"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

MAY 2018

**Monthly meeting**
This month's meeting will place on **Monday 21 May** at the **Catholic Church Hall** starting at **19.00**. Local, celebrated, astronomer Andre van Staden will be talking on 'Recent and ongoing work on pulsar light curves'.

**Stargazing** For your diaries A public event is scheduled for **18 or 19 May**, weather permitting. More details will be circulated closer to the time.

## WHAT'S UP?

**Tarantula nebula** Towards the sought-west, to the slightly lower left of Canopus, the large fuzzy area of the Large Magellanic Cloud (LMC) can be found. Towards its upper edge is the Tarantula Nebula (NGC 2070). Visible to the naked eye, the most notable object in the LMC is even more spectacular through binoculars. Formally part of the constellation Doradus (the dolphinfish), in which the LMC largely lies, this large, bright emission nebula's label is 30 Doradus. It has a diameter of over 800 light years (ly), but some of its extensions extend to 6,000 ly. The nebula is the most massive and largest-known star-forming region in the entire Local Group of galaxies, at least 500 times fore energetic than the Orion nebula (M42). The several clusters of young, blue and white stars it contains, particularity those visible towards its centre have ionised the surrounding gas, creating more than half a million solar masses of ionised particles. The nebula was discovered at the Cape during the early 1750s by Nicolas Louis de Lacaille. It was John Herschel who gave it its descriptive name, reflecting the loops which give it a spider-like shape when he observed it while also staying in the Cape during the 1830s. The loops were formed by a series of supernova explosions, each of which added another shell of expanding ionised matter.

## LAST MONTH'S ACTIVITIES

**Monthly centre meeting** The scheduled speaker at the meeting held on 19 April had to cancel his presentation. Instead, Centre member, Jenny Morris, gave a presentation on 'Unusual curvaceous geographical wonders of Earth'. She included images and summary background information on 16 features located in 14 countries. They included a sinkhole, a lake, volcanoes, rocks and rock formations, and craters of varying origins.

Peter Harvey reports: "A wonderful collection of images took us around our planet, displaying astonishing features of nature. Some weird, some inexplicable and some

delicately artistic. The latter brought to mind the art of Salvador Dali. On behalf of all the attendees, I would like to thank Jenny for a most enlightening and entertaining presentation."

## Interest groups

**Cosmology** Those who attended the meeting on 9 April watched the next two episodes of the new DVD series: The Higgs boson and beyond by Dr Sean Carroll, Research Professor of physics at CalTech. These episodes were Lecture 5 'The Higgs field' and Lecture 6: 'Mass and energy'.

**Astro-photography** There was no meeting in April

## Other activities

**Educational outreach**

**Hawston Secondary School Space Cadets** Meetings with the new group of space cadets continued during April

**Lukhanyo Youth Club** No meeting took place in April.

### THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting, will take place on **Monday 21 May** at the **Catholic Hall** starting at **19.00**. Local, celebrated, astronomer Andre van Staden will be talking on "Recent and ongoing work on pulsar light curves' Details about the speaker and the presentation will be circulated in due course.

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. The next meeting will take place on **7 May** at the **Catholic Hall**, starting at **19.00**. Attendees will watch the next two episodes in the DVD series: The Higgs boson and beyond by Dr Sean Carroll, Research Professor of physics at CalTech. The content will be Lecture 7 'Colliding particles' and Lecture 8: 'Particle accelerators and detectors'.

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 second Monday of each month. There is no meeting in April. The next meeting is on **28 May.** The topic will be image processing.

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

**Stargazing** A public star-gazing event is scheduled for **18 (or 19) May**, weather permitting. Details will be e-mailed to members and advertised closer to the time.

**Hermanus Youth Robotic Telescope Interest Group** Organisers are progressing with work towards enabling learners to take and process images themselves.

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

## FUTURE ACTIVITIES

Members are currently voting on a preferred venue for a trip later this year.

