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1. NASA Mission Uncovers Dance of Electrons in Space

You can't see them, but swarms of electrons are buzzing through the magnetic environment — the magnetosphere — around Earth. The electrons spiral and dive around the planet in a complex dance dictated by the magnetic and electric fields. When they penetrate into the magnetosphere close enough to Earth, the high-energy electrons can damage satellites in orbit and trigger auroras. Scientists with NASA's Magnetospheric Multiscale, or MMS, mission study the electrons' dynamics to better understand their behavior. A new study, published in Journal of Geophysical Research revealed a bizarre new type of motion exhibited by these electrons.

Electrons in a strong magnetic field usually exhibit a simple behavior: They spin tight spirals along the magnetic field. In a weaker field region, where the direction of the magnetic field reverses, the electrons go free style — bouncing and wagging back and forth in a type of movement called Speiser motion. New MMS results show for the first time what happens in an intermediate strength field. Then these electrons dance a hybrid, meandering motion — spiraling and bouncing about before being ejected from the region. This motion takes away some of the field's energy and it plays a key role in magnetic reconnection, a dynamic process, which can explosively release large amounts of stored magnetic energy.

"MMS is showing us the fascinating reality of magnetic reconnection happening out there," said Li-Jen Chen, lead author of the study and MMS scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

As MMS flew around Earth, it passed through an area of a moderate strength magnetic field where electric currents run in the same direction as the magnetic field. Such areas are known as intermediate guide fields. While inside the region, the instruments recorded a curious interaction of electrons with the current sheet, the thin layer through which the current travels. As the incoming particles encountered the region, they started gyrating in spirals along the guide field, like they do in a strong magnetic field, but in larger spirals. The MMS observations also saw signatures of the particles gaining energy from the electric field. Before long, the accelerated particles escaped the current sheet, forming high-speed jets. In the process, they took away some of the field's energy, causing it to gradually weaken.

The magnetic field environment where the electrons' motions were observed was uniquely created by magnetic reconnection, which caused the current sheet to be tightly confined by bunched-up magnetic fields. The new results help the scientists better understand the role of electrons in reconnection and how magnetic fields lose energy.

MMS measures the electric and magnetic fields it flies through, and counts electrons and ions to measure their energies and directions of motion. With four spacecraft flying in a compact, pyramid formation, MMS is able to
see the fields and particles in three dimensions and look at small-scale particle dynamics, in a way never before achieved.

“The time resolution of MMS is one hundred times faster than previous missions,” said Tom Moore, senior project scientist for MMS at NASA’s Goddard Space Flight Center. “That means we can finally see what’s going on in such narrow layers and will be able to better predict how fast reconnection occurs in various circumstances.”

Understanding the speed of reconnection is essential for predicting the intensity of the explosive energy release. Reconnection is an important energy release process across the universe and is thought to be responsible for some shock waves and cosmic rays. Solar flares on the sun, which can trigger space weather, are also caused by magnetic reconnection.

With two years under its belt, MMS has been revealing new and surprising phenomena near Earth. These discoveries enable us to better understand Earth’s dynamic space environment and how it affects our satellites and technology.

MMS is now heading to a new orbit which will take it through magnetic reconnection areas on the side of Earth farther from the sun. In this region, the guide field is typically weaker, so MMS may see more of these types of electron dynamics.

Related Links

- Learn more about NASA’s MMS mission

Source: NASA
The environment on Titan, Saturn's largest moon, may seem surprisingly familiar: Clouds condense and rain down on the surface, feeding rivers that flow into oceans and lakes.

Outside of Earth, Titan is the only other planetary body in the solar system with actively flowing rivers, though they're fed by liquid methane instead of water. Long ago, Mars also hosted rivers, which scoured valleys across its now-arid surface.

Now MIT scientists have found that despite these similarities, the origins of topography, or surface elevations, on Mars and Titan are very different from that on Earth.

In a paper published in Science, the researchers report that Titan, like Mars but unlike Earth, has not undergone any active plate tectonics in its recent past. The upheaval of mountains by plate tectonics deflects the paths that rivers take. The team found that this telltale signature was missing from river networks on Mars and Titan.

"While the processes that created Titan's topography are still enigmatic, this rules out some of the mechanisms we're most familiar with on Earth," says lead author Benjamin Black, formerly an MIT graduate student and now an assistant professor at the City College of New York.

