Space News Update

— April 18, 2017 —

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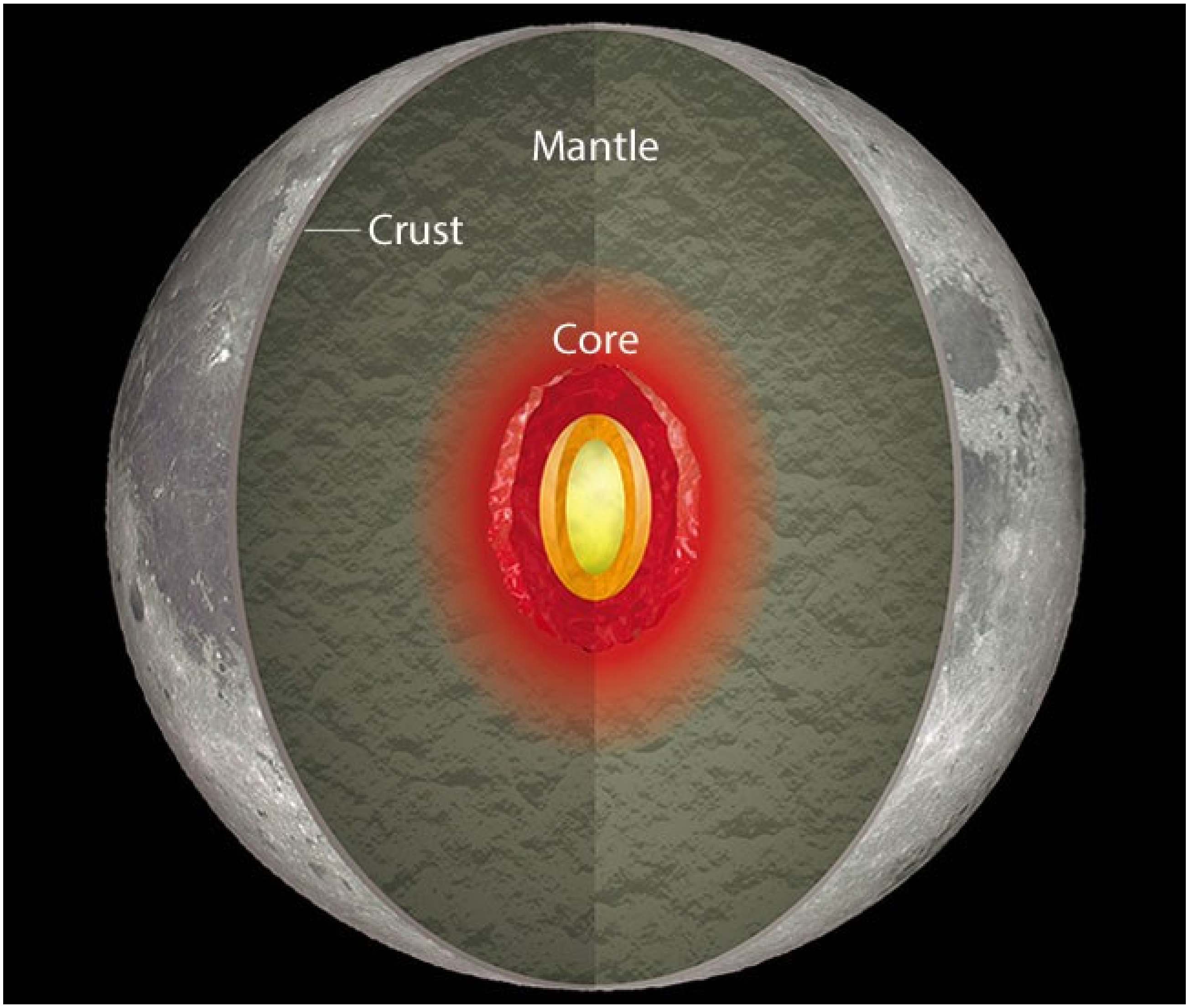
1. Dynamo at Moon's Heart Once Powered Magnetic Field Equal to Earth's



When the Apollo astronauts returned to Earth, they came bearing 380.96 kilograms (839.87 lb) of Moon rocks. From the study of these samples, scientists learned a great deal about the Moon's composition, as well as its history of formation and evolution. For example, the fact that some of these rocks were magnetized revealed that roughly 3 billion years ago, the Moon had a magnetic field.

Much like Earth, this field would have been the result of a dynamo effect in the Moon's core. But until recently, scientists have been unable to explain how the Moon could maintain such a dynamo effect for so long. But thanks to a new study by a team of scientists from the Astromaterials Research and Exploration Science (ARES) Division at NASA's Johnson Space Center, we might finally have a answer.

To recap, the Earth's magnetic core is an integral part of what keeps our planet habitable. Believed to be the result of a liquid outer core that rotates in the opposite direction as the planet, this field protects the surface from much of the Sun's radiation. It also ensures that our atmosphere is not slowly stripped away by solar wind, which is what happened with Mars.