## 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**. Details for the first few months are:

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| 21 May | 'Recent and ongoing work on pulsar light curves' Presenter: Andre van Staden |
| 18 June | 'The story of Hermanus Astronomy Club/Centre' Presenters: Pierre de Villiers and John Saunders, Centre members |
| 16 July | 'History of the Voyager spacecraft' Presenter: Johan Retief, Centre member |
| 20 August | Topcic: astro-photography. Presenter; TBA |
| 17 September | 'Gravitational waves: the new frontier in astronomy' Presenter: Dr David Buckley, SAAO, Cape Town |
| 22 October | 'Our weird and wonderful Universe' Presenter: John Saunders, Centre member |
| 19 November | 'Table Mountains: geology and astronomy' Presenter: Jenny Morris, Centre member |
| 10 December | Xmas party |

## ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

Consideration of the planning application by the Council of Overstrand Municipality continues to be awaited. Hopefully, the additional information requested by staff will enable this to take place soon. In the meantime, 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:

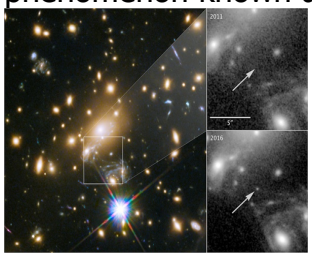
Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

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

## ASTRONOMY NEWS

**Hubble spots farthest star ever seen** 2 April: An international team of researchers has announced the discovery of the most distant star ever observed. The team detected the blue supergiant star - which shone when the universe was just one-third its current

age - with the help of both the Hubble Space Telescope and an observational phenomenon known as gravitational lensing.



This set of images shows the gravitationally lensed galaxy clusters where astronomers discovered the most distant star ever seen. The star, nicknamed Icarus, is marked by the white arrow in the bottom inset image. NASA/ESA/P. Kelly (University of California, Berkeley)

"This is the first time we're seeing a magnified, individual star," said Patrick Kelly, an astrophysicist of the University of Minnesota. "You can see individual galaxies out there, but this star is at least 100 times farther away than the next individual star we can study, except for supernova explosions." The unique discovery not only provides astronomers with insight into the formation and evolution of stars in the early universe, but also the composition of galaxy clusters, and even the very nature of dark matter itself.

The light from the record-breaking star, which the team has since nicknamed Icarus, was emitted just 4.4 billion years after the Big Bang. Although the star was undoubtedly bright, being located at such a great distance away would have typically made it impossible to view, even with our most powerful telescopes. Fortunately, "the star became bright enough to be visible for Hubble thanks to a process called graviotational lensing," said Jose Diego, an astronomer from the Instituto de Física de Cantabria.

Gravitational lensing is an effect that is predicted by Einstein's general theory of relatively. It occurs when diverging light rays from a distant object are bent back inward, or lensed, as they pass by an extremely massive object, such as a galaxy cluster. According to the study, when a galaxy cluster serendipitously wanders directly between Earth and a distant background object, gravitational lensing can magnify the distant object by up to a factor of about 50. Furthermore, if there is a smaller, impeccably aligned object within the lensing galaxy cluster, then the background object can be magnified (in a process called gravitational microlensing) by a factor of up to 5,000.

The team initially discovered Icarus while using Hubble to detect and track a known supernova named Refsdal, whose light was predicted to soon be gravitationally lensed by the galaxy cluster MACS J1149, located some 5 billion light-years away. During their observations, the team was surprised to find another point source was unexpectedly growing brighter within the same field as the expected supernova. While waiting for Refsdal to undergo its predicted lensing event, the researchers accidentally stumbled upon a new star: Icarus.

After spotting Icarus, the researchers used Hubble again to measure the star's spectrum. By breaking down the star's light into its constituent colours, the team determined that while Icarus was getting brighter, it was not getting hotter. This meant the star was not another supernova like Refsdal, but instead was a distant, non-exploding star that was being not only lensed by the intervening galaxy cluster, but also microlensed by another small, yet massive object within the cluster.

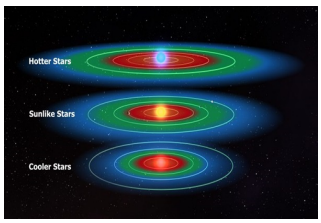
"We know that the microlensing was caused by either a star, a neutron star, or a stellar-

mass black hole," said Steven Rodney from the University of South Carolina. Therefore, the discovery of Icarus allows astronomers to gather new insights into the makeup of the galaxy cluster itself, he explained. Considering galaxy clusters are some of the most massive and sprawling structures in our universe, learning more about their makeup will inevitably help increase our overall understanding of the cosmos.

Furthermore, the newly discovered star may also help shed light on one of the most mysterious materials in our universe - dark matter. "If dark matter is at least partially made up of comparatively low-mass black holes, as it was recently proposed, we should be able to see this in the light curve of [Icarus]," said Kelly. "Our observations do not favour the possibility that a high fraction of dark matter is made of these primordial black holes with about 30 times the mass of the Sun." By: Jake Parks

**X-rays may sterilize otherwise habitable exoplanets** 6 April: Red dwarfs are far and away the most common type of star. These slow and steady burners are thought to account for roughly 75 percent of the stars in the Milky Way, and for the most part, astronomers agree that red dwarfs are prevalent throughout the entire universe. Furthermore, many exoplanets - including the seven Earth-size planets found in the TRAPPIST-1 system - have been detected around red dwarfs. Because these stable stars are relatively cool (around 4,000K) and live exceptionally long (trillions of years), it may seem like they would be the perfect places to hunt for habitable exoplanets. However, according to new research, red dwarfs may be much more inhospitable to life than we previously thought.

