Space News Update

— March 14, 2017 —

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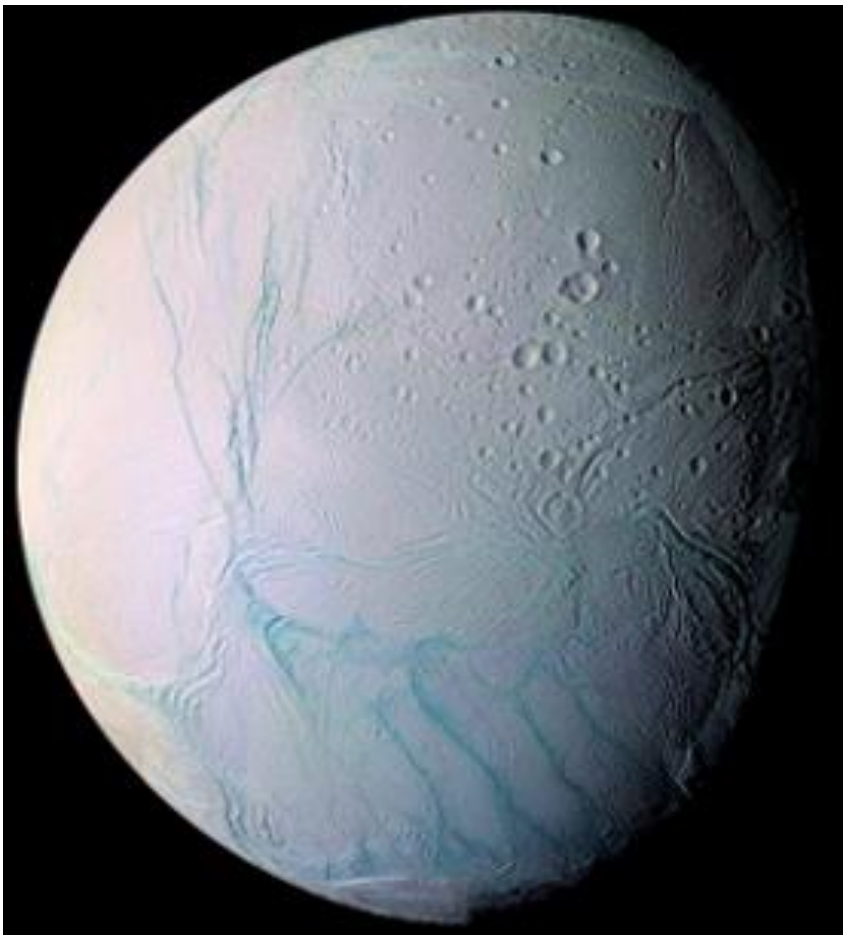
1. Enceladus' South Pole is Warm under the Frost



False-color image of Enceladus highlighting the tiger stripes in blue.
Credit: NASA/JPL/Space Science Institute

Over the past decade, the international Cassini mission has revealed intense activity at the southern pole of Saturn's icy moon, Enceladus, with warm fractures venting water-rich jets that hint at an underground sea. A new study, based on microwave observations of this region, shows that the moon is warmer than expected just a few metres below its icy surface. This suggests that heat is produced over a broad area in this polar region and transported under the crust, and that Enceladus' reservoir of liquid water might be lurking only a few kilometres beneath.

In 2005, observations by the NASA/ESA/ASI Cassini mission revealed plumes of water vapor and ice spraying into space from the south pole of Enceladus, the sixth-largest moon of Saturn. These jets originate from the so-called 'tiger stripes' – four warm fractures in the moon's icy surface. The salty composition of these jets points to an underground sea of liquid water that might interact with Enceladus' rocky core, similar to the sub-surface ocean that is thought to exist on Jupiter's moon, Europa.

Many of Cassini's flybys of Enceladus have been dedicated to understanding the structure of the interior of this fascinating body and its potentially habitable water reservoir. Now, a study based on data collected during a close flyby in 2011 indicates that the moon's hidden sea might be closer to the surface than previously thought.

"During this flyby, we obtained the first and, unfortunately, only high-resolution observations of Enceladus' south pole at microwave wavelengths," says Alice Le Gall from Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS), and Université Versailles Saint-Quentin (UVSQ), France. Alice is an associate member of the Cassini RADAR instrument team and the lead scientist of the new study, published today in *Nature Astronomy*.

"These observations provide a unique insight into what is going on beneath the surface. They show that the first few metres below the surface of the area that we investigated, although at a glacial 50-60 K, are much warmer than we had expected: likely up to 20 K warmer in some places," she adds

"*This cannot be explained only as a result of the Sun's illumination and, to a lesser extent, Saturn's heating so there must be an additional source of heat.*"

The detected heat appears to be lying under a much colder layer of frost, as no similar anomaly was found in infrared observations of the same region – these probe the temperature of the surface but are not sensitive to what is underneath.

The observations used by Alice and her collaborators cover a narrow, arc-shaped swathe of the southern polar region, about 500 km long and 25 km wide, and located just 30 km to 50 km north of the tiger-stripe fractures. Because of operational constraints of the 2011 flyby, it was not possible to obtain microwave observations of the active fractures themselves. This had the benefit of allowing the scientists to observe that the thermally anomalous terrains of Enceladus extend well beyond the tiger stripes.

