Space News Update

— October 2, 2018 —

Contents

In the News

Story 1:

A Universe Aglow

Story 2:

Martian Moon May Have Come from Impact on Home Planet, New Study Suggests

Story 3:

Gaia Spots Stars Flying Between Galaxies

Departments

The Night Sky

ISS Sighting Opportunities

NASA-TV Highlights

Space Calendar

Food for Thought

Space Image of the Week

1. A Universe Aglow

Deep observations made with the MUSE spectrograph on ESO's Very Large Telescope have uncovered vast cosmic reservoirs of atomic hydrogen surrounding distant galaxies. The exquisite sensitivity of MUSE allowed for direct observations of dim clouds of hydrogen glowing with Lyman-alpha emission in the early Universe — revealing that almost the whole night sky is invisibly aglow. Credit: ESA/Hubble & NASA, ESO/ Lutz Wisotzki et al.

MUSE spectrograph reveals that nearly the entire sky in the early Universe is glowing with Lyman-alpha emission.

An unexpected abundance of Lyman-alpha emission from atomic hydrogen in the Hubble Ultra Deep Field (HUDF) region was discovered by an international team of astronomers using the MUSE instrument on ESO's Very Large Telescope (VLT). The discovered emission covers nearly the entire field of view — leading the team to extrapolate that almost all of the sky is invisibly glowing with Lyman-alpha emission from the early Universe [1].

Astronomers have long been accustomed to the sky looking wildly different at different wavelengths, but the extent of the observed Lyman-alpha emission was still surprising. *"Realizing that the whole sky glows in optical*

when observing the Lyman-alpha emission from distant clouds of hydrogen was a literally eye-opening surprise," explained Kasper Borello Schmidt, a member of the team of astronomers behind this result.

"*This is a great discovery!*" added team member Themiya Nanayakkara. "*Next time you look at the moonless night sky and see the stars, imagine the unseen glow of hydrogen: the first building block of the universe, illuminating the whole night sky*."

The HUDF region the team observed is an otherwise unremarkable area in the constellation of Fornax (the Furnace), which was famously mapped by the NASA/ESA Hubble Space Telescope in 2004, when Hubble spent more than 270 hours of precious observing time looking deeper than ever before into this region of space.

The HUDF observations revealed thousands of galaxies scattered across what appeared to be a dark patch of sky, giving us a humbling view of the scale of the Universe. Now, the outstanding capabilities of MUSE have allowed us to peer even deeper. The detection of Lyman-alpha emission in the HUDF is the first time astronomers have been able to see this faint emission from the gaseous envelopes of the earliest galaxies. This composite image shows the Lyman-alpha radiation in blue superimposed on the iconic HUDF image.

MUSE, the instrument behind these latest observations, is a state-of-the-art integral field spectrograph installed on Unit Telescope 4 of the VLT at ESO's Paranal Observatory [2]. When MUSE observes the sky, it sees the distribution of wavelengths in the light striking every pixel in its detector. Looking at the full spectrum of light from astronomical objects provides us with deep insights into the astrophysical processes occurring in the Universe [3].

"*With these MUSE observations, we get a completely new view on the diffuse gas 'cocoons' that surround galaxies in the early Universe*," commented Philipp Richter, another member of the team.

The international team of astronomers who made these observations have tentatively identified what is causing these distant clouds of hydrogen to emit Lyman-alpha, but the precise cause remains a mystery. However, as this faint omnipresent glow is thought to be ubiquitous in the night sky, future research is expected to shed light on its origin.

"*In the future, we plan to make even more sensitive measurements,*" concluded Lutz Wisotzki, leader of the team. "*We want to find out the details of how these vast cosmic reservoirs of atomic hydrogen are distributed in space.*"

Notes

[1] Light travels astonishingly quickly, but at a finite speed, meaning that the light reaching Earth from extremely distant galaxies took a long time to travel, giving us a window to the past, when the Universe was much younger.

[2] Unit Telescope 4 of the VLT, Yepun, hosts a suite of exceptional scientific instruments and technologically advanced systems, including the Adaptive Optics Facility, which was recently awarded the 2018 Paul F. Forman Team Engineering Excellence Award by the American Optical Society.

[3] The Lyman-alpha radiation that MUSE observed originates from atomic electron transitions in hydrogen atoms which radiate light with a wavelength of around 122 nanometers. As such, this radiation is fully absorbed by the Earth's atmosphere. Only red-shifted Lyman-alpha emission from extremely distant galaxies has a long enough wavelength to pass through Earth's atmosphere unimpeded and be detected using ESO's ground-based telescopes.