The problem lies in the fact that red dwarfs are so cool. For any exoplanet to get enough heat to be in a red dwarf's habitable zone - the region around a star where liquid water can exists - the planet must sit extremely close to the star itself. And since red dwarfs often emit large radiation flares, spew out charged particles, and undergo coronal mass ejections (CMEs; think plasma torpedoes), being near one is a risky proposition.



Green sections indicate the habitable zones that surround various types of stars. For cooler red-dwarf stars, their habitable zone — the region where liquid water can exist — is much closer in. New research indicates that being this close to a red dwarf star could mean trouble for an otherwise habitable exoplanet. NASA

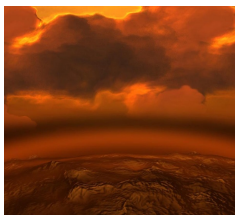
To assess just how risky being near a red dwarf truly is, a team of astronomers led by Eike Guenther, an astronomer at the Thueringer Observatory in Germany, intensively monitored a number of red dwarfs in hopes of observing some flare-ups. And, just a few short months ago, they spotted an interesting one.

In February 2018, the researchers observed a large flare coming from the red dwarf AD Leo, located 16 light-years away in the constellation Leo. This star is particularly intriguing because it is known to have a giant planet orbiting it at a distance of about 3,000,000 km - or 50 times closer than the Earth is to the Sun. Additionally, AD Leo may have more Earth-sized worlds farther out, which would place them within the star's habitable zone.

Although the research is still in its early stages, the team's initial results indicate that the giant planet was relatively unaffected by the red dwarf's powerful flare. This is largely due to the fact that the flare was not accompanied by a CME, as is usually the case with similar flares from the Sun. This is a relief for any hypothetical, Earth-size planets located farther away from AD Leo, as CMEs are capable of stripping away the atmospheres of smaller planets. That is the good news, but here is the bad: the X-ray radiation associated with the flare-up would have cut through an Earth-sized planet's atmosphere like a hot knife through butter. This means that copious amounts of harmful X-rays would penetrate straight down to the surface of any potential exoplanet in the habitable zone around AD Leo, effectively sterilising the entire planet.

"Astronomers are mounting a global effort to find Earth-like worlds, and to answer the age-old question of whether we are alone in the Universe," said Guenther. "With sporadic outbursts of hard X-rays, our work suggests planets around the commonest low-mass stars are not great places for life, at least on dry land." Though the team is still refining the details of their model to ensure the results can be trusted, according to Royal Astronomical Society representatives, "If they are right, then talk of 'Earth 2.0' [being located around a red dwarf] may be premature." By: Jake Parks

**Could alien life be hiding in the clouds of Venus?** 11 April: When it comes to searching for life elsewhere in the solar system, astronomers typically fixate on Mars or the handful of ice-encrusted moons around Jupiter and Saturn. However, according to a new study, to find extraterrestrial life, we may only need to look to our nearest neighbour - Venus.



Artist's impression of the clouds above the surface of Venus. ESA

An international team of researchers suggests that the thick and acidic atmosphere of Venus may actually serve as a potential safe haven for microbial life. In the hypothesis, they not only present multiple lines of evidence showing the Venusian clouds could harbour extreme forms of life, but also show that airborne life on Venus would help explain the fluctuating appearance of the planet's clouds - a mystery that has plagued astronomers for nearly a century.

Although scientists have debated the habitability of Venus' atmosphere for many decades, our sister world is often still ignored as a target for astrobiological research. This is primarily because the surface of Venus is now almost undoubtedly inhospitable to life, sporting temperatures of over 450°C and surface pressures about 90 times greater than those found on Earth. However, despite the fact that Venus is now a hellish landscape (largely due to a run-away greenhouse effect), at one point, the planet looked a lot more like Earth does today.