For the sake of their study, which was recently published in the journal Earth and Planetary Science Letters, the ARES team sought to determine how a molten, churning core could generate a magnetic field on the

Moon. While scientists have understood how the Moon's core could have powered such a field in the past, they have been unclear as to how it could have been maintained it for such a long time.

Towards this end, the ARES team considered multiple lines of geochemical and geophysical evidence to put constraints on the core's composition. As Kevin Righter, the lead of the JSC's high pressure experimental petrology lab and the lead author of the study, explained in a NASA press release:

"Our work ties together physical and chemical constraints and helps us understand how the moon acquired and maintained its magnetic field – a difficult problem to tackle for any inner solar system body. We created several synthetic core compositions based on the latest geochemical data from the moon, and equilibrated them at the pressures and temperatures of the lunar interior."

Specifically, the ARES scientists conducted simulations of how the core would have evolved over time, based on varying levels of nickel, sulfur and carbon content. This consisted of preparing powders or iron, nickel, sulfur and carbon and mixing them in the proper proportions – based on recent analyses of Apollo rock samples.

Once these mixtures were prepared, they subjected them to heat and pressure conditions consistent with what exists at the Moon's core. They also varied these temperatures and pressures based on the possibility that the Moon underwent changes in temperature during its early and later history – i.e. hotter during its early history and cooler later on.

What they found was that a lunar core composed of iron/nickel that had a small amount of sulfur and carbon – specifically 0.5% sulfur and 0.375% carbon by weight – fit the bill. Such a core would have a high melting point and would have likely started crystallizing early in the Moon's history, thus providing the necessary heat to drive the dynamo and power a lunar magnetic field.

This field would have eventually died out after heat flow led the core to cool, thus arresting the dynamo effect. Not only do these results provide an explanation for all the paleomagnetic and seismic data we currently have on the Moon, it is also consistent with everything we know about the Moon's geochemical and geophysical makeup.

Prior to this, core models tended to place the Moon's sulfur content much higher. This would mean that it had a much lower melting point, and would have meant crystallization could not have occurred until much more recently in its history. Other theories have been proposed, ranging from sheer forces to impacts providing the necessary heat to power a dynamo.

However, the ARES team's study provides a much simpler explanation, and one which happens to fit with all that we know about the Moon. Naturally, additional studies will be needed before there is any certainty on the issue. No doubt, this will first require that human beings establish a permanent outpost on the Moon to conduct research.

But it appears that for the time being, one of the deeper mysteries of the Earth-Moon system might be resolved at last.

Source: Universe Today Return to Contents

2. NASA inspector general foresees additional SLS/Orion delays

A report from NASA's Office of Inspector General (OIG) April 13 concluded that the first two missions of the Space Launch System rocket and Orion spacecraft will likely slip from their currently scheduled dates.

The report on NASA's human exploration programs, the outcome of a nine-month audit by OIG, also recommended that NASA provide more details about its long-term plans to send humans to Mars, citing constrained budgets and the need to develop a number of key technologies to enable such missions.

NASA's current schedule calls for the launch of the first SLS/Orion mission, Exploration Mission 1 (EM-1), no later than November 2018 without a crew. That would be followed by EM-2, the first SLS/Orion mission to carry astronauts, as soon as August 2021.

The OIG report, though, was skeptical NASA could maintain that schedule. "NASA's first exploration missions – EM-1 and EM-2 – face multiple technical challenges that will likely delay their launch," the report stated.

The report outlines a number of technical challenges that SLS, Orion and associated ground systems are facing that makes it unlikely NASA can maintain its current schedule for those missions. Work on SLS, it said, has consumed nearly all of the 11 months of schedule reserve it originally had. "With only 30 days of schedule reserves available, the SLS Program may be hard pressed to meet a November 2018 launch date," OIG concluded.

Orion also faces issues. "NASA considers Orion to be one of the biggest challenges to meeting the EM-1 flight date of no later than November 2018," the report stated. Delays in the development of the Orion service module, provided by the European Space Agency are the leading factor in the overall Orion delay, as well as technical risks involved with changes in the design of Orion's heat shield.

In addition to SLS and Orion issues, the OIG report stated that work on ground systems at the Kennedy Space Center has only one month of schedule reserve remaining. Development of software needed for SLS, Orion and ground systems have also suffered delays that could delay the first SLS/Orion launch. “We are concerned NASA will not be able to resolve all necessary [exploration systems] software validation and verification efforts in time to meet a November 2018 launch date for EM-1,” OIG said in the report.

Recent events could exacerbate those delays. The report briefly mentions damage from a Feb. 7 tornado that hit the Michoud Assembly Facility in New Orleans. It estimated repairs to Michoud buildings could result in a two-month delay in work on the SLS, whose core stage is built there.

NASA officials have provided similar estimates on the potential delays caused by the tornado. “The tornado probably cost us two to three months,” said Bill Hill, deputy associate administrator for exploration systems development, in a March 29 presentation to the NASA Advisory Council’s Human Exploration and Operations Committee. “We’re still evaluating that and seeing what the options are.”