"*The thermal anomaly we see at microwave wavelengths is especially pronounced over three fractures that are not unlike the tiger stripes, except that they don't seem to be the source of jets at the moment*," Alice says.

These seemingly dormant fractures lying above the warm, underground sea point to a dynamic character of Enceladus' geology: the moon may have experienced several episodes of activity at different locations during its past history.

Even if the observations cover only a small patch of the southern polar terrains, it is likely that the entire region is warm underneath and Enceladus' ocean could be a mere 2 km under the icy surface. The finding agrees well with the results of a recent study, led by Ondrej Cadek and published in 2016, which estimated the thickness of the crust on Enceladus. With an average depth of 18–22 km, the ice shell appears to reduce to less than 5 km at the south pole.

Alice and her collaborators think that the underground heating source is linked to the tidal cycle of the moon along its eccentric orbit around Saturn. This induces stress compressions and deformations on the crust, leading to the formation of faults and fractures while at the same time heating up the sub-surface layers. In this scenario, the thinner icy crust in the south pole region is subject to a larger tidal deformation that, in turn, releases more heat and contributes to maintaining the underground water in liquid form.

"This discovery opens new perspectives to investigate the emergence of habitable conditions on the icy moons of the gas giant planets," says Nicolas Altobelli, ESA's Project Scientist for Cassini–Huygens.

"If Enceladus' underground sea is really as close to the surface as this study indicates, then a future mission to this moon carrying an ice-penetrating radar sounding instrument might be able to detect it."

Source: NASA/ESA Return to Contents

2. Ancient Stardust Sheds Light on the First Stars

This artist's impression shows what the very distant young galaxy A2744_YD4 might look like. Observations using ALMA have shown that this galaxy, seen when the Universe was just 4% of its current age, is rich in dust. Such dust was produced by an earlier generation of stars and these observations provide insights into the birth and explosive deaths of the very first stars in the Universe. Credit: ESO/M. Kornmesser

Astronomers have used ALMA to detect a huge mass of glowing stardust in a galaxy seen when the Universe was only four percent of its present age. This galaxy was observed shortly after its formation and is the most distant galaxy in which dust has been detected. This observation is also the most distant detection of oxygen in the Universe. These new results provide brand-new insights into the birth and explosive deaths of the very first stars.

An international team of astronomers, led by Nicolas Laporte of University College London, have used the Atacama Large Millimeter/submillimeter Array (ALMA) to observe A2744_YD4, the youngest and most remote galaxy ever seen by ALMA. They were surprised to find that this youthful galaxy contained an abundance of interstellar dust — dust formed by the deaths of an earlier generation of stars.

Follow-up observations using the X-shooter instrument on ESO's Very Large Telescope confirmed the enormous distance to A2744_YD4. The galaxy appears to us as it was when the Universe was only 600 million years old, during the period when the first stars and galaxies were forming.

"Not only is A2744_YD4 the most distant galaxy yet observed by ALMA," comments Nicolas Laporte, "but the detection of so much dust indicates early supernovae must have already polluted this galaxy."

Cosmic dust is mainly composed of silicon, carbon and aluminum, in grains as small as a millionth of a centimeter across. The chemical elements in these grains are forged inside stars and are scattered across the cosmos when the stars die, most spectacularly in supernova explosions, the final fate of short-lived, massive stars. Today, this dust is plentiful and is a key building block in the formation of stars, planets and complex molecules; but in the early Universe — before the first generations of stars died out — it was scarce.

The observations of the dusty galaxy A2744_YD4 were made possible because this galaxy lies behind a massive galaxy cluster called Abell 2744. Because of a phenomenon called gravitational lensing, the cluster acted like a giant

cosmic "telescope" to magnify the more distant A2744_YD4 by about 1.8 times, allowing the team to peer far back into the early Universe.

The ALMA observations also detected the glowing emission of ionized oxygen from A2744_YD4. This is the most distant, and hence earliest, detection of oxygen in the Universe, surpassing another ALMA result from 2016.

The detection of dust in the early Universe provides new information on when the first supernovae exploded and hence the time when the first hot stars bathed the Universe in light. Determining the timing of this "cosmic dawn" is one of the holy grails of modern astronomy, and it can be indirectly probed through the study of early interstellar dust.