Instead, the authors suggest Titan's topography may grow through processes like changes in the thickness of the moon's icy crust, due to tides from Saturn.
The study also sheds some light on the evolution of the landscape on Mars, which once harbored a huge ocean and rivers of water. The MIT team provides evidence that the major features of Martian topography formed very early in the history of the planet, influencing the paths of younger river systems, even as volcanic eruptions and asteroid impacts scarred the planet's surface.

"It's remarkable that there are three worlds in the solar system where flowing rivers have carved into the landscape, either presently or in the past," says Taylor Perron, associate professor of geology in MIT's Department of Earth, Atmospheric and Planetary Sciences (EAPS). "There's this amazing opportunity to use the landforms the rivers have created to learn how the histories of these worlds are different."

Perron and Black's co-authors include former MIT undergraduate Elizabeth Bailey and researchers from the University of California at Berkeley, the University of California at Santa Cruz, and Stanford University.

Fuzzy flows

Since 2004, NASA's Cassini spacecraft has been circling Saturn and sending back to Earth stunning images of the planet's rings and moons. Images of Titan's surface have given scientists a first view of the moon's river valleys, rolling sand dunes, and active weather patterns. Cassini has also made rough measurements of Titan's topography in some locations, though these measurements are much coarser in resolution.

Perron and Black wondered whether they might refine their view of Titan's topography by applying what is known about the topography on Earth and Mars, and how their rivers have evolved.

For instance, on Earth, the process of plate tectonics has continuously reshaped the landscape, pushing mountain ranges up between colliding continental plates, and opening ocean basins as landmasses slowly pull apart. Rivers, therefore, are constantly adapting to changes in topography, sidestepping around growing mountain ranges to reach the ocean.

Mars, on the other hand, is thought to have been shaped mostly during the period of primordial accretion and the so-called Late Heavy Bombardment, when asteroids carved out massive impact basins and pushed up huge volcanoes.

Scientists now have well-resolved maps of river networks and topography on both Earth and Mars, along with a growing understanding of their respective histories. Perron and Black used this foundation to gain insight into Titan's topographic history.

"We know something about rivers, and something about topography, and we expect that rivers are interacting with topography as it evolves," Black says. "Our goal was to use those pieces to crack the code of what formed the topography in the first place."

Conforming with topography

The team first compiled a map of river networks for Earth, Mars, and Titan. Such maps were previously made by others for Earth and Mars; Black generated a river map for Titan using images taken by Cassini. For all three maps, the researchers marked the direction each river appeared to flow.

They then compared topographic maps for all three planetary bodies, at varying degrees of resolution. Maps of Earth are sharp in detail, as are those for Mars, showing mountain peaks and impact basins in high relief. By contrast, due to Titan's thick, hazy atmosphere, the global map of Titan's topography is extremely fuzzy, showing only the broadest features.
In order to make direct comparisons between topographies, the researchers dialed down the resolution of maps for Earth and Mars, to match the resolution available for Titan. They then superimposed maps of each planetary body's river networks, onto their respective topographies, and marked every river that appeared to flow downhill.

Of course, rivers only flow downhill. But the team observed that rivers might appear to flow uphill, simply because a map at low resolution may not capture finer details such as mountain ranges which would divert a river's flow.

When the researchers tallied the percentage of rivers on Titan that appeared to flow downhill, the number more closely matched with Mars. They also compared what they called "topographic conformity" -- the degree of divergence between a topography's slope and the direction of a river's flow. Here too, they found that Titan resembled Mars over Earth.

"One prediction we can make is that, when we eventually get more refined topographic maps of Titan, we will see topography that looks more like Mars than Earth," Perron says. "Titan might have broad-scale highs and lows, which might have formed some time ago, and the rivers have been eroding into that topography ever since, as opposed to having new mountain ranges popping up all the time, with rivers constantly fighting against them."

**Filling in a picture**

One last question the researchers looked to answer was how cratering due to asteroid impacts on Mars has reshaped its topography.

Black used a simulation that the group previously developed, to model river erosion on Mars with different impact cratering histories. He found that the pattern of river networks on Mars today limits the extent to which cratering has remodeled the surface of Mars. This suggests that the biggest impact craters formed very early in Mars’ history, and that later pummeling by asteroids mostly dented and dinged the surface.

As Cassini's mission is scheduled to come to an end in September, Perron says further investigation of Titan's surface will help to guide future missions to the distant moon.

"Any way of filling in the details of what Titan's surface is like, beyond what we can see directly in the images and topography Cassini has collected, will be valuable for planning a return," Perron says.