Another wild card that could delay EM-1 is a decision to put a crew on that first flight. NASA is currently examining such a move, which would delay the mission regardless of other technical issues. The target date for a crewed EM-1 mission is mid-2019, according to ground rules for that study cited in the OIG report.

The report said that, as of early April, the study about putting a crew on EM-1 was still in progress. “To achieve a crewed EM-1 flight, in our judgment NASA must address not only the additional risks associated with human travel but also a host of existing risks to planned missions,” OIG said in the report, citing work needed on Orion’s life support systems and a decision to either human-rate the Interim Cryogenic Propulsion Stage that will be used on EM-1 or accelerate work on the Exploration Upper Stage.

Beyond EM-1 and EM-2, OIG called on the agency to provide more details on future missions and technology requirements needed to enable the long-term goal of human missions to the surface of Mars. Only recently has NASA started to flesh out a manifest of future SLS/Orion missions, primarily for flights through the 2020s to develop a cislunar “gateway” station in preparations for Mars missions.

“While we agree that finalizing requirements for the Journey to Mars through 2046 is impractical at this point in time, we believe that adding more detail to the plan would help NASA focus funding priorities for the systems the Agency will need to develop to accomplish its goals,” the report stated.

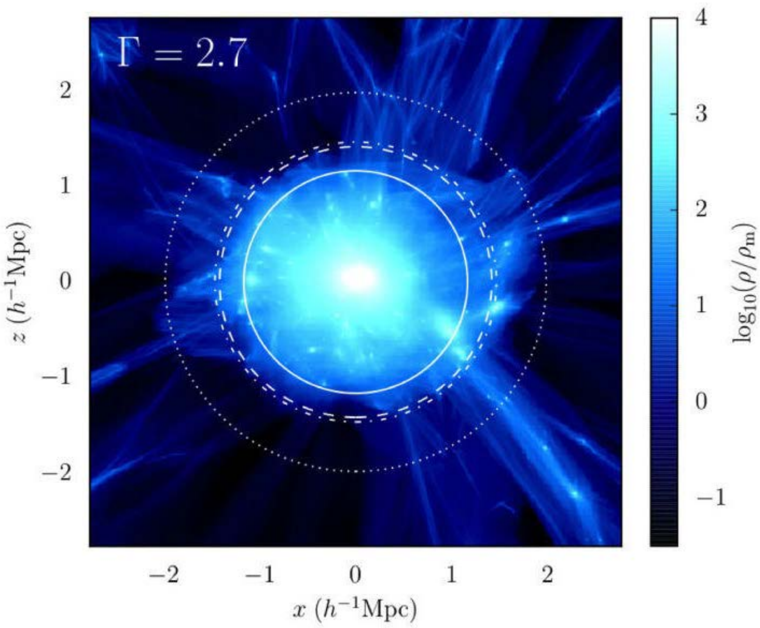
That planning is needed soon because of concerns of a potential shortfall in funding. A comparison of projected budgets for NASA’s exploration programs, assuming they grow at only the rate of inflation, compared to the cost estimate from a Jet Propulsion Laboratory study of one proposed Mars mission architecture, found a gap of $18 billion from 2018 through 2026.

Another factor in that planning is a potential extension of the International Space Station beyond 2024, which could cost NASA $3 to 4 billion a year that would otherwise go to exploration programs.

“Whether to extend the ISS beyond 2024 is a critical decision for NASA and its Journey to Mars, particularly because of the funding shortfalls projected during the 2020s and the need for development of key systems during that time period,” the report argued.

Source: SpaceNews Return to Contents

3. Researchers provide new insight into dark matter halos



Research from the University of Pennsylvania could shed light on the distribution of one of the most mysterious substances in the universe.

In the 1970s, scientists noticed something strange about the motion of galaxies. All the matter at the edge of spiral galaxies was rotating just as fast as material in the inner part of the galaxy. But according to the laws of gravity, objects on the outskirts should be moving slower.

The explanation: A form of matter called dark matter that does not directly interact with light.

Many scientists now believe that more than 80 percent of the matter of the universe is locked away in mysterious, as yet undetected, particles of dark matter, which affect everything from how objects move within a galaxy to how galaxies and galaxy clusters clump together in the first place.

This dark matter extends far beyond the reach of the furthest stars in the galaxy, forming what scientists call a dark matter halo. While stars within the galaxy all rotate in a neat, organized disk, these dark matter particles are like a swarm of bees, moving chaotically in random directions, which keeps them puffed up to balance the inward pull of gravity.

Bhuvnesh Jain, a physics professor in Penn's School of Arts & Sciences, and postdoc Eric Baxter are conducting research that could give new insights into the structure of these halos.

The researchers wanted to investigate whether these dark matter halos have an edge or boundary.