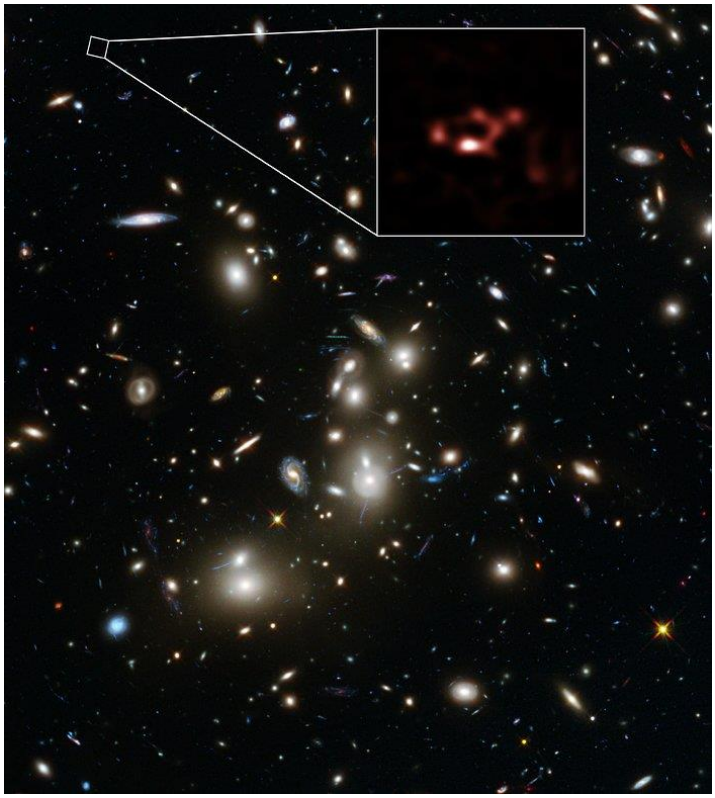
The team estimates that A2744_YD4 contained an amount of dust equivalent to 6 million times the mass of our Sun, while the galaxy's total stellar mass — the mass of all its stars — was 2 billion times the mass of our Sun. The team also measured the rate of star formation in A2744_YD4 and found that stars are forming at a rate of 20 solar masses per year — compared to just one solar mass per year in the Milky Way.

"This rate is not unusual for such a distant galaxy, but it does shed light on how quickly the dust in A2744_YD4 formed," explains Richard Ellis (ESO and University College London), a co-author of the study. "Remarkably, the required time is only about 200 million years — so we are witnessing this galaxy shortly after its formation."

This means that significant star formation began approximately 200 million years before the epoch at which the galaxy is being observed. This provides a great opportunity for ALMA to help study the era when the first stars and galaxies "switched on" — the earliest epoch yet probed. Our Sun, our planet and our existence are the products — 13 billion years later — of this first generation of stars. By studying their formation, lives and deaths, we are exploring our origins.

"With ALMA, the prospects for performing deeper and more extensive observations of similar galaxies at these early times are very promising," says Ellis.

And Laporte concludes: "Further measurements of this kind offer the exciting prospect of tracing early star formation and the creation of the heavier chemical elements even further back into the early Universe."



This image is dominated by a spectacular view of the rich galaxy cluster Abell 2744 from the NASA/ESA Hubble Space Telescope.

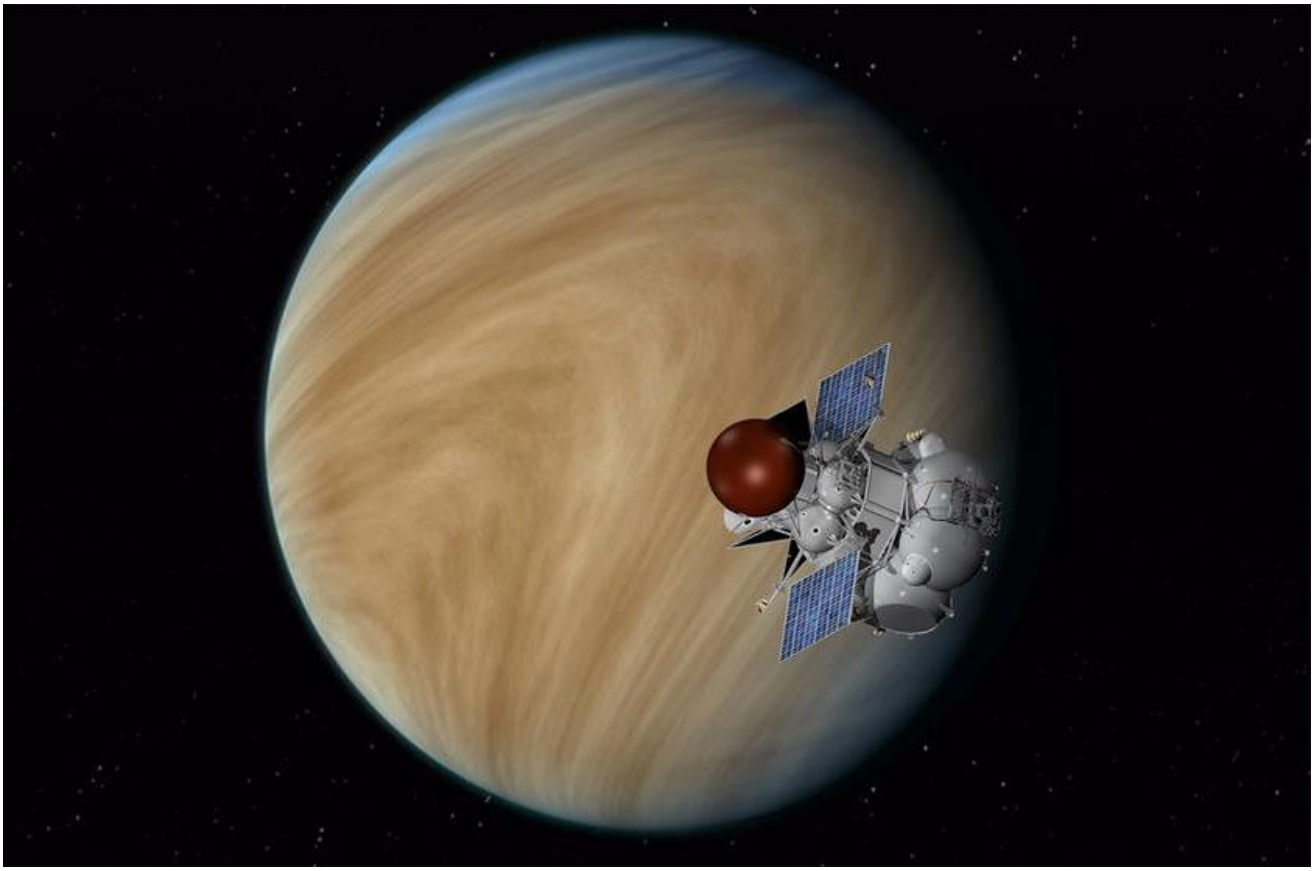
But, far beyond this cluster, and seen when the Universe was only about 600 million years old, is a very faint galaxy called A2744_YD4.