Source: Spaceref.com
For the first time, astronomers have detected a magnetic field associated with the Magellanic Bridge, the filament of gas stretching 75 thousand light-years between the Milky Way Galaxy's nearest galactic neighbours: the Large and Small Magellanic Clouds (LMC and SMC, respectively).

Visible in the southern night sky, the LMC and SMC are dwarf galaxies that orbit our home galaxy and lie at a distance of 160 and 200 thousand light-years from Earth respectively,

"There were hints that this magnetic field might exist, but no one had observed it until now," says Jane Kaczmarek, a PhD student in the School of Physics, University of Sydney, and lead author of the paper describing the finding.

Such cosmic magnetic fields can only be detected indirectly, and this detection was made by observing the radio signals from hundreds of very distant galaxies that lie beyond the LMC and SMC. The observations were made with the Australia Telescope Compact Array radio telescope at the Paul Wild Observatory in New South Wales, Australia.

"The radio emission from the distant galaxies served as background 'flashlights' that shine through the Bridge," says Kaczmarek. "Its magnetic field then changes the polarization of the radio signal. How the polarized light is changed tells us about the intervening magnetic field."

A radio signal, like a light wave, oscillates or vibrates in a single direction or plane; for example, waves on the surface of a pond move up and down. When a radio signal passes through a magnetic field, the plane is rotated. This phenomenon is known as Faraday Rotation and it allows astronomers to measure the strength and the polarity--or direction--of the field.
The observation of the magnetic field, which is one millionth the strength of the Earth's, may provide insight into whether it was generated from within the Bridge after the structure formed, or was "ripped" from the dwarf galaxies when they interacted and formed the structure.

"In general, we don't know how such vast magnetic fields are generated, nor how these large-scale magnetic fields affect galaxy formation and evolution," says Kaczmarek. "The LMC and SMC are our nearest neighbours, so understanding how they evolve may help us understand how our Milky Way Galaxy will evolve."

"Understanding the role that magnetic fields play in the evolution of galaxies and their environment is a fundamental question in astronomy that remains to be answered."

The paper is one of a growing number of new results that are building a map of the Universe's magnetism. According to Prof. Bryan Gaensler, Director of the Dunlap Institute for Astronomy & Astrophysics, University of Toronto, and a co-author on the paper, "Not only are entire galaxies magnetic, but the faint delicate threads joining galaxies are magnetic, too. Everywhere we look in the sky, we find magnetism."


The Night Sky

Friday, May 19

• With the Moon gone from the evening sky, can you see the big Coma Berenices star cluster? Does your light pollution really hide it, or do you just not know exactly where to look? It's 2/5 of the way from Denebola (Leo's tail) to the end of the Big Dipper's handle (Ursa Major's tail).

The cluster's brightest members form an inverted Y. The whole group is about 5° wide — a big, dim glow to the unaided eye when seen in a dark sky. It nearly fills a binocular view.

Saturday, May 20

• With summer still a month away (astronomically speaking), the last star of the Summer Triangle rises above the eastern horizon around 10 or 11 p.m. That's Altair, the Triangle's lower right corner. Its highest and brightest corner is Vega. The third is Deneb, less far to Vega's lower left.

Sunday, May 21

• Arcturus, 30° to the upper right of Jupiter after dusk, is the second-brightest point of light on the southern side of the sky. The brightest star low in the northeast is Vega.

Look a third of the way from Arcturus to Vega for the delicate semicircle of Corona Borealis, the Northern Crown, with its brighter gem star Alphecca.

Two thirds of the way from Arcturus to Vega is the dim Keystone of Hercules.

• Telescope challenge: Catch the fast-pulsing star VX Herculis, an old RR-Lyrae-type variable, rising from 11th to 10th magnitude tonight in the course of about an hour (roughly 3:30 May 22nd UT). See our article, comparison-star chart, and timetable in the June Sky & Telescope, page 48.

Monday, May 22

• Look east in early dawn Tuesday morning for Venus with the waning crescent Moon, as shown above. And can you make out Mercury yet? (In these scenes, the Moon is always shown three times its actual apparent size.)