"People have generally imagined a pretty smooth transition from the matter bound to the galaxy to the matter between galaxies, which is also gravitationally attracted to the galaxies and clusters," Jain said. "But theoretically, using computer simulations a few years ago, researchers at the University of Chicago showed that for galaxy clusters a sharp boundary is expected, providing a distinct transition that we should be able to see through a careful analysis of the data."

Scientists believe that this region, or "edge" is due to the "splashback effect."

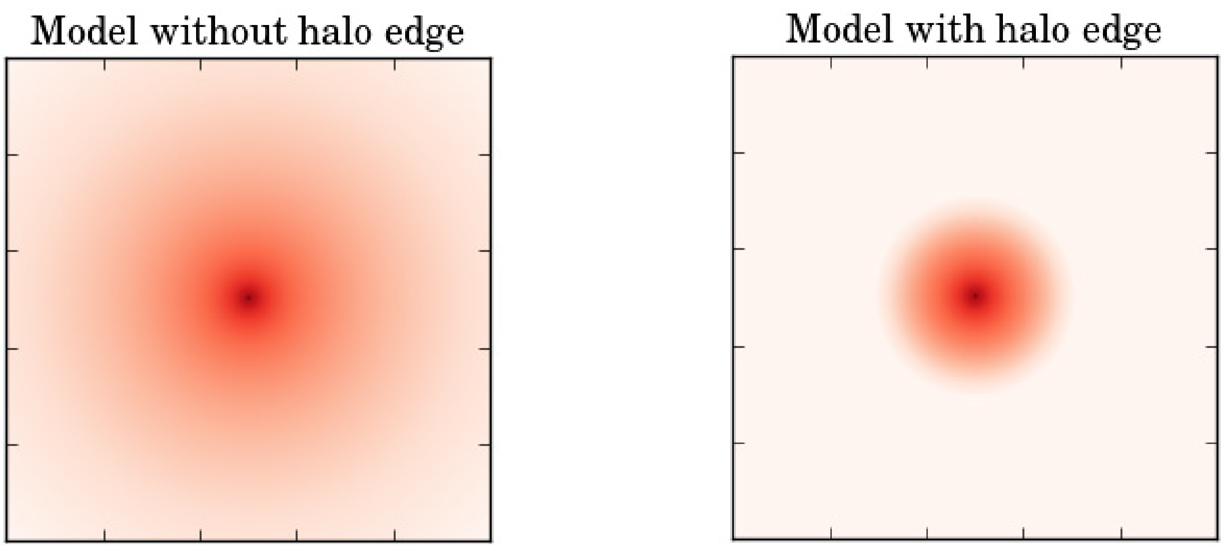
"You have this big dark matter halo sitting there," Baxter said, "and it's been accreting matter gravitationally over its entire history. As that matter gets pulled in, it gets faster and faster. When it finally falls into the halo, it turns around and starts to orbit. That turnaround is what people have started calling splashback, because stuff is splashing back in some sense."

As the matter "splashes back," it slows down. Because this effect is happening in many different directions, it leads to a buildup of matter right at the edge of the halo and a steep fall-off in the amount of matter right outside of that position. This is what the Penn researchers explored in the data.

Using a galaxy survey called the Sloan Digital Sky Survey, or SDSS, Baxter and Jain looked at the distribution of galaxies around clusters. They formed a team of experts at the University of Chicago and other institutions around the world to examine thousands of galaxy clusters. Using statistical tools to do a joint analysis of several million galaxies around them, they found a drop at the edge of the cluster. Baxter and collaborator Chihway Chang at the University of Chicago led a paper reporting the findings, accepted for publication in the *Astrophysical Journal*.

In addition to seeing this edge when they looked at galaxy distribution, the researchers also saw evidence of it in the form of galaxy colors.

When a galaxy is full of gas and forming many big, hot stars, the heat causes it to appear blue when scientists takes images of it.



A two-dimensional comparison of two models for the density profile of a halo. Both of these models come from fitting to data in SDSS. Models with a splashback feature (an "edge") fit the data better than models that don't have an edge. New measurements provide evidence that this "edge" exists. Credit: University of Pennsylvania

"But those big stars live very short lives," Baxter said. "They blow up. What you're left with are these smaller, older stars that live for long periods of time, and those are red."

When scientists look at galaxies within clusters, they appear red because they aren't forming stars.

"Previous studies have shown that there are interactions inside of the cluster that can cause galaxies to stop forming stars," Baxter said. "You could imagine for instance that a galaxy falls into a cluster, and the gas from the galaxy gets stripped off by gas within the cluster. After losing its gas, the galaxy will be unable to form many stars."

Because of this, scientists expect that galaxies that have spent more time orbiting through a cluster will appear red, while galaxies that are just starting to fall in will appear blue.

The researchers noticed a sudden shift in the colors of galaxies right at the boundary, providing them with more evidence that dark matter halos have an edge.

"It was really interesting and surprising to see this sharp change in colors," Jain said, "because the change of galaxy colors is a very slow and complex process."

The researchers are working on another paper using a deeper survey of over a hundred million galaxies called the Dark Energy Survey, or DES.