New observations of this galaxy with ALMA, shown in red, have demonstrated that it is rich in dust.

Credit: ALMA (ESO/NAOJ/NRAO), NASA, ESA, ESO and D. Coe (STScI)/J. Merten (Heidelberg/Bologna)

Source: European Southern Observatory/AstronomyNow.com Return to Contents

3. NASA Studying Shared Venus Science Objectives with Russian Space Research Institute



The Russian Academy of Sciences' Space Research Institute (IKI) Venera-D mission concept includes a Venus orbiter that would operate for up to three years, and a lander designed to survive the incredibly harsh conditions a spacecraft would encounter on Venus' surface for a few hours. Credits: NASA/JPL-Caltech

A team of NASA-sponsored scientists will meet with the Russian Academy of Sciences' Space Research Institute (IKI) next week to continue work on a Joint Science Definition Team study focused on identifying shared science objectives for Venus exploration. The visit comes after a report was recently delivered to both NASA Headquarters in Washington and IKI in Moscow, assessing and refining the science objectives of the IKI Venera-D (Venera-Dolgozhivuschaya) Mission to Venus, Earth's closest planetary neighbor.

"While Venus is known as our 'sister planet,' we have much to learn, including whether it may have once had oceans and harbored life," said Jim Green, director of the Planetary Science Division at NASA Headquarters in Washington. "By understanding the processes at work at Venus and Mars, we will have a more complete picture about how terrestrial planets evolve over time and obtain insight into the Earth's past, present and future."

Venus has intrigued scientists for decades. Similar to Earth in composition and size, it spins slowly in the opposite direction. The rocky world's thick atmosphere traps heat in a runaway greenhouse effect, making it the warmest planet in our solar system with surface temperatures hot enough to melt lead. Glimpses below the clouds reveal volcanoes and an intricate landscape. Venus is named for the Roman goddess of love and beauty, the counterpart to the Greek goddess Aphrodite.

"On a solar-system scale, Earth and Venus are very close together and of similar size and makeup," said David Senske, co-chair of the U.S. Venera-D science definition team, and a scientist at NASA's Jet Propulsion

Laboratory in Pasadena, California. "Among the goals that we would like to see if we can accomplish with such a potential partnership is to understand how Venus' climate operates so as to understand the mechanism that has given rise to the rampant greenhouse effect we see today."

The IKI Venera-D mission concept as it stands today would include a Venus orbiter that would operate for up to three years, and a lander designed to survive the incredibly harsh conditions a spacecraft would encounter on Venus' surface for a few hours. The science definition team is also assessing the potential of flying a solar-powered airship in Venus' upper atmosphere. The independent flying vehicle could be released from the Venera-D lander, enter the atmosphere, and independently explore Venus' atmosphere for up to three months.

NASA first visited Venus when the JPL-managed Mariner 2 collected data during a flyby in December 1962. NASA's last dedicated mission to explore Venus was Magellan. Launched in 1990, and managed by JPL, Magellan used radar to map 98 percent of the planet at a resolution of 330 feet (100 meters) or better during its four-year mission.

The Venera spacecraft program is the only one to date to successfully land on Venus and survive its harsh environment. Said Adriana Ocampo, who leads the Joint Science Definition Team at NASA Headquarters in Washington, "This potential collaboration makes for an enriching partnership to maximize the science results from Venera-D, and continue the exploration of this key planet in our solar system."

Source: NASA

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Earth's Twisted Sister: How Will We Reveal Venus' Secrets?

If a distant civilization searched our Solar System for potentially habitable planets, using the same criteria we do, then Venus would be front page news for them. It's on the edge of the habitable zone and it has an atmosphere. But we know better. Venus is a hellish world, hot enough to melt lead, with crushing atmospheric pressure and acid rain falling from the sky. Even so, Venus still holds secrets we need to reveal.

Chief among those secrets is, "Why did Venus develop so differently?

Conditions on Venus pose unique challenges. The history of Venus exploration is littered with melted Soviet Venera Landers. Orbital probes like Pioneer 12 and Magellan have had more success recently, but Venus' dense atmosphere still limits their effectiveness. Advances in materials, and especially in electronic circuitry that can withstand Venus' heat, have buoyed our hopes of exploring the surface of Venus in greater detail.

