"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

JANUARY 2016

As the Centre enters its ninth year, we wish all our members a very happy New Year and all the best for 2016.

2016 membership renewal reminder

The fees for 2016 are as follows:

Member: R140

Member's spouse/partner/child, student: R70

Six-month membership from July – December 2016:
Member: R70 Member's spouse etc, student: R40

Payment can be made in cash (at meetings directly to the Treasurer), or via online transfer. The Standard Bank details, for the latter, 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 'membership', and your name, or it is not possible to attribute the payment to you.

This month's Centre meeting

The first meeting of 2016 will take place on **Monday 25 January** at 19.00 in the **Scout Hall.** Retired senior astronomer at the SAAO, **Dr Ian Glass** will be talking on 'Proxima, our nearest star'. Dr Glass, who is also author of a number of excellent books relating to astronomy, has given a number of presentations at the Centre in the past, all of which have been fascinating to hear.

2016 monthly meeting dates

Unless changed to accommodate holiday seasons, the monthly meetings will, in future, take place on the **third Monday of the month.** The remaining dates for 2016 are as follows: 15 February, 21 March, 18 April, 16 May, 20 June, 18 July, 15 August, 14 September, 17 October, 21 November and 13 December. See further details below.

WHAT'S UP?

Orion is both the most easily identifiable and most representative constellation of the southern summer night sky. The eponymous hunter, being followed by his two dogs, Canis Major and Minor, is the 26th largest of the 88 named constellations. In Greek mythology, Orion was stung to death by a scorpion. Astronomically, this legend fits conveniently with the fact that Orion's 'enemy' Scorpius is only seen in our night skies during winter. Orion contains a wide range of celestial objects. These include a red supergiant star (Betelgeuse) and a blue-white supergiant (Rigel), respectively, the 10th and 7th brightest stars after the Sun. Betelgeuse is also a variable star whose magnitude (brightness) varies over several years. The constellation also contains several nebulae (the most impressive being those which form the sword), giant molecular clouds, open clusters, and double and multiple star systems. In addition, every October, the Orionid meteor shower, a remnant of Halley's comet, radiates from the constellation.

LAST MONTH'S ACTIVITIES

Monthly centre meeting The meeting on 14 December was the annual Christmas party. The thirty members and partners who attended enjoyed a festive evening with an astronomical theme. First, they participated in two short interactive presentations led by Johan Retief. It took a few clues before the first person identified that the person born on Christmas Day 1642 was Isaac Newton. Then, drawing on his long-standing interest in science fiction novels, Johan identified how prophetic the worlds described so many decades ago have been. Authors' imaginations came up with, amongst other developments, manned space travel, computers, electronic forms of communication and robots. Then, while enjoying a variety of savoury and sweet snacks, the partygoers participated in the now traditional Christmas quiz in which the four teams vied enthusiastically in their attempt to win the prize of Christmas chocolates.

Interest groups

Cosmology Seventeen people (all members) attended the meeting on 7 December. They viewed the fourth pair of episodes of the 24 part DVD series on Time, given by Prof Sean Carroll from CalTech. The topics were: Lecture 7: 'Time reversal in particle physics' and Lecture 8: 'Time in quantum mechanics'. As usual, the content initiated lively discussion.

Astro-photography No meeting was held in December.

Other activities

Sidewalk astronomy The events scheduled for December were cancelled.

Educational outreach

Hawston Secondary School Astronomy Group Meetings will recommence when the new term begins.

Lukhanyo Youth Club No meetings took place in December.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This will take place on **Monday 25 January** at the **Scout Hall** at **19.00.**. Dr Ian Glass, retired Senior astronomer at the SAAO in Cape Town will be talking about 'Proxima, our nearest star'.

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

Interest group meetings

The **Cosmology** group meets on the first Monday of each month at 19.00. This month's meeting will take place on **11 January** at the **Scout Hall.** Attendees will view the fifth pair of episodes of the new DVD series on Time given by Prof Sean Carroll from CalTech. The topics for this month are: Lecture 9: 'Entropy and counting' and Lecture 10: 'Playing with entropy'.