Source: European Southern Observatory Return to Contents

2. Martian Moon May Have Come from Impact on Home Planet, New Study Suggests

Phobos, the larger of Mars' two tiny satellites, is the darkest moon in the solar system. This dark aspect inspired the hypothesis that the close-orbiting moon may be a captured asteroid, but its orbital dynamics seemed to disagree. A new study suggests Phobos' composition may be more like the volcanic crust of the Red Planet than it appears, consistent with an origin for the moon in an ancient, violent impact on Mars. Credit: G. Neukum (FU Berlin) et al./ Mars Express/ DLR/ ESA; Acknowledgement: Peter Masek

The weird shapes and colors of the tiny Martian moons Phobos and Deimos have inspired a long-standing debate about their origins.

The dark faces of the moons resemble the primitive asteroids of the outer solar system, suggesting the moons might be asteroids caught long ago in Mars' gravitational pull. But the shapes and angles of the moons' orbits do not fit this capture scenario.

A fresh look at 20-year-old data from the Mars Global Surveyor mission lends support to the idea the moons of Mars formed after a large impact on the planet threw a lot of rock into orbit, according to a new study in the *Journal of Geophysical Research: Planets,* a publication of the American Geophysical Union.

The dataset held unplumbed clues to the stuff Phobos is made of, which may be more similar to the crust of the Red Planet than it appears, according to the study's authors.

"The fun part for me has been taking a poke at some of the ideas out there using an old dataset that's has been underutilized," said Tim Glotch, a geoscientist at Stony Brook University in New York and the lead author of the new study.

Marc Fries, a planetary scientists and curator of cosmic dust at NASA's Johnson Space Center, who was not involved in the new study, said the inability to explain the genesis of two moons around a neighboring planet is a glaring shortcoming in scientists' understanding of moon formation. Clearing it up will help with interpretations of how other moons and planets formed in our solar system and beyond. The new study does not clinch the mystery, but it is a step in the right direction, he said.

"The issue of the origins of Phobos and Deimos is a fun sort of mystery, because we have two competing hypotheses that cannot both be true," Fries said. "I would not consider this to be a final solution to the mystery of the moons' origin, but it will help keep the discussion moving forward."

Dark objects -- The debate over the origin of Mars' moons has split scientists for decades, since the early days of planetary science. In visible light, Phobos and Deimos look much darker than Mars, lending weight to the adoption hypothesis.

Scientists study the mineral composition of objects by breaking the light they reflect into component colors with a spectrophotometer, creating distinctive visual "fingerprints." By comparing the spectral fingerprints of planetary surfaces to a library of spectra for known materials, they can infer the composition of these distant objects. Most of the research into the composition of asteroids has examined their spectra in visible light and in near-infrared light, which is just beyond human vision on the red side of the visible spectrum.

In visible and near-infrared light, Phobos and D-class asteroids look much the same—that is, both their spectra are nearly featureless because they are so dark. D-class asteroids are nearly black as coal because, like coal, they contain carbon. This dark aspect of Phobos led to the hypothesis that the moon is a captive asteroid that flew a little too close to Mars.

But scientists looking at the orbits of Mars' moons argued they could not have been captured. These scientists believe the moons must have formed at the same time as Mars, or resulted from a massive impact on the planet during its formative millennia.

"If you talk to the people who are really good at orbital dynamics and figuring out why certain bodies orbit the way they do, they say that, given the inclination and the details of Phobos' orbit, it's almost impossible that it was captured. So you have the spectroscopists saying one thing and the dynamicists saying something else," Glotch said.

Heat fingerprints -- Glotch decided to look at the problem in a different light: the mid-infrared, which is in the same range as body temperature. He looked at the heat signature of Phobos captured in 1998 by an instrument he describes as a fancy thermometer carried on the Mars Global Surveyor. The robotic spacecraft spent most of its lifetime looking down at Mars, but took a quick look at Phobos when it passed near the moon before settling into a closer orbit around the planet.

Heat energy, like visible light, can be split into a spectrum of "colors." Even objects that look black in visible light may glow in a distinctive infrared spectrum. Although Phobos is very cold, its heat spectrum has a discernable signature.

Glotch and his students compared the mid-infrared spectra of Phobos glimpsed by the Mars Global Explorer to samples of a meteorite that fell to Earth near Tagish Lake, British Columbia, which some scientists have suggested is a fragment of a D-class asteroid, and other rock types. In the lab, they subjected their samples to Phobos-like conditions of cold vacuum, heating them from above and below to simulate the extreme changes in temperature from the sunny to the shady sides of airless objects in space.