At the Planetary Science Vision 2050 Workshop 2017, put on by the Lunar and Planetary Institute (LPI) a team from the Southwest Research Institute (SWRI) examined the future of Venus exploration. The team was led by James Cutts from JPL.

Since the Vision 2050 Workshop is all about the next 50 years, Cutts and his team looked at the challenges posed by Venus' unique conditions, and how they could answer questions in the near-term, mid-term, and long-term.

Near Term Exploration (Present to 2019)

Near-Term goals for the exploration of Venus include improved remote-sensing from orbital probes. This will tell us more about the gravity and topography of Venus. Improved radar imaging and infrared imaging will fill in more blanks. The team also promoted the idea of a sustained aerial platform, a deep probe, and a short duration lander. Multiple probes/dropsondes are also part of the plan.

Dropsondes are small devices that are released into the atmosphere to measure winds, temperature, and humidity. They're used on Earth to understand the weather, and extreme phenomena like hurricanes, and can fulfill the same purpose at Venus.

In the near-term, missions whose final destination is not Venus can also answer questions. Fly-bys by craft such as Bepi-Colombo, Solar Probe Plus, and the Solar Orbiter missions can give us good information on their way to Mercury and the Sun respectively. These missions will launch in 2018.

The ESO's Venus Express and Japan's Akatsuki, (Venus Climate Orbiter), have studied Venus' climate in detail, especially its chemistry and the interactions between the atmosphere and the surface. Venus Express ended in 2015, while Akatsuki is still there.

Mid-Term Exploration (2020-2024)

The mid-term goals are more ambitious. They include a long-term lander to study Venus' geophysical properties, a short-duration tessera lander, and two balloons.

The tesserae lander would land in a type of terrain found on Venus known as tesserae. We think that at one time, Venus had liquid water on it. The fundamental evidence for this may lie in the tesserae regions, but the terrain is extremely rough. A short duration lander that could land and operate in the tesserae regions would help us answer Venus' liquid water question.

Thanks to the continued development of heat-hardy electronics, a long-term duration lander (months or more) is becoming more feasible in the mid-term. Ideally, any long-term mobile lander would be able to travel tens to hundreds of kilometers, in order to acquire a regional sample of Venus' surface. This is the only way to take geochemistry and mineralogy measurements at multiple sites.

On Mars the landers are solar-powered. Venus' thick atmosphere makes that impossible. But the same dense atmosphere that prohibits solar power might offer another solution: a sail-powered rover. Old-fashioned sail power might hold the key to moving around on the surface of Venus. Because the atmosphere is so dense, only a small sail would be necessary.

Long-Term Exploration (2025 and Beyond)

The long-term goals from Cutts and his team are where things get really interesting. A long-lived surface rover is still on the list, or possibly a near-surface craft like a balloon. Also on there is a long-lived seismic network.

A seismic network would really start to reveal the secrets behind Venus' geophysical life. Whereas a lander would give us estimates of seismic activity, they would be crude compared to what a network of seismic sensors would reveal about Venus' inner workings. A more thorough understanding of quake mechanisms and locations would really get the theorists buzzing. But it's the final thing on the list that would be the end-goal. A sample-return mission.

We're getting good at in situ measurements on other worlds. But for Venus, and for all the other worlds we have visited or want to visit, a sample return is the Holy Grail. The Apollo missions brought back hundreds of kilograms of lunar samples. Other sample-return missions have been sent to Phobos, which failed, and to asteroids, with varying degrees of success.

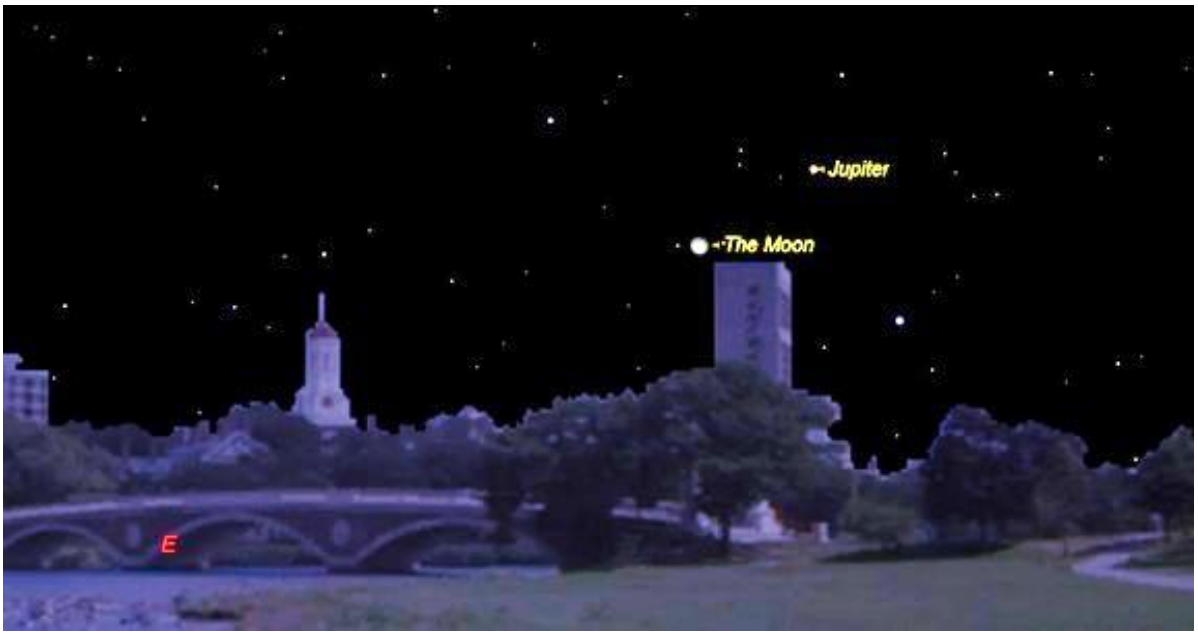
Subjecting a sample to the kind of deep analysis that can only be done on labs here on Earth is the end-game. We can keep analyzing samples as we develop new technologies to examine them with. Science is iterative, after all.