Both the SDSS and the DES make massive maps of the sky using a huge camera that Jain said isn't very fundamentally different from the cameras in smartphones but bigger and more precise and costing millions of dollars to build.

In the DES, when the camera opens, it takes an exposure of a couple minutes, and then moves to a different part of the sky. This process is repeated during the course of several years using different filters to allow scientists to get a survey in multiple colors.

The DES allows the researchers to do expanded measurements, pushing to higher distances.

Instead of measuring the distribution of galaxies, the researchers are using an astrophysical phenomenon called gravitational lensing to probe the dark matter halos. In gravitational lensing, light coming to an observer bends as matter exerts gravitational force on it.

The researchers can analyze images of the sky to see how clusters stretch images of the galaxies behind them.

"Light is going to bend if there's mass," Baxter said. "By measuring these deflections we can measure the mass directly which is cool because most of the mass is dark matter which we can't see so it's kind of a unique way to probe the dark matter."

In terms of fundamental understanding of the universe, Baxter said, dark matter is one of the biggest mysteries there is right now.

"You look in the sky, even with the biggest optical telescopes, and you see nothing beyond the light of the galaxies," Jain said. "There's just this dark matter."

The researchers hope that their research will contribute to a better understanding of the mysterious substance that makes up about 80 percent of matter in the universe. If they can mark the edge of a dark matter halo, it would allow them to test things like Einstein's theory of gravity and the nature of dark matter.

"It's just a new way of looking at clusters," Jain said. "Once you find the boundary you can study both the standard physics of how galaxies interact with the cluster and the possible unknown physics of what the nature of dark matter and gravity is."

Source: Phys.org

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The Night Sky

Tuesday, April 18

• As twilight fades away, modest Mars glows less than 4° from the Pleiades from now through Sunday.

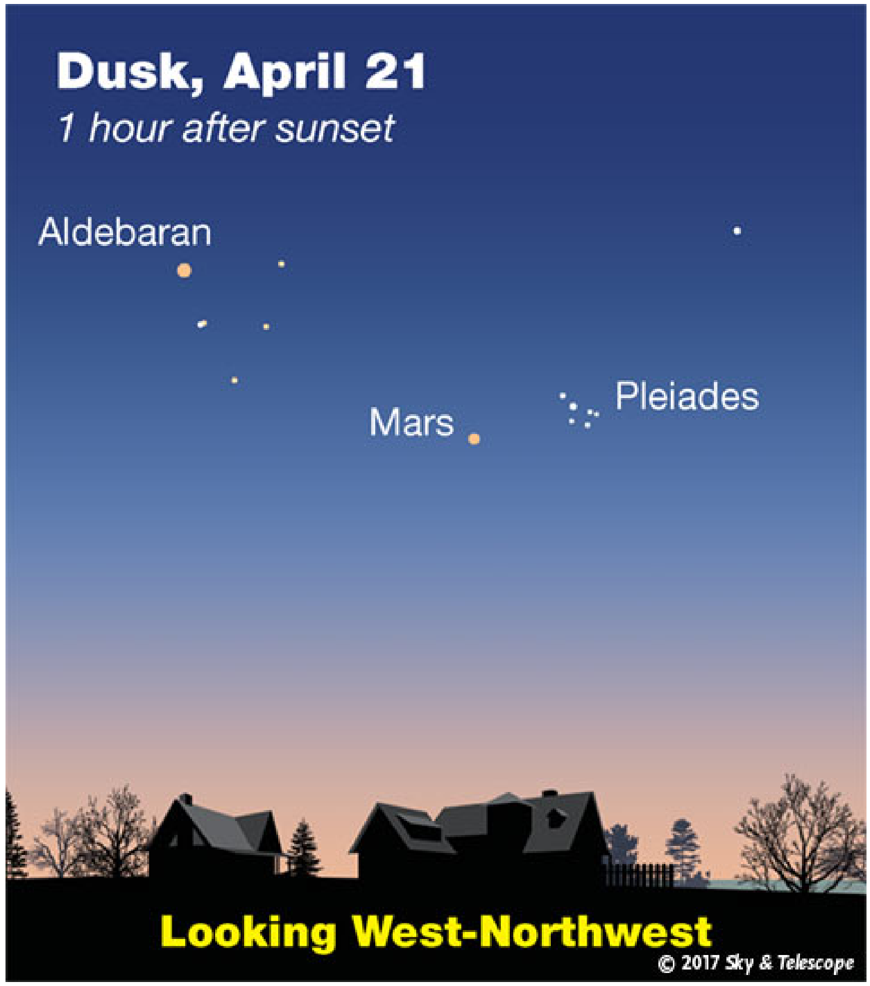
Wednesday, April 19

• Right after dark, the Sickle of Leo stands vertical high due south. Its bottom star is Regulus, Leo's brightest. Leo himself is walking horizontally westward, with the Sickle forming his front leg, chest, mane, and part of his head.

• Last-quarter Moon (exact at 5:57 a.m. EDT this morning.)