"Venus had plenty of time to evolve life on its own," said lead author Sanjay Limaye, a planetary scientist at the University of Wisconsin-Madison's Space Science and Engineering

Centre. In fact, previous research suggests that Venus could have once maintained a habitable climate with liquid water on its surface for as long as 2 billion years. "That's much longer than is believed to have occurred on Mars," he said. This would have allowed life to initially form on the surface of Venus (when the toxic planet looked more like present-day Earth) before eventually migrating up into the Venusian clouds. Although this scenario may seem unlikely, on Earth, micro-organisms such as bacteria can (and do) get swept high up into the atmosphere. According to co-author David Smith of NASA's Ames Research Centre, by using specialized research balloons, scientists have even found such high-altitude micro-organisms surviving up to 41km above the Earth's surface.

Furthermore, a series of space probes sent to Venus between 1962 and 1978 showed that, though the surface of Venus is not conducive to life, the Venusian atmosphere very well could be. At altitudes between 40 and 60km, the atmospheric temperature of Venus ranges between about 30°C to 70°C, and the pressure is almost the same as you would find at sea level on our own planet. On the other hand, the acidic, sulphur-laden Venusian air is rather toxic - that is, at least to most forms of life.

Over the years, though, scientists have compiled a large catalogue of microbes that are known to survive and thrive in incredibly harsh environments here on Earth. One such organism is the humble tardigrade - a microscopic animal (often called a 'water bear') that can survive even the most extreme conditions. These hardy critters have been found almost everywhere on the planet, ranging from the driest deserts to the tallest mountaintops. In 2007, researchers even found that tardigrades could survive up to 10 days in the irradiated vacuum of space.


Tardigrades are one of the most resilient forms of life on Earth. These microscopic animals can go decades without food or water, can exist in the most extreme temperatures, and can survive in the harsh, radiation-filled vacuum of space. NASA/N. Ottawa/O. Meckes/Eye of Science/Science Source Images

So, is it possible a certain type of micro-organism could endure living in Venus' highly toxic atmosphere? It may not be probable, but it is certainly possible. "On Earth, we know that life can thrive in very acidic conditions, can feed on carbon dioxide, and produce sulphuric acid," said Rakesh Mogul, a professor of biological chemistry at California State Polytechnic University, Pomono. Considering this, Mogul says it is worth noting that the atmosphere of Venus is primarily made of carbon dioxide and water containing lots of sulphuric acid, meaning the toxic clouds do not necessarily rule out Venusian life.

Perhaps most importantly, the physical and chemical conditions within Venus' atmosphere allow for micro-organisms to not only exist, but also contribute to the persistently changing appearance of the planet's clouds. "Venus shows some episodic dark, sulphuric rich patches, with contrasts up to 30-40 percent in the ultraviolet, and muted in longer wavelengths," said Limaye. "These patches persist for days, changing their shape and contrasts continuously, and appear to be scale dependent."

The researchers also point out that, based on previous spectroscopic observations, the dark patches are made up of particles that are almost the same size and shape as some light-absorbing bacteria found here on Earth. According to Limaye and Mogul, this means that the atmospheric patches could be living colonies of micro-organisms, similar to algal blooms commonly found in large bodies of water on Earth. However, every instrument used to sample Venus' atmosphere so far has been incapable of distinguishing between inorganic and organic compounds. "To really know, we need to go there and sample the clouds," said Mogul. "Venus could be an exciting new chapter in astrobiology exploration."

By: Jake Parks

**NASA's Juno Mission Provides Infrared Tour of Jupiter's North Pole** 12 April: Scientists working on NASA's Juno mission to Jupiter have released a 3-D infrared movie depicting densely packed cyclones and anticyclones that permeate the planet's polar regions, and the first detailed view of a dynamo, or engine, powering the magnetic field for any planet beyond Earth.

This infrared 3-D image of Jupiter's north pole was derived from data collected by the Jovian Infrared Auroral Mapper (JIRAM) instrument aboard NASA's Juno spacecraft. NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM

Juno mission scientists have taken data collected by the spacecraft's Jovian InfraRed Auroral Mapper (JIRAM) instrument and generated the 3-D fly-around of the Jovian world's north pole. Imaging in the infrared part of the spectrum, JIRAM captures light emerging from deep inside Jupiter equally well, night or day. The instrument probes the weather layer down to 50 to 70 km below Jupiter's cloud tops. The imagery will help the team understand the forces at work in the animation - a north pole dominated by a central cyclone surrounded by eight circumpolar cyclones with diameters ranging from 2,500 to 4,000 to 4,600km.