The 2003 Planetary Science Decadal Survey identified the importance of a sample return mission to Venus' atmosphere. A balloon would float aloft in the clouds, and an ascending rocket would launch a collected sample back to Earth. According to Cutts and his team, this kind of sample-return mission could act as a stepping stone to a surface sample mission.

A surface sample would likely be the pinnacle of achievement when it comes to understanding Venus. But like most of the proposed goals for Venus, we'll have to wait awhile.

Source: Universe Today Return to Contents

The Night Sky



Starting in late evening on Tuesday, March 14, Jupiter and the waning gibbous moon will rise together in the eastern sky about 9:40 pm local time. Credit: Space.com

Tuesday, March 14

- Jupiter, Spica, and the waning gibbous Moon form a triangle that rises in the east around 9 or 10 p.m. tonight.
- Algol shines at its minimum brightness, magnitude 3.4 instead of its usual 2.1, for roughly two hours centered on 9:24 p.m. Pacific Daylight Time.

Wednesday, March 15

- The tiny black shadow of Jupiter's moon Europa crosses the planet's face tonight from 10:48 p.m. to 1:17 a.m. EDT, with Europa itself following behind from 11:55 p.m. to 2:16 a.m. EDT. Subtract 1 hour from these times to get CDT, 2 hours to get MDT, 3 hours to get PDT.

Thursday, March 16

- We've entered the time of year when Orion declines in the southwest after dark, with his Belt turning horizontal. But when does Orion's Belt appear *exactly* horizontal? That depends on where you're located east-west in your time zone, *and* on your latitude.
- Can you time this event? If you're near your time zone's standard longitude, expect it around 9:10 this evening. . . more or less.

Friday, March 17

- On the traditional divide between the winter and spring sky is the dim constellation Cancer. It lies between Gemini to its west and Leo to its east. Dim it may be, but Cancer holds something unique: the Beehive Star Cluster, M44, in its middle. The Beehive shows dimly to the naked eye if you have little or no light pollution. With binoculars, it's a snap even from fairly polluted areas. Look for it a little less than halfway from Pollux in Gemini to Regulus in Leo.

Source: Sky and Telescope Return to Contents

ISS Sighting Opportunities (from Denver

Date	Visible	Max Height	Appears	Disappears
Wed Mar 15, 5:43 AM	2 min	11°	10° above NNW	10° above NNE
Thu Mar 16, 4:52 AM	< 1 min	10°	10° above NNE	10° above NNE
Thu Mar 16, 6:27 AM	3 min	19°	10° above NNW	16° above NE
Fri Mar 17, 5:35 AM	3 min	14°	10° above NNW	12° above NE
Sat Mar 18, 4:44 AM	< 1 min	11°	11° above NNE	10° above NNE

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

NASA-TV Highlights **(all times Eastern Time Zone)**

Friday, March 17

- 10:30 a.m. - ISS Expedition 50 Educational In-Flight Event with the Clay Center for the Arts and Sciences in Charleston, West Virginia and Commander Shane Kimbrough and Flight Engineer Peggy Whitson of NASA (Starts at 10:25a.m.) (all channels)

Watch NASA TV online by going to the NASA website.