There is an entrance fee of R10 per person for members, R20 per person for non-members, and R10 for children, students and U3A members. For further information on these meetings, or any of the group's activities, please contact Pierre Hugo at pierre@hermanus.co.za

Astro-photography This group meets on the third Monday of each month. The next meeting will take place on **18 January**. Members will continue to work on 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

Sidewalk astronomy No events have been scheduled for this month. Details will be e-mailed out if this situation changes.

Hermanus Youth Robotic Telescope Interest Group Work to gain access to the telescopes will recommence soon.

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

FUTURE ACTIVITIES

None is currently being planned.

2016 MONTHLY MEETINGS

Meetings take place on the **third Monday** of each month at the Scout Hall beginning at 19.00. Details for 2016 are:

25 Jan	'Proxima, our nearest star'. Presenter: Dr Ian Glass, retired Senior Astronomer, SAAO, CT
15 Feb	AGM
21 Mar	'Missions into the solar system'. Presenter: Case Rijsdijk, Chair, Garden Route Centre
18 Apr, 16 May, 20 June, 18 July, 15 Aug, 14 Sept	TBA
17 Oct	'Dark skies: the unseen Universe". Presenter: Jenny Morris, Committee member
21 Nov	TBA
13 Dec	Xmas party

HERMANUS ASTRONOMY EDUCATION CENTRE (HAEC)

Work continues on the application to Overstrand Municipality for consent use of the preferred site, confirming details of the amended of architectural plans, and updated costings. 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. NLB 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:

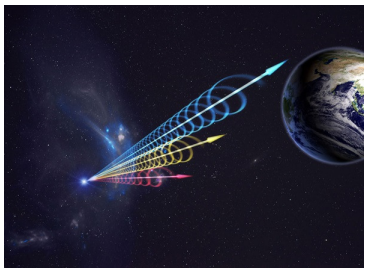
Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

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

Science Centre The committee continues to work on the project. Consultation with interested and affected organizations and parties is being planned.

ASTRONOMY NEWS

'Fast radio burst' sheds new light on origin of these extreme events 2 December: Fast radio bursts (FRB), brief yet brilliant eruptions of cosmic radio waves, have baffled astronomers since they were first reported nearly a decade ago. Though they appear to come from the distant universe, none of these enigmatic events has revealed more than the slimmest details about how and where it formed, until now. By poring over 650 hours of archival data from the National Science Foundation's (NSF) Green Bank Telescope (GBT), a team of astronomers uncovered the most detailed record ever of an FRB. Their research indicates that the burst originated inside a highly magnetized region of space, possibly linking it to a recent supernova or the interior of an active star-forming nebula.



Artist impression of a Fast Radio Burst (FRB) reaching Earth. The colors represent the burst arriving at different radio wavelengths, with long wavelengths (red) arriving several seconds after short wavelengths (blue). This delay is called dispersion and occurs when radio waves travel through cosmic plasma.
Jingchuan Yu, Beijing Planetarium

Lasting only a fraction of a second, yet packing a phenomenal amount of energy, FRBs are brief radio flashes of unknown origin that appear to come from random directions on the sky. Though only a handful have been documented previously, astronomers believe that the observable universe is rocked by thousands of these events each day.

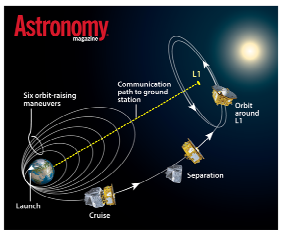
"Hidden within an incredibly massive dataset, we found a very peculiar signal, one that matched all the known characteristics of a fast radio burst, but with a tantalising extra polarisation element that we simply have never seen before," said Jeffrey Peterson from Carnegie Mellon's McWilliams Center for Cosmology in Pittsburgh, Pennsylvania.

Polarisation is a property of electromagnetic radiation, including light and radio waves, and indicates the orientation of the wave. Polarising sunglasses use this property to block out a portion of the Sun's rays, and 3-D movies use it to achieve the illusion of depth. The researchers used this information to determine that the radio light from the FRB exhibited Faraday rotation, a corkscrew-like twisting radio waves acquire by passing through a powerful magnetic field.

