter is just as exciting as the initial discovery of DF2," said van Dokkum, lead author of the DF4 paper. "This means the chances of finding more of these galaxies are now higher than we previously thought. Since we have no good ideas for how these galaxies were formed, I hope these discoveries will encourage more scientists to work on this puzzle."

According to the study, DF2 and DF4 are very similar in terms of size, surface brightness, morphology, and distance. Because of this, the paper says, "We conclude that NGC 1052-DF2 is not an isolated case but that a class of such objects exists. The origin of these large, faint galaxies with an excess of luminous globular clusters and an apparent lack of dark matter is, at present, not understood With a sample size of just two galaxies, itis hard to draw any sweeping conclusions just yet. However, by showing that some galaxies contain no appreciable dark matter, the team has surprisingly provided strong evidence for the existence of dark matter.

Because the effects of dark matter are evident in every other known galaxy except DF2 and DF4, the team's findings indicate dark matter must be a tangible substance that is separable from normal matter. This means that some alternative theories to dark matter, such as Modified Newtonian Dybamics (MOND) - which introduces extra gravitational forces on galactic scales - fall flat. "We hope to next find out how common these galaxies are and whether they exist in other areas of the universe," said Danieli. "We want to find more evidence that will help us understand how the properties of these galaxies work with our current theories. Our hope is that this will take us one step further in understanding one of the biggest mysteries in our universe - the nature of dark matter." By: Jake Parks

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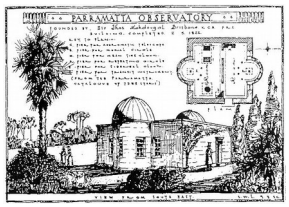
DID YOU KNOW

Astronomical catalogues Part 6 James Dunlop's catalogues – first based on observations in Australia


James Dunlop



Paramatta Observatory


Centaurus A

In the early 19th century, another astronomer added further to the work done by Nicolas-Louis de Lacaille seventy years earlier. The observations took place in the new colony of Australia within only four decades of its European settlement. The Scottish-born astronomer James Dunlop (1793 – 1848) developed an interest in astronomy early in life, constructing his own telescopes in his late teens. His direction in life was decided by a chance meeting with another keen amateur astronomer, Sir Thomas Brisbane. When Brisbane was appointed Governor General of New South Wales in 1820, he saw the opportunity to develop astronomy in sunnier climes and employed Dunlop to work in the observatory he planned to build.

Within months of their arrival in 1821, Brisbane began construction of his observatory, in Paramatta, about 23 km west of the nascent town of Sydney. Although Dunlop had little experience of systematic observation and lacked the necessary mathematical skills to do astrometric calculations and reductions, he learned the former quickly and became a prodigious observer. From 1823 – 1826, Dunlop made over 40,000 observations. Although he later catalogued 7,385 single stars, his main achievements were the discovery of double stars and other deep sky objects

Back in Scotland, in 1828, he published his first catalogue, *A catalogue of nebulae and clusters of stars in the Southern Hemisphere observed from New South Wales.* It contained 629 objects. A year later, he published another, more specialised catalogue, of 256 southern double stars in Approximate *places of double stars in the Southern Hemisphere, observed at Paramatta in New South Wales.*

John Herschel praised Dunlop's achievements in Australia during a medal ceremony in London in 1828. However, in 1834, during his time in the Cape, when he and the Royal Astronomer at the Cape, Thomas Maclear, were able to utilise his tables, Herschel found that only about half of Dunlop's recorded observations were correct. Of the others, the details on many were inaccurate, possibly reflecting Dunlop's limited mathematical abilities. Others could not be found by Herschel and Maclearat all. These were mostly small, nebulous objects which were probably artificially created by the limitations of the handmade telescope Dunlop had built himself.

Despite these limitations, Dunlop did find many southern open and globular clusters, and bright and planetary nebulae, most previously unknown. His most famous discovery was probably the radio galaxy Centaurus A. Although Herschel had also had some difficulty identifying some of Dunlop's double stars, he did confirm the others, becoming the first to designate Dunlop's double stars with the Greek letter Λ eg Λ5, Λ124. Modern double star observers have discarded this designation, preferring to use the observer abbreviation 'DUN' eg DUN 5, DUN 124.

Overall, Dunlop's work and catalogues did not exhibit the precise mathematical accuracy which de Lacaille's did. However, he was only the second astronomer to undertake a full-sky survey of the southern skies, and his catalogues provided an important platform for later southern observers, particularly in relation to double stars and non-stellar deep sky objects.

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

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