Thursday, April 20

• This is the time of year when, as the last of twilight fades away, the bowl of the dim Little Dipper extends straight to the right of Polaris. High above the end-stars of the Little Dipper's bowl, you'll find the end-stars of the Big Dipper's bowl.



Friday, April 21

• As night descends, look high in the west for Pollux and Castor lined up almost horizontally (depending on your latitude). These two stars, the heads of the Gemini twins, form the top of the enormous Arch of Spring. To their lower left is Procyon, the left end of the Arch. Farther to their lower right is the other end, formed by Menkalinan (Beta Aurigae) and then brilliant Capella. The whole thing sinks in the west through the evening.

• The weak Lyrid meteor shower should peak in the hours before Saturday's dawn. The Moon will be only a waning crescent. The shower's peak usually lasts just a few hours, but this year the predicted timing (12h Universal Time April 22) is good for North America, especially the West.

Source: Sky & Telescope Return to Contents

ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Tue Apr 18, 8:09 PM	< 1 min	10°	10° above SW	10° above SW
Mon May 1, 5:37 AM	< 1 min	10°	10° above SE	10° above SE

Sighting information for other cities can be found at NASA's Satellite Sighting Information

NASA-TV Highlights
(all times Eastern Daylight Time)

- **2:30 p.m., Tuesday, April 18 -** Orbital ATK Cygnus Post-Launch News Conference (all channels)
- **4 p.m., 8 p.m., 10 p.m., Tuesday, April 18 -** Replay of the Orbital ATK Cygnus Post-Launch News Conference (all channels)
- **3 p.m., Wednesday, April 19 -** Replay of the Russian State Commission Meeting and Final ISS Expedition 51-52 Pre-Launch Crew News Conference in Baikonur, Kazakhstan (Fischer, Yurchikhin) (all channels)
- **2 a.m., Thursday, April 20 -** ISS Expedition 51-52/Soyuz MS-04 Launch Coverage (Fischer, Yurchikhin; launch scheduled at 3:13 a.m. ET; includes video B-roll of the crew's launch day pre-launch activities at 2:25 a.m. ET) (starts at 2:15 a.m.) (all channels)
- **5 a.m., Thursday, April 20 -** Video File of ISS Expedition 51-52/Soyuz MS-04 (Fischer, Yurchikhin) Pre-Launch and Launch Video and Post-Launch Interviews (all channels)
- **8:30 a.m., Thursday, April 20 -** ISS Expedition 51-52/Soyuz MS-04 Docking to the ISS Coverage (Fischer, Yurchikhin; docking scheduled at 9:23 a.m. ET) (all channels)
- **10:30 a.m., Thursday, April 20 -** ISS Expedition 51-52/Soyuz MS-04 Hatch Opening and Welcoming Ceremony (Fischer, Yurchikhin; hatch opening scheduled at appx. 11:05 a.m. ET) (starts at 10:45 a.m.) (all channels)
- **1:30 p.m., Thursday, April 20 -** Video File of ISS Expedition 51-52/Soyuz MS-04 Docking, Hatch Opening and Other Activities (all channels)