In addition, measurements of the dispersion delay can be used to place a lower limit on the size of the source region. In this case, the measurement rules out models for FRBs involving stars in our galaxy and, for the first time, shows that the FRB must have originated in another galaxy. Further analysis of the signal reveals that it also passed through two distinct regions of ionized gas, called screens, on its way to Earth. By using the interplay between the two screens, the astronomers were able to determine their relative locations. The strongest screen is near the burst's source - within a hundred thousand light-years - placing it inside the source's galaxy. Only two things could leave such an imprint on the signal, the researchers note: a nebula surrounding the source or the environment near the centre of a galaxy.

By: NRAO, Charlottesville, VA

How LISA Pathfinder will 'hear' the universe 3 December: LISA Pathfinder, the first step toward a space-based gravitational wave detector, launched into orbit last night from Kourou, French Guiana, but its origin goes back a century. In 1916, following his revolutionary General Relativity theory, Albert Einstein predicted that extreme objects could create gravitational waves. However, no one has ever found them. The European Space Agency hopes to change that with LISA and allow astronomers to study the universe for the first time outside the electromagnetic spectrum - letting them 'hear' the universe, as the mission managers put it.

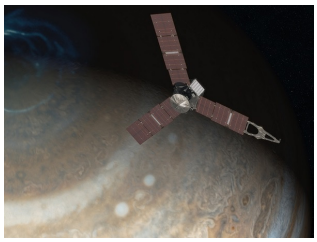


Astronomy: Roen Kelly

The proof-of-concept mission uses lasers to connect several spacecraft into a sensitive interferometer. The flying physics lab packs an optical bench with 22 mirrors and beam splitters. One laser beam aims at two free-falling test masses, while the other reflects through the bench. The two beam lengths are then compared in search of tiny distance changes.

By: Eric Betz, an *Astronomy* associate editor.

NASA returns to Jupiter 20 years after Galileo 7 December: When Galileo Galilei turned his telescope to Jupiter in 1610, he uncovered the planet's four large moons, as well as a new vision of the cosmos: not everything had to orbit Earth. NASA's first dedicated mission to Jupiter, named in honour of the great astronomer, was intended to bring about a similar revolution, and it mostly did.



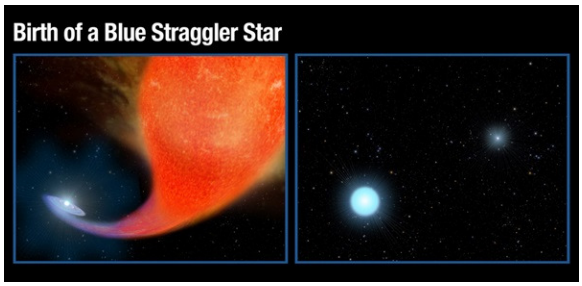
The Juno spacecraft will enter orbit around Jupiter on July 4, 2016, picking up the exploration efforts NASA's Galileo mission began 20 years ago.

NASA/JPL-Caltech

Much of what astronomers know about the gas giant and its satellites still comes from Galileo's dataset. However, that is poised to change on 4 July 2016. NASA's Juno spacecraft will beam breathtaking views of the gas giant and its atmosphere back to Earth. Every two weeks, the solar-powered spacecraft will plunge past Jupiter at a distance as close as 5,000 km above the cloudtops. An array of scientific instruments will also help Juno peer into the heart of the largest planet in the solar system, uncovering the planet's structure, atmosphere, and magnetosphere. Another visit to the system, the Europa Multiple Flyby Mission, is also in the works.

By: Eric Betz, an *Astronomy* associate editor.

Hubble helps solve mystery of 'born again' stars 8 December: Natalie Gosnell from the University of Texas has used the Hubble Space Telescope to better understand why some stars are not evolving as predicted. These so-called 'blue stragglers' look hotter and bluer than they should for their advanced age. It is almost as if they were somehow reinvigorated to look much younger than they really are.