In the animation the viewer is taken low over Jupiter's north pole to illustrate the 3-D aspects of the region's central cyclone and the eight cyclones that encircle it. The movie utilises imagery derived from data collected aboard NASA's Juno mission during its fourth pass over the massive planet. Infrared cameras are used to sense the temperature of Jupiter's atmosphere and provide insight into how the powerful cyclones at Jupiter's poles work. In the animation, the yellow areas are warmer (or deeper into Jupiter's atmosphere) and the dark areas are colder (or higher up in Jupiter's atmosphere). In this picture the highest 'brightness temperature' is about -13°C and the lowest about -83°C. The 'brightness temperature' is a measurement of the radiance, at 5 μm, travelling upward from the top of the atmosphere towards Juno, expressed in units of temperature.

The new global portrait reveals unexpected irregularities and regions of surprising magnetic field intensity. Red areas show where magnetic field lines emerge from the planet, while blue areas show where they return. As Juno continues its mission, it will improve our understanding of Jupiter's complex magnetic environment. "Before Juno, we could only guess what Jupiter's poles would look like," said Alberto Adriani, Juno co-investigator from the Institute for Space Astrophysics and Planetology, Rome. "Now, with

Juno flying over the poles at a close distance it permits the collection of infrared imagery on Jupiter's polar weather patterns and its massive cyclones in unprecedented spatial resolution."

Another Juno investigation has focussed understanding how Jupiter's deep interior rotates. "Prior to Juno, we could not distinguish between extreme models of Jupiter's interior rotation, which all fitted the data collected by Earth-based observations and other deep space missions," said Tristan Guillot, a Juno co-investigator from the Université Côte d'Azur, Nice, France. "But Juno is different -- it orbits the planet from pole-to-pole and gets closer to Jupiter than any spacecraft ever before. Thanks to the amazing increase in accuracy brought by Juno's gravity data, we have essentially solved the issue of how Jupiter's interior rotates: The zones and belts that we see in the atmosphere rotating at different speeds extend to about 3,000 km. "At this point, hydrogen becomes conductive enough to be dragged into near-uniform rotation by the planet's powerful magnetic field."

The same data used to analyse Jupiter's rotation contain information on the planet's interior structure and composition. Not knowing the interior rotation was severely limiting the ability to probe the deep interior. "Now our work can really begin in earnest -- determining the interior composition of the solar system's largest planet," said Guillot.

The researchers have also released the first detailed view of the dynamo, or engine, powering the magnetic field of Jupiter. Jack Connerney and colleagues produced the new magnetic field model from measurements made during eight orbits of Jupiter. From those, they derived maps of the magnetic field at the surface and in the region below the surface where the dynamo is thought to originate. Because Jupiter is a gas giant, 'surface' is defined as one Jupiter radius, which is about 71,450km.

These maps provide an extraordinary advancement in current knowledge and will guide the science team in planning the spacecraft's remaining observations. "We're finding that Jupiter's magnetic field is unlike anything previously imagined,"said Connerney. The map Connerney's team made of the dynamo source region revealed unexpected irregularities, regions of surprising magnetic field intensity, and that Jupiter's magnetic field is more complex in the northern hemisphere than in the southern hemisphere. About halfway between the equator and the north pole lies an area where the magnetic field is intense and positive. It is flanked by areas that are less intense and negative. In the southern hemisphere, however, the magnetic field is consistently negative, becoming more and more intense from the equator to the pole.

The researchers are still figuring out why they would see these differences in a rotating planet that's generally thought of as more-or-less fluid. "Juno is only about one third the way through its planed mapping mission and already we are beginning to discover hints on how Jupiter's dynamo works," said Connerney. "The team is really anxious to see the data from our remaining orbits." Juno has logged nearly 200 million km to complete those 11 science passes since entering Jupiter's orbit on 4 July 2016. Juno's 12th science pass will be on 24 May. By: NASA/JPL

**Suppressing starlight reveals zoo of disks around young stars** 13 April: ESO's Very Large Telescope's direct imaging instrument, SPHERE, usually spends its time surveying stars close to Earth, hoping to uncover exoplanets looming in their orbits. Recently, however, an international team of researchers temporarily relieved SPHERE of

its planet-hunting duties to focus it on a new task: suppressing the bright light of stars to reveal the planet-forming disks that surround them.

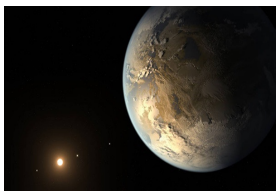
In a recent survey, researchers were able to eliminate starlight and expose the disks' distinct properties. ESO/H. Avenhaus et al./E. Sissa et al./DARTT-S and SHINE collaborations

SPHERE is an important tool for astronomers because the immense amount of light emitted by a star usually overshadows the faint light that emanates from its circumstellar disk - a circular pancake of material found around the youngest stars. This makes circumstellar disks notoriously difficult objects to study. However, by using SPHERE to drown out starlight, researchers were able to clearly image the otherwise dominated disks. The new imagery, which is a just a small sample of what was observed, reveals a veritable zoo of disks, each with their own distinct and unique features. They range in size and shape, with some extending far past their stars, while others remain close and compact. They also vary in brightness, with some disks shining much more vividly than others.