Source: Sky & Telescope  

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# ISS Sighting Opportunities

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Sighting information for other cities can be found at NASA's [Satellite Sighting Information](https://nasa.gov/)

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# NASA-TV Highlights

(All times Eastern Daylight Time)

**Friday, May 19**

1 p.m., 2017 Astronaut Hall of Fame Induction Ceremony (Starts at 1:05 p.m.) (all channels)

4 p.m., 8 p.m., Replay of the 2017 Astronaut Hall of Fame Induction Ceremony (all channels)

6 p.m., 11 p.m, Replay of SpaceCast Weekly (all channels)

**Saturday, May 20**

1 a.m., 2 a.m., 7 a.m., 11 p.m., Replay of the ISS Expedition 51 In-Flight Educational Event with the Space Dynamics Laboratory in North Logan, Utah and ISS Commander Peggy Whitson and Flight Engineer Jack Fischer of NASA (NTV-1 (Public))

3 a.m., Replay of the ISS Expedition 51 In-Flight Educational Event with the Space Dynamics Laboratory in North Logan, Utah and ISS Commander Peggy Whitson and Flight Engineer Jack Fischer of NASA (NTV-3 (Media))

8 a.m., 5 p.m., 8 p.m., Replay of the 2017 Astronaut Hall of Fame Induction Ceremony (all channels)

10 a.m., Replay of STEM in 30: World War I: Legacy, Letters and Belgian War Lace (NTV-1 (Public))

11 a.m., 3 p.m, 7 p.m., Replay of the ISS Expedition 51 In-Flight Educational Event with the Space Dynamics Laboratory in North Logan, Utah and ISS Commander Peggy Whitson and Flight Engineer Jack Fischer of NASA (all channels)

2 p.m., 7 p.m, Replay of SpaceCast Weekly (all channels)
Sunday, May 21

1 a.m., 2 a.m., 7 a.m., Replay of the ISS Expedition 51 In-Flight Educational Event with the Space Dynamics Laboratory in North Logan, Utah and ISS Commander Peggy Whitson and Flight Engineer Jack Fischer of NASA (NTV-1 (Public))

3 a.m., Replay of the ISS Expedition 51 In-Flight Educational Event with the Space Dynamics Laboratory in North Logan, Utah and ISS Commander Peggy Whitson and Flight Engineer Jack Fischer of NASA (NTV-3 (Media))

Watch NASA TV on the Net by going to the NASA website.  

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Space Calendar

- May 19 - [May 12] Juno, Jupiter Flyby
- May 19 - Comet C/2016 A8 (LINEAR) Closest Approach To Earth (2.639 AU)
- May 19 - Comet C/2014 OE4 (PANSTARRS) Closest Approach To Earth (6.247 AU)
- May 19 - Asteroid 3153 Lincoln Closest Approach To Earth (1.680 AU)
- May 19 - Asteroid 15058 Billcooke Closest Approach To Earth (2.608 AU)
- May 19 - Giuseppe Marchesini Memorial Conference, Florence, Italy
- May 20 - Moon Occults Neptune
- May 20 - Comet C/2016 T1 (Matheny) At Opposition (1.578 AU)
- May 20 - Comet 229P/Gibbs Perihelion (2.456 AU)
- May 20 - Comet C/2014 W5 (Lemmon-PANSTARRS) At Opposition (4.219 AU)
- May 20 - Comet C/2015 T2 (PANSTARRS) Perihelion (6.935 AU)
- May 20 - Apollo Asteroid 2017 JO2 Near-Earth Flyby (0.062 AU)
- May 20 - Asteroid 20103 de Vico Closest Approach To Earth (1.277 AU)
- May 20 - Asteroid 6542 Jacquescousteen Closest Approach To Earth (1.347 AU)
- May 20 - Russell Bancroft Law's 130th Birthday (1887)
- May 21 - Gaspard-Gustave de Coriolis' 225th Birthday (1792)
- May 21 - Cassini, Distant Flyby of Atlas, Janus & Aegaeon
- May 22 - Comet 130P/McNaught-Hughes Closest Approach To Earth (1.691 AU)
- May 22 - Comet P/2015 D6 (Lemmon-PANSTARRS) At Opposition (4.528 AU)
- May 22 - Asteroid 1069 Planckia Closest Approach To Earth (2.001 AU)
- May 22 - Asteroid 4115 Peternorton Closest Approach To Earth (2.019 AU)
- May 22 - CASBAA Satellite Industry Forum, Singapore
- May 22 - 5th Anniversary (2012), Katol Meteorite Fall (Hit Houses in India)
- May 22 - 65th Anniversary (1952), Aerobee Launch (Monkeys Patricia & Mike)
- May 23 - Apollo Asteroid 2015 VX105 Near-Earth Flyby (0.072 AU)
- May 23 - [May 17] Apollo Asteroid 2017 JD3 Near-Earth Flyby (0.079 AU)
- May 23 - Amor Asteroid 2017 HO49 Near-Earth Flyby (0.083 AU)
- May 23 - Aten Asteroid 5381 Sekmet Closest Approach To Earth (0.802 AU)
- May 23 - Asteroid 2521 Heidi Closest Approach To Earth (1.697 AU)
- May 23 - Asteroid 4729 De Gasparis Closest Approach To Earth (1.842 AU)
- May 23 - Asteroid 9499 Excalibur Closest Approach To Earth (1.937 AU)
- May 23 - Lecture: Astropy and James Webb Space Telescope, Baltimore, Maryland
- May 23 - Lucy McFadden's 65th Birthday (1952)
Food for Thought