Left: A normal star in a binary system gravitationally pulls in matter from an aging companion star that has swelled to a bloated red giant that has expanded to a few hundred times of its original size. Right: After a couple hundred million years the red giant star has burned out and collapsed to the white dwarf that shines intensely in ultraviolet wavelengths. The companion star has bulked up on the hydrogen siphoned off of the red giant star to become much hotter, brighter, and bluer than it was previously. NASA/ESA/A. Feild (STScI)

Though blue stragglers were first identified 62 years ago, astronomers have yet to converge on a solution for their odd appearance. The most popular explanation among several competing theories is that an aging star spills material onto a smaller companion star. The small star bulks up on mass to become hotter and bluer while the aging companion burns out and collapses to a white dwarf - a burned out cinder.

To test this theory, Gosnell's team conducted a survey of the open star cluster NGC 188 that has 21 blue stragglers. Of those, she found that seven had white dwarf companions by identifying their ultraviolet glow that is detectable by Hubble. Of the remaining 14 of the 21 blue stragglers, a further seven show evidence of so-called mass transfer between stars in other ways. Gosnell said she believes these are older white dwarf-blue straggler binaries, and indicate two-thirds of blue stragglers form through mass transfer.

This discovery sheds light on the physical processes responsible for changing the appearance of 25 percent of evolved stars. The problem came to light because in recent

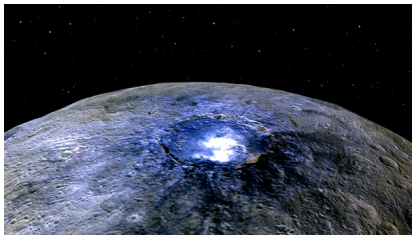
years astronomers have been able to make a complete and accurate census of stars in a number of open star clusters, Gosnell said. The cluster population studies revealed that up to a quarter of the oldest stars "are not evolving like we think they're supposed to," Gosnell said. Stars that astronomers expected to become red giants (like Aldebaran, the eye of Taurus the bull) instead became 'blue stragglers', unexpectedly bright blue stars with a host of strange characteristics.

Gosnell and her collaborators, designed a study using Hubble Space Telescope's Advanced Camera for Surveys to try to differentiate between three theories of how these stars became blue stragglers. The theories included: collisions between stars in the cluster (with debris coalescing to form a blue straggler), the merger of two of the stars in a triple star system, or mass transfer between two stars in a binary pair. In a binary pair of stars, the larger star will evolve faster, Gosnell said. That star becomes a red giant. A red giant is so bloated that the outermost layers of gas on its surface are only tenuously held by the star's gravity. They can be pulled off by the gravity of the companion star. This is mass transfer. As the gas is siphoned off by the partner, the red giant is left with only its core, making it into a white dwarf. The partner, initially the least massive of the pair, but now the heavier one, becomes a blue straggler.

Knowing more about how these stars form is important because astronomers use their assumptions to model the stellar populations of distant galaxies — where the light from all the stars blends together. "You don't want to be ignoring 25 percent of the evolved stars in those galaxies," Gosnell said.

By: McDonald Observatory at University of Texas, Austin

The salty truth about Ceres' bright spots 10 December: Earlier this year, images of two bright spots captured by NASA's Dawn spacecraft on the dwarf planet Ceres sent scientists and theory-happy Internet commentators into a frenzy. While most hypotheses suggested that the spots were the result of ice or metallic minerals on the surface, the possibility of them being alien cities was equally irresistible to some.

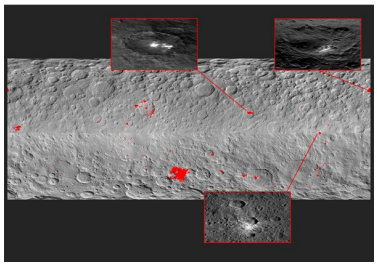


The Occator crater as seen in a false-color image of Ceres.
(Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

However, a study published in *Nature* indicates that Ceres' spots are likely caused by hydrated magnesium sulphate - similar to Epsom salt – that is present at the bottom of craters. The magnesium sulphate is mixed with water-ice molecules and stands out brightly against the dark, asphalt-coloured surface of Ceres, which is composed mostly of clay and carbonates.

Ceres, at 900 km across, is the largest body in the asteroid belt and is thought be around 25% water, most of which is contained in an icy layer just beneath the surface. Astronomers considered it a planet for five decades following its discovery in 1801, and humanity got its first up-close glimpse of Ceres earlier in 2015 when Dawn reached the dwarf planet following a 14-month tango with the asteroid Vesta. Dawn's close encounter allowed researchers to document more than 130 glimmering spots all over Ceres' surface, but they could not figure out what they were composed of, which

sparked the aforementioned speculative furore. But as Dawn circled closer and closer, researchers ruled out ice as the culprit and began to suspect salt deposits.