The researchers took the images during their Discs ARound T Tauri Stars with SPHERE survey (DARTTS-S). For the survey, they focused on a class of young stars known as T Tauri stars, which have low to intermediate masses and are no more than 10 million years old. Because disks are already tough to study, they chose to focus on stars that live between 230 and 550 light-years from Earth. When considering the 100,000 light-year diameter of the Milky Way, these stars may as well be in our backyard. These disks are made up of dust, gas, and planetesimals - precursors to the formation of planetary systems. By studying their properties, researchers can begin to correlate different types of disks with the planets that form within them.

The researchers were able to observe disks at different orientations in the sky, capturing both face-on and edge-on disks. Finding an edge-on disk is quite rare in and of itself, and the one they found circling the star GSC 07396-00759 is especially peculiar. This star was discovered during the SpHere INfrared survey for Exoplanets (SHINE) survey and is part of a multiple star system, which also houses a second T Tauri star. These two stars are the same age, classification, and orbit around a common centre of mass, yet GSC 07396-00759's disk has evolved more than the disk of its companion. Researchers are hoping to further study these kinds of anomalies to learn how two stars, that are almost identical on paper, could have disks in completely different evolutionary stages.  By: Amber Joegenson

**The world's most advanced camera aims to image habitable exoplanets** 17 April: Astronomers have put significant time and effort toward identifying habitable exoplanets, and with new technology emerging, it looks like their hard work could pay off sooner rather than later. NASA's Transiting Exoplanet Survey Satellite (TESS), a mission expected to identify thousands of exoplanet candidates, is scheduled for launch within the next few weeks, and the exoplanet-hunting James Webb Sapce Telescope is set to launch in 2020. If those advancements are not promising enough, a new technology could soon be added to the planetary pursuit: the world's largest and most advanced camera.


Artist's illustration of Kepler-186f. In 2014, it was the first Earth-sized exoplanet confirmed to be orbiting in a star's habitable zone. NASA Ames/JPL-Caltech/T. Pyle

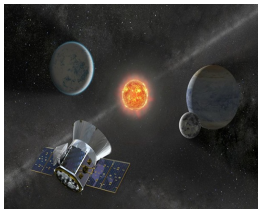
Developed by an international team of researchers, the DARK-speckle Near-infrared Energy-resolved Superconducting Spectrophotometer (DARKNESS) is a 10,000-pixel integral field spectrograph that's able to differentiate between light emitted by planets and light emitted by stars. "Taking a picture of an exoplanet is extremely challenging because the star is much brighter than the planet, and the planet is very close to the star," said lead researcher Benjamin Mazin, a physicist at the University of California Santa Barbara.

DARKNESS, which is designed to fit the 200-inch Hale telescope at the Palomar Observatory in California, functions as a focal-plane wave-front sensor as well as a camera. The sensor measures the light from planets and stars fast enough to adjust its light-collecting mirror 2,000 times per second, which allows it to counteract atmospheric distortions and create higher contrast ratios between the two light sources. Its accuracy at this rate is quite impressive, too. Even at the equivalent of thousands of frames per second, the camera does not produce any read noise, which is generated when the charge from pixels is sent to the camera. It also does not produce any dark current, which is noise caused by thermal electrons falling on pixels in the absence of light. These noise factors are common causes of photographic errors and inaccuracies.

DARKNESS also uses Microwave Kinetic Inductance Detectors to establish the arrival time and wavelength of each photon detected by the camera. Determining the photons' arrival time enables researchers to differentiate planetary light from 'speckles' - scattered light from a star that could be mistaken for a planet. "This technology will lower the contrast floor so that we can detect fainter planets," said Mazin. "We hope to approach the photon noise limit, which will give us contrast ratios close to 10-8, allowing us to see planets 100 million times fainter than the star. At those contrast levels, we can see some planets in reflected light, which opens up a whole new domain of planets to explore. The really exciting thing is that this is a technology pathfinder for the next generation of telescopes."