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Space Calendar

- **Mar 14 - Pi Day**
- **Mar 14 - Cassini, Distant Flyby of Epimetheus & Pandora**
- Mar 14 - Comet C/2017 C1 (NEOWISE) Closest Approach To Earth (0.959 AU)
- Mar 14 - Comet P/2015 X6 (PANSTARRS) At Opposition (1.744 AU)
- Mar 14 - Apollo Asteroid 2017 EK3 Near-Earth Flyby (0.027 AU)
- Mar 14 - Apollo Asteroid 2017 EU2 Near-Earth Flyby (0.032 AU)
- Mar 14 - Aten Asteroid 2005 ES70 Near-Earth Flyby (0.056 AU)
- Mar 14 - Atira Asteroid 2015 DR215 Closest Approach To Earth (0.529 AU)
- Mar 14 - Asteroid 2343 Siding Spring Closest Approach To Earth (1.891 AU)
- Mar 14 - Asteroid 83360 Catalina Closest Approach To Earth (2.235 AU)
- **Mar 15 - IGS Radar 5 H-2A Launch**
- Mar 15 - Comet 73P-Q/Schwassmann-Wachmann At Opposition (0.712 AU)
- Mar 15 - Comet 73P-AV/Schwassmann-Wachmann Perihelion (0.972 AU)
- Mar 15 - Comet 73P-AH/Schwassmann-Wachmann Closest Approach To Earth (1.083 AU)
- Mar 15 - Apollo Asteroid 9162 Kwiila Closest Approach To Earth (0.533 AU)
- Mar 15 - Asteroid 5441 Andymurray Closest Approach To Earth (2.079 AU)
- **Mar 16 - Echostar 23 Falcon 9 Launch**
- Mar 16 - Mercury Passes 9.5 Degrees From Venus
- Mar 16 - Comet 73P/Schwassmann-Wachmann Perihelion (0.972 AU)
- Mar 16 - Comet 73P-L/Schwassmann-Wachmann Closest Approach To Earth (1.048 AU)
- Mar 16 - Comet 73P-AN/Schwassmann-Wachmann Closest Approach To Earth (1.050 AU)
- Mar 16 - Comet 73P-BT/Schwassmann-Wachmann Perihelion (0.972 AU)
- Mar 16 - Comet C/2016 S1 (PANSTARRS) Perihelion (2.412 AU)
- Mar 16 - Comet P/2012 O1 (McNaught) At Opposition (3.953 AU)
- Mar 16 - Apollo Asteroid 2017 EE4 Near-Earth Flyby (0.018 AU)
- Mar 16 - Apollo Asteroid 1998 SL36 Near-Earth Flyby (0.021 AU)
- Mar 16 - Amor Asteroid 4055 Magellan Closest Approach To Earth (1.275 AU)
- Mar 16 - Asteroid 2191 Uppsala Closest Approach To Earth (2.109 AU)
- Mar 16 - Asteroid 13897 Vesuvius Closest Approach To Earth (3.403 AU)
- Mar 16 - 55th Anniversary (1962), 1st Titan 2 Rocket Launch
- **Mar 17 - Wideband Gapfiller Satellite 9 (WGS-9) Delta 4 Launch**
- Mar 17 - Comet 73P-C/Schwassmann-Wachmann Perihelion (0.972 AU)
- Mar 17 - Comet 73P-G/Schwassmann-Wachmann Perihelion (0.972 AU)
- Mar 17 - Comet 73P-X/Schwassmann-Wachmann Closest Approach To Earth (1.042 AU)
- Mar 17 - Comet P/2000 R2 (LINEAR) At Opposition (3.957 AU)
- Mar 17 - Comet C/2016 C1 (PANSTARRS) At Opposition (7.789 AU)
- Mar 17 - Apollo Asteroid 2017 EG3 Near-Earth Flyby (0.011 AU)

Source: JPL Space Calendar

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Food for Thought

Find New Worlds, Film an Eclipse & Do Some Citizen Science!

A very blue Neptune-like planet, dubbed Planet 9, may be lurking dozens of times further from the sun than Pluto, as depicted in this artist's rendering. Citizen scientists who join the Backyard Worlds: Planet 9 project may be the first to spot it. NASA / Caltech

Do you ever feel an itch to understand the universe a little better, be part of something greater, and just do some science? I get to learn and write about science for a living, yet I still have a hankering to get my hands dirty from time to time.

Well, hanker no more, science has us covered. Citizen science has long proven a boon to astronomers as data continues to pour in, and sometimes even the smartest computer algorithms stumble on problems that human eyes and brains solve without a second thought.

Here are some up-and-coming projects that you can get involved in, listed in order of effort involved, from "armchair astronomy" to "going pro."

Citizen Science: Backyard Worlds & Planet 9

This project, based on data from the Wide-field Infrared Survey Explorer (WISE), is part of the larger Zooniverse group of citizen science initiatives. If you're familiar with Galaxy Zoo and PlanetHunters, then you already know how Backyard Worlds works: you'll undergo simple training via a tutorial then be set loose to categorize images.

The project's goal is stated in its name: to discover worlds in the Sun's backyard. Brown dwarfs, for example, should be numerous in the solar neighborhood, betraying their existence by their faint infrared glow. But the main lure is to discover the putative Planet 9. This planet, which could be as much as 10 times Earth's mass, might orbit the Sun at 1,000 times the Earth-Sun distance. Astronomers posited its existence due to a weird alignment in the far-out orbit of Kuiper Belt worlds, so we don't have a good idea of where it is. But Planet 9, if it exists, should also glow dimly with infrared radiation.

WISE mapped the entire infrared sky several times over during the course of its 7-year primary mission. In doing so, it discovered 750 million sources — far too many to hand off to a graduate student, and filled with imaging artifacts that confuse computer algorithms.

To find the needles in this enormous haystack, motion will be key. Nearby sources will move across the sky compared to more distant stars in the background. Citizen scientists will have the fun job of watching a flipbook of the infrared universe to catch the movements that betray new worlds in our backyard.

For more information and to get started, visit the Backyard Worlds: Planet 9 website.

Total Solar Eclipse: The Megamovie

You'll have to wait to participate in the next two citizen science projects, because the real action won't happen until August 21st, the day a total solar eclipse briefly becomes visible across the continental U.S. But now's the time to learn about the projects and decide if and how you want to get involved.