Most of Ceres' spots, shown in red, are located within craters. (Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)

The researchers also solved a second mystery as they combed through their data. Two of the spots are far brighter than the rest, the most dazzling of which is located at the bottom of a 3 km deep crater called Occator. Using data from Herschel, along with reflectivity readings, researchers determined that they contain a haze of dust and ice that appears and disappears as the sun rises and sets on Ceres. When the sun is shining, ices in the craters sublimate, or transition from a solid into a vapour. The same process also occurs on the surface of comets.

Confirming that the icy dust clouds are caused by sublimation, as opposed to geothermal or cryo-volcanic activity, validates previous theories that Ceres is composed of a rocky core overlain by a briny mantle. Scientists believe that impacts on the surface of Ceres punch holes through to the mantle and allow briny water to seep through, creating the shiny patches.

The new findings indicate the dwarf planet is a hybrid of sorts between rocky asteroids and icy comets, adding a wrinkle to classic definitions of extraterrestrial objects. NASA hopes to glean even more information from Dawn in the coming weeks as it spirals closer to the surface before flying back into orbit. Researchers are still trying to explain the presence of fissures at the bottom of Occator, and they hope the continuing stream of images will provide some insights.

By: Nathaniel Scharping, DiscoverMagazine.com

Hubble solves missing water mystery for Hot Jupiters 14 December: A survey of 10 hot, Jupiter-sized exoplanets conducted with NASA's Hubble and Spitzer space telescopes has led a team to solve a long-standing mystery - why some of these worlds seem to have less water than expected. The findings offer new insights into the wide range of planetary atmospheres in our galaxy and how planets are assembled.

Illustrations of the 10 exoplanets observed for the study are shown here. While astronomers don't know what most of these planets look like yet, HD189733 b is actually known to be blue in color.

NASA/ESA

Of the nearly 2,000 planets confirmed to be orbiting other stars, a subset are gaseous planets with characteristics similar to those of Jupiter but that orbit very close to their stars, making them blistering hot. Their close proximity to the star makes them difficult to observe in the glare of starlight. Due to this difficulty, Hubble has only explored a

handful of hot Jupiters in the past. These initial studies have found several planets to hold less water than predicted by atmospheric models.

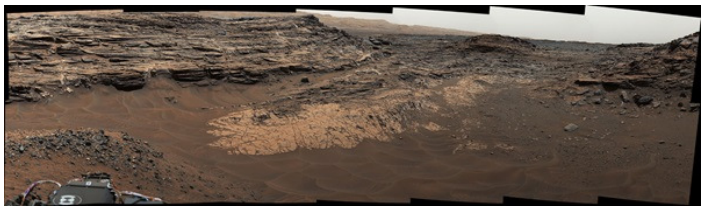
The international team of astronomers has tackled the problem by making the largest-ever spectroscopic catalogue of exoplanet atmospheres. All of the planets in the catalogue follow orbits oriented so the planet passes in front of their parent star, as seen from Earth. During this so-called transit, some of the starlight travels through the planet's outer atmosphere. "The atmosphere leaves its unique fingerprint on the starlight, which we can study when the light reaches us," explained co-author Hannah Wakeford of NASA's Goddard Space Flight Centre in Greenbelt, Maryland.

By combining data from NASA's Hubble and Spitzer Space telescopes, the team was able to attain a broad spectrum of light covering wavelengths from the optical to infrared. The difference in planetary radius as measured between visible and infrared wavelengths was used to indicate the type of planetary atmosphere being observed for each planet in the sample, whether hazy or clear. A cloudy planet will appear larger in visible light than at infrared wavelengths, which penetrate deeper into the atmosphere. It was this comparison that allowed the team to find a correlation between hazy or cloudy atmospheres and faint water detection.