By: Amber Jorgenson

**To Seek Out New Life: The TESS Mission** 19 April: Yesterday, the Transiting Exoplanet Survey Satellite (TESS) spacecraft was launched successfully into space to continue the search for planets outside our solar system. It could soon provide the breakthrough identification of dozens of potentially habitable exoplanets right in our cosmic backyard

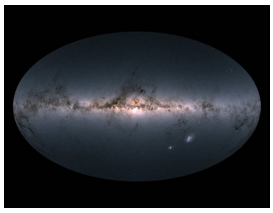

Artist's impression of the Transiting Exoplanet Survey Satellite (TESS) and some of its planetary quarry. NASA

The field of exoplanet discovery and research has veritably exploded in recent years, as our ability to find ever-smaller, more Earth-like planets around fellow Milky Way stars - and even, in rare cases, other galaxies altogether. With the Kepler telescope running out of fuel, now is the perfect time for TESS to step into the transiting planet detection scene, helping to grow our catalogue of nearby planets immensely in preparation for the launch of the James Webb Sapce Telescope, now anticipated to occur in 2020.

Over the next two years, TESS will scan the 200,000 or so nearest and brightest stars to Earth for telltale dimming caused when exoplanets cross their stars' faces. Among the thousands of new worlds TESS is expected to discover should be hundreds ranging in size from about one to two times Earth. These small, mostly rocky planets will serve as prime targets for detailed follow-up observations by other telescopes in space and on the ground. The goal for those telescopes will be to characterise the new-found exoplanets' atmospheres. The particular mixtures of gases in an atmosphere will reveal key clues about a world's climate, history, and if it may even be hospitable to life.

By: Alison Klesman

**Gaia mission creates most detailed star catalogue to date** 26 April: The European Space Agency (ESA)'s Gaia space observatory spent 22 months conducting a comprehensive survey of 1.7 billion stars in our sky, creating the most detailed star catalogue to date. The data, released this month, is expected to contribute to countless discoveries over the course of its analysis.



ESA's Gaia space observatory created this image of the Milky Way and its surrounding galaxies using data from its comprehensive survey of stars, galaxies, and globular clusters. ESA/Gaia/DPAC

From July 2014 to May 2016, Gaia logged the positions, motions, and distances of over one billion stars, analysed surrounding dwarf galaxies, and took measurements of stars outside of the Milky Way galaxy. By studying Gaia's stellar motion and population data, researchers hope to better understand the Milky Way's formation and evolution. "The observations collected by Gaia are redefining the foundations of astronomy," said ESA Director of Science, Günther Hasinger. "Gaia is an ambitious mission that relies on a huge human collaboration to make sense of a large volume of highly complex data. It demonstrates the need for long-term projects to guarantee progress in space science and technology and to implement even more daring scientific missions of the coming decades."

Launched in 2013, Gaia compiled the motions and distances of two million stars during its first year in operation. Now, with star data climbing into the billions, Anthony Brown, chair of the Gaia Data Processing and Analysis Consortium Executive, relies on a staff of 450 scientists and software engineers to catalogue it all. When calculating the distances to stars, researchers typically measure stellar parallax - the perceived movement of a star based on Earth's changing position in its orbit around the Sun. However, thanks to Gaia's meticulous measurements, the researchers will be able to differentiate between a star's parallax and its actual stellar movement. Both the parallax and actual movements of 1.3

billion stars will be featured in the catalogue, with direct distances estimated for about 10 percent of those stars.

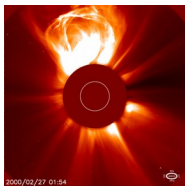
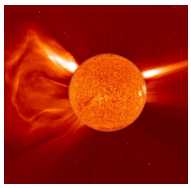
Gaia also recorded the brightness of each star and measured the colour of almost all of the 1.7 billion stars surveyed. From this, the researchers created an extremely detailed Hertzsprung-Russell diagram - a chart that compares the brightness of stars to their colours. The diagram, which is made up of four million stars that lie within 5,000 light-years of the Sun, will allow astronomers to study the population and evolution of stars in various parts of the Milky Way.