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

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Space Calendar

- Apr 18 - [Apr 16] OA-7 (S.S. John Glenn)/ Atlas 5 Launch (International Space Station)
- Apr 18 - Cassini, Orbital Trim Maneuver #469 (OTM-469)
- Apr 18 - Asteroid 11949 Kagayayutaka Occults HIP 42353 (6.5 Magnitude Star)
- Apr 18 - Apollo Asteroid 143404 (2003 BD44) Near-Earth Flyby (0.056 AU)
- Apr 18 - Apollo Asteroid 2006 HE2 Near-Earth Flyby (0.062 AU)
- Apr 18 - Asteroid 1743 Schmidt Closest Approach To Earth (1.152 AU)
- Apr 18 - Asteroid 1193 Africa Closest Approach To Earth (1.360 AU)
- Apr 18 - Asteroid 416 Vaticana Closest Approach To Earth (1.389 AU)
- Apr 18 - Asteroid 7536 Fahrenheit Closest Approach To Earth (1.848 AU)
- Apr 18 - Charles Elachi's 70th Birthday (1947)
- Apr 18 - Brian Mason's 100th Birthday (1917)
- Apr 19 - Cassini, Distant Flyby of Methone, Aegaeon, Atlas, Pandora & Daphnis
- Apr 19 - Comet 251P/LINEAR At Opposition (0.916 AU)
- Apr 19 - Comet C/2015 ER61 (PANSTARRS) Closest Approach To Earth (1.178 AU)
- Apr 19 - Apollo Asteroid 2014 JO25 Near-Earth Flyby (0.012 AU)
- Apr 19 - Aten Asteroid 2014 UR Near-Earth Flyby (0.048 AU)
- Apr 19 - [Apr 15] Amor Asteroid 2017 GK7 Near-Earth Flyby (0.085 AU)
- Apr 19 - Asteroid 11083 Caracas Closest Approach To Earth (1.556 AU)
- Apr 19 - 35th Anniversary (1982), Salyut 7 Space Station Launch
- Apr 19 - Glenn Seaborg's 105th Birthday (1912)
- Apr 19 - Grigory Shajn's 125th Birthday (1892)
- Apr 20 - [Apr 13] Soyuz MS-4 Soyuz-2.1.a Launch (International Space Station 50S)
- Apr 20 - Comet 103P/Hartley Perihelion (1.064 AU)
- Apr 20 - Comet 212P/NEAT At Opposition (1.740 AU)
- Apr 20 - Comet 103P/Hartley Closest Approach To Earth (2.062 AU)
- Apr 20 - Apollo Asteroid 2017 GM4 Near-Earth Flyby (0.034 AU)
- Apr 20 - Amor Asteroid 2017 GL4 Near-Earth Flyby (0.045 AU)
- Apr 20 - Amor Asteroid 4957 Brucemurray Closest Approach To Earth (1.141 AU)
- Apr 20 - Asteroid 11926 Orinoco Closest Approach To Earth (1.684 AU)
- Apr 20 - Asteroid 8722 Schirra Closest Approach To Earth (2.068 AU)
- Apr 20 - Asteroid 246913 Slocum Closest Approach To Earth (2.114 AU)
- Apr 21 - Comet 73P-AC/Schwassmann-Wachmann Perihelion (0.968 AU)
- Apr 21 - Comet C/2013 X1 (PANSTARRS) At Opposition (3.709 AU)
- Apr 21 - Apollo Asteroid 2016 UW80 Near-Earth Flyby (0.072 AU)
- Apr 21 - Asteroid 1704 Wachmann Closest Approach To Earth (1.049 AU)
- Apr 21 - Asteroid 5799 Brewington Closest Approach To Earth (1.931 AU)
- Apr 21 - 20th Anniversary (1997), Cremated Remains of 24 People Launched into Space
- Apr 21 - 315th Anniversary (1702) - Maria Margarethe Kirch Becomes 1st Woman to Discover a Comet (C/1702 H1)

Source: JPL Space Calendar

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Food for Thought

Washington State University physicists create 'negative mass'

Washington State University physicists have created a fluid with negative mass, which is exactly what it sounds like. Push it, and unlike every physical object in the world we know, it doesn't accelerate in the direction it was pushed. It accelerates backwards.

The phenomenon is rarely created in laboratory conditions and can be used to explore some of the more challenging concepts of the cosmos, said Michael Forbes, a WSU assistant professor of physics and astronomy and an affiliate assistant professor at the University of Washington. The research appears today in the journal *Physical Review Letters*, where it is featured as an "Editor's Suggestion."

Hypothetically, matter can have negative mass in the same sense that an electric charge can be either negative or positive. People rarely think in these terms, and our everyday world sees only the positive aspects of Isaac Newton's Second Law of Motion, in which a force is equal to the mass of an object times its acceleration, or F=ma. In other words, if you push an object, it will accelerate in the direction you're pushing it. Mass will accelerate in the direction of the force.

"That's what most things that we're used to do," said Forbes, hinting at the bizarreness to come. "With negative mass, if you push something, it accelerates toward you."

Conditions for negative mass

He and his colleagues created the conditions for negative mass by cooling rubidium atoms to just a hair above absolute zero, creating what is known as a Bose-Einstein condensate. In this state, predicted by Satyendra Nath Bose and Albert Einstein, particles move extremely slowly and, following the principles of quantum mechanics, behave like waves. They also synchronize and move in unison as what is known as a superfluid, which flows without losing energy.

Led by Peter Engels, WSU professor of physics and astronomy, researchers on the sixth floor of Webster Hall created these conditions by using lasers to slow the particles, making them colder, and allowing hot, high energy particles to escape like steam, cooling the material further.

The lasers trapped the atoms as if they were in a bowl measuring less than a hundred microns across. At this point, the rubidium superfluid has regular mass. Breaking the bowl will allow the rubidium to rush out, expanding as the rubidium in the center pushes outward.

To create negative mass, the researchers applied a second set of lasers that kicked the atoms back and forth and changed the way they spin. Now when the rubidium rushes out fast enough, if behaves as if it has negative mass. "Once you push, it accelerates backwards," said Forbes, who acted as a theorist analyzing the system. "It looks like the rubidium hits an invisible wall."