"We found the planetary atmospheres to be much more diverse than we expected," said David Sing of the University of Exeter, United Kingdom. "Our results suggest it's simply clouds hiding the water from prying eyes, and therefore rule out dry hot Jupiters," explained Jonathan Fortney of the University of California, Santa Cruz. "The alternative theory to this is that planets form in an environment deprived of water, but this would require us to completely rethink our current theories of how planets are born." The study of exoplanetary atmospheres is currently in its infancy. Hubble's successor, the James Webb Space Telescope, will open a new infrared window on the study of exoplanets and their atmospheres.

By: ESA, Noordwijk, Netherlands, NASA

Silica presents puzzles for Mars rover team 18 December: NASA's Curiosity rover has found much higher concentrations of silica at some sites it has investigated in the past seven months than anywhere else it has visited since landing on Mars 40 months ago. Silica makes up nine-tenths of the composition of some of the rocks. It is a rock-forming chemical combining the elements silicon and oxygen, commonly seen on Earth as quartz, but also in many other minerals.



This view from the Mast Camera (Mastcam) in NASA's Curiosity Mars rover shows the "Marias Pass" area where a lower and older geological unit of mudstone - the pale zone in the centre of the image - lies in contact with an overlying geological unit of sandstone.

NASA/JPL-Caltech/MSSS

"These high-silica compositions are a puzzle. You can boost the concentration of silica either by leaching away other ingredients while leaving the silica behind, or by bringing

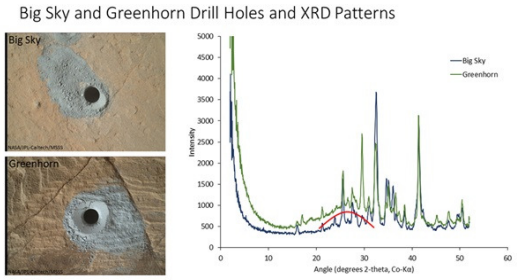
in silica from somewhere else," said Albert Yen, a Curiosity science team member at NASA's Jet Propulsion Laboratory, Pasadena, California. "Either of those processes involves water. If we can determine which happened, we'll learn more about other conditions in those ancient wet environments."

Water that is acidic would tend to carry other ingredients away and leave silica behind. Alkaline or neutral water could bring in dissolved silica that would be deposited from the solution. Apart from presenting a puzzle about the history of the region where Curiosity is working, the recent findings on Mount Sharp have intriguing threads linked to what an earlier NASA rover, Spirit, found halfway around Mars. There, signs of sulphuric acidity were observed, but Curiosity's science team is still considering both scenarios - and others - to explain the findings on Mount Sharp.

Adding to the puzzle, some silica at one rock Curiosity drilled, called 'Buckskin', is in a mineral named tridymite, rare on Earth and never seen before on Mars. The usual origin of tridymite on Earth involves high temperatures in igneous or metamorphic rocks, but the finely layered sedimentary rocks examined by Curiosity have been interpreted as lakebed deposits. Furthermore, tridymite is found in volcanic deposits with high silica content. Rocks on Mars' surface generally have less silica, like basalts in Hawaii, though some silica-rich (silicic) rocks have been found by Mars rovers and orbiters. Magma, the molten source material of volcanoes, can evolve on Earth to become silicic. Tridymite at Buckskin may be evidence for magmatic evolution on Mars.

Curiosity has been studying geological layers of Mount Sharp, going uphill, since 2014, after two years of productive work on the plains surrounding the mountain. The mission delivered evidence in its first year that lakes in the area billions of years ago offered favourable conditions for life, if microbes ever lived on Mars. As Curiosity reaches successively younger layers up Mount Sharp's slopes, the mission is investigating how ancient environmental conditions evolved from lakes, rivers and deltas to the harsh aridity of today's Mars.

"The high silica was a surprise - so interesting that we backtracked to investigate it with more of Curiosity's instruments," said Jens Frydenvang of Los Alamos National Laboratory in New Mexico and the University of Copenhagen, Denmark.
Gathering clues about silica was a major emphasis in rover operations over a span of four months and a distance of about half a kilometre. Buckskin was the first of three rocks where drilled samples were collected. Identification of tridymite prompted the team to look at possible explanations: "We could solve this by determining whether trydymite in the sediment comes from a volcanic source or has another origin," said Liz Rampe, of Aerodyne Industries at NASA's Johnson Space Center, Houston. "A lot of us are in our labs trying to see if there's a way to make tridymite without such a high temperature."