For any given location on eclipse day, totality will last under three minutes. Even those flying along the path won't extend their view longer than five minutes. But if you tally together the observations from across the country, totality will last a full hour and a half. That's a good length of time to study an ephemeral phenomenon and get a rare glimpse of the Sun's outer atmosphere. (The corona is visible to ground-based solar telescopes if a coronagraph blocks out the Sun's glare, but lower layers of the corona remain difficult to see except during a total solar eclipse.)

The Eclipse Megamovie Project, led by Hugh Hudson (University of California, Berkeley) and Scott McIntosh (National Center for Atmospheric Research's High Altitude Observatory), and funded by Google's Making & Science Initiative, aims to create two versions of eclipse movie. The first requires some training, as well as a digital single-lens reflex (DSLR) with a zoom lens of at least 300mm, plus a tripod and the ability to record their GPS location and time to within a second in coordinated universal time (UTC).

But anyone with a smartphone can also participate. The team will make an app available to help users take time-coded photos of the eclipse and upload them for inclusion in a second, much lower-resolution movie.

A first version of the megamovie will be available mere hours after the eclipse wraps up, though higher-resolution versions of the movie, analysis, and science results will come later. "The movie is a tool for scientific exploration," Hudson said in a recent press release. "We'll be collecting this level of data for the first time."

To find out more about the project and how you can participate, visit the Eclipse Megamovie Project website.

Total Solar Eclipse, Take 2: Citizen Cate

The megamovie project won't be the only ones filming the eclipse. The Citizen Continental America Telescopic Eclipse (CATE) experiment will also create a 90-minute movie of the eclipse to specific standards. (See *Sky & Telescope*'s February 2016 article: Citizen Science for the Great American Solar Eclipse.)

Compared to the Megamovie project, where observers will be scattered all along the path of totality, Citizen CATE is more of a relay race. Sixty trained observers will be stationed along specific points along totality, each one "handing off" the lunar shadow to the next one in line. CATE is providing equipment and training, so that all observations will be made with nearly identical telescopes. You can read more about the specific science goals of the experiment at Citizen CATE's website.

Solar relay: The planned observing sites for the Citizen CATE Experiment (yellow dots) are spaced to provide continuous observation of the solar corona as the Moon's shadow whisks across the continent from Oregon to South Carolina. S&T: Gregg Dinderman, Source: National Solar Observatory

Observers for the primary sites have already been selected: 24 university groups are involved, as well as 16 high schools, 7 informal education groups and about 12 citizen scientists. But you can still join the project! If you are interested in purchasing a telescope to become a CATE site, visit the Citizen CATE website to find out what next steps to take.

Exoplanet Data Made Public

This illustration represents GJ 411b, one of more than 100 candidate exoplanets found using radial velocity data from the HIRES instrument on the Keck 10-meter telescope.
Ricardo Ramirez

If you're ready to graduate from citizen science to Science with a capital "S", this next data trove is for you.

Before Kepler and its bevy of transiting-planet discoveries, there was radial velocity. Astronomers discovered hundreds of planets by the gravitational tugs they make on their host stars, the wobbling stars' spectral lines shifting blueward and then redward as they move toward and away from Earth.

Now a team led by the Carnegie Institution for Science is releasing a two-decade program that made almost 61,000 measurements of more than 1,600 stars, looking for these radial velocity shifts. Using statistical analysis, the team has already discovered more than 100 planets, but now they are making the data public for further finds.

Admittedly, the dataset and software package aren't exactly for average Jane and Joe Citizen. Professional astronomers will make great use of this data, combining it with existing data of their own or applying for follow-up observations. But if you're an astronomy enthusiast who also happens to like data analysis (and in this era of Big Data, you're not alone!) then you might want to take some time with the online tutorial and give it a go.

Source: Sky and Telescope Return to Contents

Space Image of the Week

Three Rockets Launched within Hours Explore Auroras over Alaska

Credit: NASA/Terry Zaperach

Explanation: Two NASA sounding rockets are launched 90-seconds apart into an active aurora from the Poker Flat Research Range in Alaska. Three NASA rockets carrying instruments into active auroras over Alaska to aid scientists studying the northern lights and the interactions of the solar wind with Earth's upper atmosphere and ionosphere were launched within a nearly two-hour period March 2, 2017.

The instruments were successfully carried on Black IX sounding rockets from the Poker Flat Research Range north of Fairbanks. The first two rockets were launched nearly simultaneously as part of the Neutral Jets in Auroral Arcs mission. The third rocket launched at 2 was part of the Ionospheric Structuring: In Situ and Groundbased Low Altitude StudieS or ISINGLASS mission.

Preliminary reports indicate that data was received from instruments aboard all three rockets.

Neutral Jet scientists at NASA's Goddard Space Center in Greenbelt, Maryland, explain that electric fields drive the ionosphere, which, in turn, are predicted to set up enhanced neutral winds within an aurora arc. This experiment seeks to understand the height-dependent processes that create localized neutral jets within the aurora.

Kristina Lynch, ISINGLASS principal investigator from Dartmouth College in Hanover, New Hampshire, said, "The visible light produced in the atmosphere as aurora is the last step of a chain of processes connecting the solar wind to the atmosphere. We are seeking to understand what structure in these visible signatures can tell us about the electrodynamics of processes higher up."

Source: NASA

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