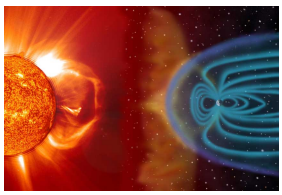
In addition to surveying local stars, Gaia observed the motions of globular clusters in the Milky Way's halo, and also went outside our galactic borders to measure the motions of nearby dwarf galaxies, like the Small and Large Magellanic Clouds. Travelling even further out, Gaia pinpointed the positions of distant quasars - the extremely luminous cores of galaxies that are controlled by the supermassive black holes in their centres. In total, Gaia logged orbital data for 12 neighbouring dwarf galaxies, 75 globular clusters, and positioned nearly half a million quasars. Gaia's survey data goes beyond stars, too. It observed the motions of over 14,000 asteroids in our solar systems, enabling researchers to track their orbits. Gaia is expected to announce details of a significantly larger asteroid sample in future data releases. By: Amber Jorgenson

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

## DID YOU KNOW?

**The Sun** Part 26: **Coronal mass ejection**



Coronal mass ejections


CME threatening Earth

A coronal mass ejection (CME) is a massive burst of gas and magnetic field arising from above the sun's surface either in the corona or further into space (interplanetary CME). The ejected plasma consists mainly of electrons and protons in addition to small quantities of heavier elements, plus the entraining coronal closed magnetic field regions. CMEs are associated with huge changes and disturbances in the coronal magnetic field. Small-scale energetic signatures eg plasma heating observed as compact soft X-ray brightening may be indicative of impending CMEs. CMEs also often follow solar flares. However, they remain difficult to forecast.

Although the solar flare observed during the 1859 Carrington event was probably associated with a CME, the first official detection of a CME, as such, occurred as recently as 1971. R Tousey of the US Naval Research Laboratory made the discovery while using the Orbiting Solar Observatory (OSO) 7 when he noted a very bright area during routine imaging. Once recognised as a discrete phenomenon, it was realised that earlier observations of coronal transients or even those seen visually during solar eclipses were probably also CMEs.

Like solar flares, CMEs have been studied with terrestrial and space-based equipment. There is clear evidence from probes that CMEs increase solar wind speeds and densities, and stimulate rapidly varying magnetic fields. When CMEs reach Earth's atmosphere they cause geomagnetic storms.

They most often originate from active regions on the Sun's surface eg sunspot groupings and are associated with other forms of solar activity eg solar flares, although the link between them is both complex and poorly understood. For example, while CMEs and solar flares are usually closely related, sometimes CMEs occur without an associated flare. Also, most weak flares do not have CMEs, but stronger ones do. Furthermore, even when associated with flares, the two events do not always occur in the same order. These findings undermined the proposal that CMEs are driven by the heat of solar flares.

Despite these anomalies, it is thought that CMEs and solar flares are caused by a common event – large scale restructuring of the magnetic field. The Sun's active regions have closed magnetic field lines, in which the magnetic field strength is large enough to contain the plasma. However, these lines must be broken or weakened for the ejection to escape the Sun. This process is that of magnetic reconnection whereby highly twisted or stretched field lines break, forming a more relaxed system. As for solar flares, CMEs are the result of the accompanying sudden release of energy stored in the original stressed magnetic fields. CMEs are also possible in quiet surface regions, although the latter is often a recently active area. Despite commonality in their cause, study of their behaviour has confirmed that CMEs and solar flares are different solar features.

CME frequency varies with the sunspot cycle. Near solar maximum, there are about 2 CMEs per day (maximum 6) while, near solar minimum one occurs about every 5 days. At solar minimum, CMEs form mainly in the coronal streamer belt near the solar magnetic equator. At solar maximum, they originate from active regions with more homogeneous latitudinal distributions. While CME energy is released into the solar wind at speeds of 10 -3,000 km/sec., this is somewhat slower than the speed of solar flares which can be up to 70% of speed of light. While the energy from flares can reach Earth within 15 minutes, CME travel time to Earth varies from 13 hours up to several weeks, depending on the trajectory they follow. The average travel time is 3.5 days.

A typical CME has 3 features: a cavity of low electron density, a dense core (the prominence, which appears as a bright region embedded in the cavity, and a bright leading edge. Ejection starts with an initial pre-acceleration phase characterised by a slow rising motion. This is followed by a period of rapid acceleration away from the Sun until a near-constant velocity is reached.

**Hazards** When a CME directed towards Earth is powerful enough to reach it as an interplanetary CME, the shock waves of the travelling mass of solar energetic particles cause a geomagnetic storm that may disrupt Earth's magnetosphere, compressing it on the day side, and extending the night side magnetic tail. When the magnetosphere reconnects on the night side, it releases huge amounts of energy, which are redirected back towards Earth's upper atmosphere. The solar energetic particles can cause extra strong aurorae, disrupt radio transmission, damage satellites and electrical transmission lines, potentially resulting in massive and long-lasting power outages. Humans at high altitudes, in planes or space stations, also risk exposure to relatively intense cosmic rays, which are potentially lethal in high quantities.

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

For more information on the Hermanus Astronomy Centre and its activities, visit our website at www.hermanusastronomy.co.za

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| | |
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