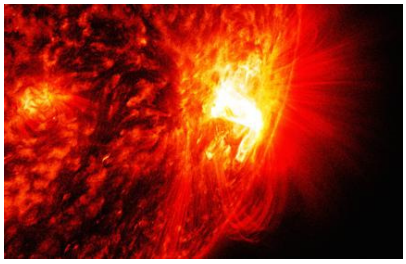
Curiosity drilled two different samples, "Big Sky" and "Greenhorn." The rover used its Chemistry and Mineralogy (CheMin) instrument to reveal an abundance of silica in both samples in the form of noncrystalline opal.

NASA/JPL-Caltech/MSSS

"What we're seeing on Mount Sharp is dramatically different from what we saw in the first two years of the mission," said Curiosity Project Scientist Ashwin Vasavada of JPL. "There's so much variability within relatively short distances. The silica is one indicator of how the chemistry changed. It's such a multifaceted and curious discovery, we're going to take a while figuring it out."

By: Jet Propulsion Laboratory, Pasadena, California

What stops solar eruptions? 28 December: Among the most feared events in space physics are solar eruptions, massive explosions that hurl millions of tons of plasma gas and radiation into space. These outbursts can be deadly: if the first moon-landing mission had encountered one, the intense radiation could have been fatal to the astronauts. When eruptions reach the magnetic field that surrounds the Earth, the contact can create geomagnetic storms that disrupt cell phone service, damage satellites and knock out power grids.



This solar flare occurred at the peak of the solar cycle in October 2014 with no observed eruptions. PPPL researchers say this is a promising candidate for studying the effect of guide magnetic fields.

NASA

NASA is eager to know when an eruption is coming and when what looks like the start of an outburst is just a false alarm. Knowing the difference could affect the timing of future space missions such as journeys to Mars, and show when steps to protect satellites, power systems and other equipment need to be taken. At the US Department of Energy's Princeton Plasma Physics Laboratory (PPPL), researchers have identified a mechanism that may halt eruptions before they leave the Sun. The finding provides a potentially important way to distinguish the start of explosions from buildups that will fail.

The violent eruptions, called 'coronal mass ejections', stem from a sudden release of magnetic energy that is stored in the Sun's corona, the outermost layer of the star. This energy is often found in what are called 'magnetic flux ropes', massive arched structures that can twist and turn like earthly twine. When these long-lived structures twist and destabilise, they can either erupt out into the solar system or fail and collapse back toward the Sun.

The researchers found in laboratory experiments that such failures occur when the guide magnetic field - a force that runs along the flux rope - is strong enough to keep the rope from twisting and destabilising. Under these conditions, the guide field interacts with electric currents in the flux rope to produce a dynamic force that halts the eruptions. PPPL has discovered the importance of this force, called the 'toroidal field tension force', which is missing from existing models of solar eruptions.

The researchers discovered this importance using the Laboratory's Magnetic Reconnection Experiment (MRX), the world's leading device for studying how magnetic fields in plasma converge and violently snap apart. The scientists modified the device to produce both a flux rope, which stores a significant amount of energy that seeks to drive the rope outward, and a 'potential magnetic field' like the ones that enclose the rope in the solar corona. This potential magnetic field is composed of magnetic 'strapping' and 'guide' fields, each of which provides restraining forces. Eruptions burst forth when the restraining forces in the strapping field become too weak to hold the rope down, creating a 'torus instability' that shoots plasma into space. The guide field, which reduces the twist in the flux rope, had long been thought to be of secondary importance.

However, the researchers found that the guide field can play an important role in halting eruptions. When the flux rope starts to move outward in the presence of a sufficiently powerful guide field, the plasma undergoes an internal reconfiguration or 'self-organisation' that causes the eruption to lose energy and collapse. Solar physicists should thus be on the lookout for guide fields, which can be found in relatively simple reconstructions of the Sun's potential magnetic field. A promising candidate for study is the largest active region in the peak solar cycle that took place in October 2014, which produced many large flares but no observed eruptions. Preliminary analysis of this region shows that a number of these flares were associated with failed eruptions that could have been caused by the mechanism the MRX experiments found.