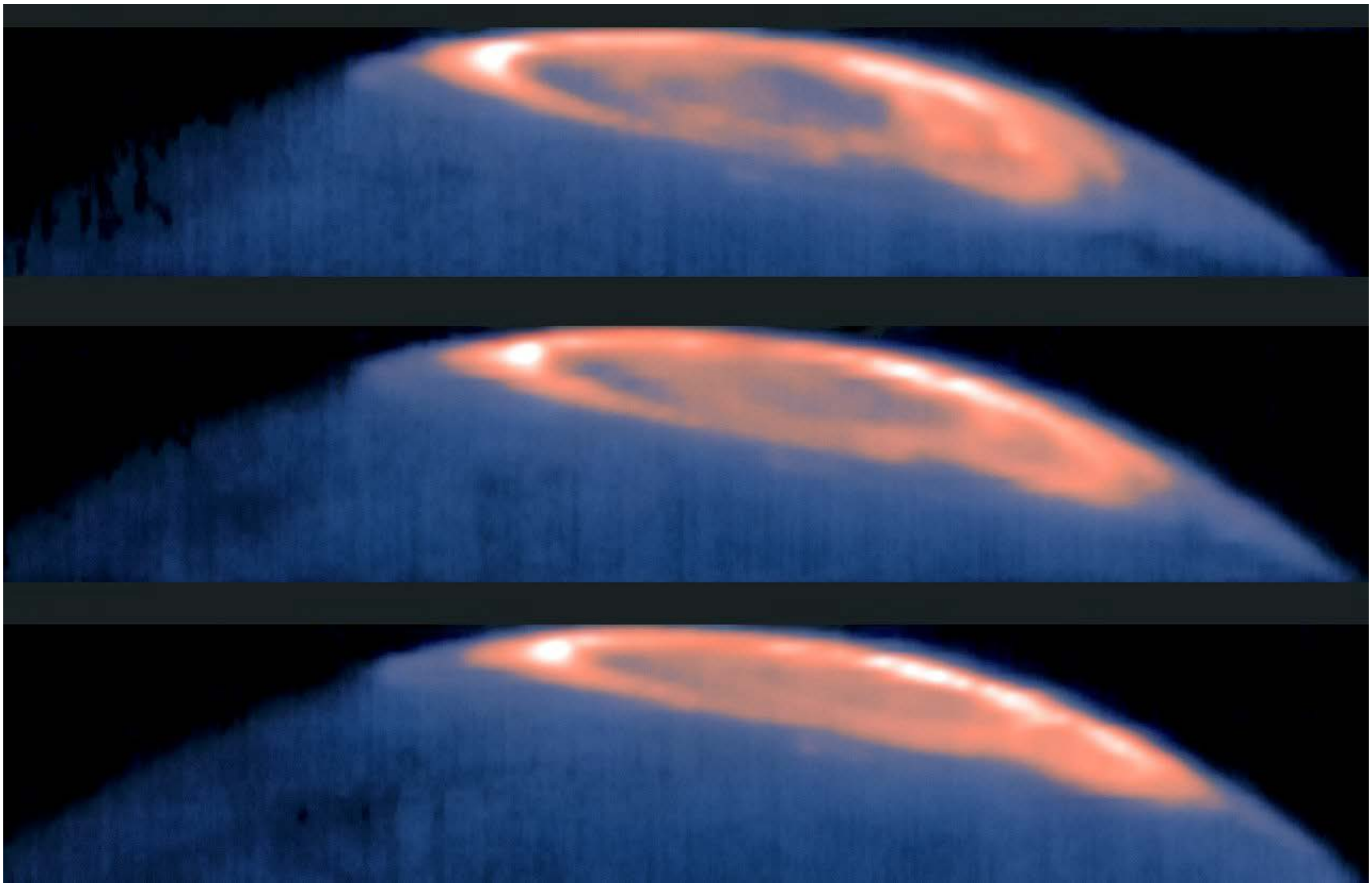
Avoiding underlying defects

The technique used by the WSU researchers avoids some of the underlying defects encountered in previous attempts to understand negative mass.

"What's a first here is the exquisite control we have over the nature of this negative mass, without any other complications" said Forbes. Their research clarifies, in terms of negative mass, similar behavior seen in other systems. This heightened control gives researchers a new tool to engineer experiments to study analogous physics in astrophysics, like neutron stars, and cosmological phenomena like black holes and dark energy, where experiments are impossible. "It provides another environment to study a fundamental phenomenon that is very peculiar," Forbes said.

Source: EurekAlert Return to Contents

Space Image of the Week



Great Cold Spot discovered on Jupiter

So big it could engulf several Earths, Jupiter's Great Red Spot is a gigantic storm that has been raging for centuries with winds blasting at over 600 kilometres per hour. But it has a rival: astronomers have discovered that Jupiter has a second Great Spot, this time a cold one.

In the polar regions of the planet, astronomers using the CRIRES instrument on ESO's Very Large Telescope, along with other facilities, have found a dark spot in the upper atmosphere (below the aurora to the left) about 200 °C cooler than its surroundings. Aptly nicknamed the "Great Cold Spot", this intriguing feature is comparable in size to the Great Red Spot — 24 000 km across and 12 000 km tall. But data taken over 15 years show that the Great Cold Spot is much more volatile than its slowly-changing cousin. It changes dramatically in shape and size over days and weeks — but never disappears, and always stays roughly in the same location.

The Great Cold Spot is thought to be caused by the planet's powerful aurorae, which drive energy into the atmosphere in the form of heat that flows around the planet. This creates a cooler region in the upper atmosphere, making the Great Cold Spot the first weather system ever observed to be generated by aurorae.

Source: ESO

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