NASA Asks Scientific Community to Think on Possible Europa Lander Instruments

NASA is asking scientists to consider what would be the best instruments to include on a mission to land on Jupiter’s icy moon, Europa.

NASA Wednesday informed the science community to prepare for a planned competition to select science instruments for a potential Europa lander.

While a Europa lander mission is not yet approved by NASA, the agency’s Planetary Science Division has funding in Fiscal Year 2017 to conduct the announcement of opportunity process.

“The possibility of placing a lander on the surface of this intriguing icy moon, touching and exploring a world that might harbor life is at the heart of the Europa lander mission,” said Thomas Zurbuchen, associate administrator of NASA’s Science Mission Directorate in Washington. “We want the community to be prepared for this announcement of opportunity, because NASA recognizes the immense amount of work involved in preparing proposals for this potential future exploration.”

The community announcement provides advance notice of NASA’s plan to hold a competition for instrument investigations for a potential Europa lander mission. Proposed investigations will be evaluated and selected through a two-step competitive process to fund development of a variety of relevant instruments and then to ensure the instruments are compatible with the mission concept.

Approximately 10 proposals may be selected to proceed into a competitive Phase A. The Phase A concept study will be limited to approximately 12 months with a $1.5 million budget per investigation. At the conclusion of these studies, NASA may select some of these concepts to complete Phase A and subsequent mission phases.

Investigations will be limited to those addressing the following science objectives, which are listed in order of decreasing priority:
• Search for evidence of life on Europa
• Assess the habitability of Europa via in situ techniques uniquely available to a lander mission
• Characterize surface and subsurface properties at the scale of the lander

In early 2016, in response to a congressional directive, NASA’s Planetary Science Division began a study to assess the science and engineering design of a future Europa lander mission. NASA routinely conducts such studies -- known as Science Definition Team (SDT) reports -- long before the start of any mission to gain an understanding of the challenges, feasibility and science value of the potential mission. The 21-member team began work almost one year ago, submitting a report to NASA on Feb. 7.

The agency briefed the community on the Europa Lander SDT study at recent town halls at the 2017 Lunar and Planetary Science Conference (LPSC) at The Woodlands, Texas, and the Astrobiology Science Conference (AbSciCon) in Mesa, Arizona.

The proposed Europa lander is separate from and would follow its predecessor -- the Europa Clipper multiple flyby mission – which now is in preliminary design phase and planned for launch in the early 2020s. Arriving in the Jupiter system after a journey of several years, the spacecraft would orbit the planet about every two weeks, providing opportunities for 40 to 45 flybys in the prime mission. The Clipper spacecraft would image Europa’s icy surface at high resolution, and investigate its composition and structure of its interior and icy shell.

Wednesday’s community announcement in no way obligates NASA to solicit future proposals.

To view the Europa Lander Science Definition Team report:

https://solarsystem.nasa.gov/europa/technical.cfm

For more information about NASA’s Europa Clipper mission:

http://www.nasa.gov/europa

Source: NASA
Space Image of the Week

May 18, 1969 - Apollo 10 View of the Earth

**Explanation:** A view of Earth from 36,000 nautical miles away as photographed from the Apollo 10 spacecraft during its trans-lunar journey toward the moon. While the Yucatan Peninsula is obscured by clouds, nearly all of Mexico north of the Isthmus of Tehuantepec can be clearly delineated. The Gulf of California and Baja California and the San Joaquin Valley can be easily identified. Also, the delta of the Rio Grande River and the Texas coast are visible. Note the color differences (greens - east, browns - west) along the 100 degrees meridian.

The crew members on Apollo 10 are astronauts Thomas P. Stafford, commander; John W. Young, command module pilot; and Eugene E. Cernan, lunar module pilot. Astronaut Young remained in lunar orbit, in the Command and Service Module (CSM) "Charlie Brown", while astronauts Stafford and Cernan descended to within nine miles of the lunar surface, in the Lunar Module (LM) "Snoopy".

**Image Credit:** NASA

Source: NASA