By: Princeton Plasma Physics Laboratory

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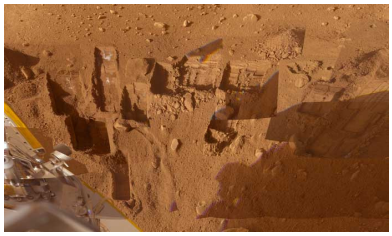
DID YOU KNOW?

Mission: Mars Part 7: Roving on Mars – 2



Phoenix lander – image of areas of digging

Size comparison – Sojourner (front), Spirit/Opportunity (left) and Curiosity (right)

Curiosity self-portrait

In 2008, the rovers *Spirit* and *Opportunity* were joined on Mars by another NASA vehicle for six months. Launched nine months earlier in 2007, the Phoenix static lander would investigate the icy north polar region of Mars. The two objectives were to study the geological history of the ice to unlock the history of past climate change, and to evaluate past and potential planetary habitability in the ice-soil boundary. Its robotic arm scooped up samples of soil and ice for analysis by instruments aboard the lander. Phoenix was the first Mars mission to return data directly from either pole.

The Surface Stereo Imager camera photographed the surrounding landscape, while a set of meteorological instruments recorded temperature, pressure and other atmospheric conditions. In July 2008, NASA announcement that Phoenix confirmed the presence of sub-surface water on Mars, as Odyssey's data had suggested. In addition to

showing that the rocks in polar areas appear to be small, Phoenix also observed snowfall from cirrus clouds. Temperatures meant that the clouds would have to be composed of water ice, as opposed to dry carbon dioxide ice. An important conclusion is that water ice snow accumulates in the polar regions, an important finding regarding Martian weather.

The lander managed to successfully complete its mission before the rigours of the Martian polar winter seem to have 'killed' it. Communication could not be re-established during the following Martian summer and, unlike the other NASA missions of this and the following decade, Phoenix did not survive more than a couple of months beyond its scheduled lifespan.

In contrast to the US success with the Phoenix mission, the Russian-Chinese Phobos-Grunt mission, launched in late 2011, only reached low Earth orbit before a complete systems failure resulted in it remaining stranded until later falling back to Earth in a destructive re-entry in early 2012. The 2-part mission had planned to land a Russian probe on moon Phobos and return samples to Earth and also launch the Chinese orbiter Ynghou-1.

In 2011, NASA launched the Mars Science Laboratory mission and successfully landed the rover *Curiosity* on the Martian surface. The most accurate and complex landing ever (using parachutes and powered descent rather than airbags) was achieved onto a very small target. The six-wheeled rover is the largest ever sent to Mars, with a mass of 900 kg and the ability to travel up to 90m per hour. It carries a variety of instruments designed to look for past or present conditions relevant to past or future habitability on the red planet, particularly investigating whether Mars has or had an environment able to support microbial life. A dozen main instruments consist of cameras, spectrometers, environmental detectors and small sample analysis laboratories.

Curiosity has achieved its main mission: it has shown that Mars could have once sustained life. By drilling into Martian rocks it discovered carbon, hydrogen, oxygen, phosphorus and sulphur, the key ingredients for life. More recently, it also discovered organic molecules, particularly methane. The methane levels were much lower than atmospheric levels, and quickly diminished, suggesting a localised source. The presence of methane does not prove the existence of biological life as it is also a product of non-biological processes, but it adds to the existing suggestive evidence.

Other minerals found also confirm the past presence of liquid water with constituents positive for living organisms to survive. In addition to identifying a wide variety of soil and rocks, it also found further geological evidence of water flows on the planet's surface. The findings of levels of radiation dangerous for humans will require careful design of future manned spacecraft and spacesuits.

In late 2012, *Curiosity's* two year mission was extended indefinitely. Further findings may help confirm the theory that, at the same time as like began on Earth, Mars had the same conditions: liquid water, a warm environment and organic matter.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed, revised, www.en.wikipedia.org, www.planetary.org, www.nasa.org, www.space.com, www.computerworld.com, www.astrobio.net

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