"We found, at these wavelength ranges, the Tagish Lake meteorite doesn't look anything like Phobos, and in fact what matches Phobos most closely, or at least one of the features in the spectrum, is ground-up basalt, which is a common volcanic rock, and it's what most of the Martian crust is made out of," Glotch said. "That leads us to believe that perhaps Phobos might be a remnant of an impact that occurred early on in Martian history."

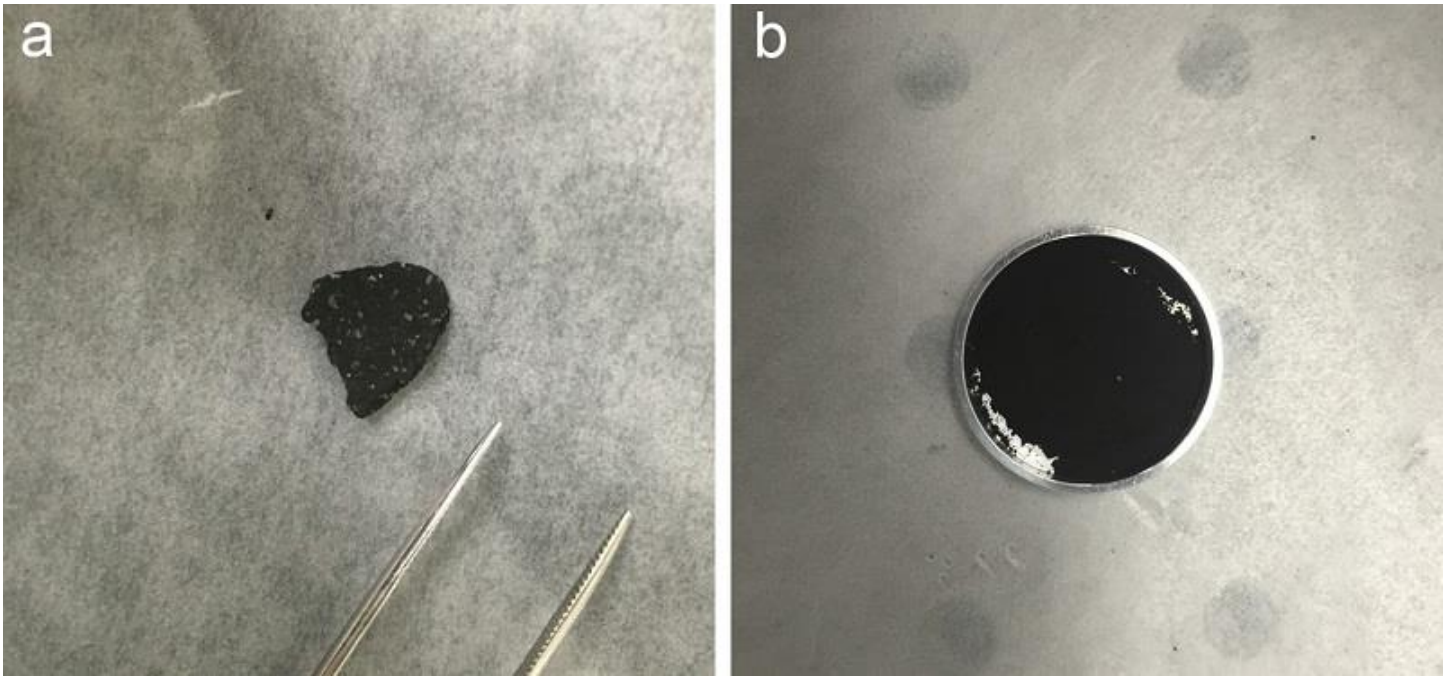
Planetary crust baked in? -- The new study does not argue Phobos is made entirely of material from Mars, but the new results are consistent with the moon containing a portion of the planet's crust, perhaps as an amalgamation of debris from the planet and the remnants of the impacting object.

Fries, the scientist who was not involved in the new study, said the Tagish Lake meteorite is unusual, and perhaps not the best example of a D-class asteroid available for a compelling comparison with Phobos. Fries added the new study was unlikely to be able to produce a definitive answer because Phobos is subject to space weathering, which affects its reflectance spectrum and is difficult to replicate in the lab.

But Fries said he found it interesting that a mix of basalt and carbon-rich material made an appropriate match for Phobos. Another possibility is that carbon-rich space dust in the vicinity of Mars has collected on the close-orbiting moons, darkening their surfaces, he said.

Scientists may get their answer to Phobos' origins in the next couple of years, if the Martian Moon eXploration spacecraft and the OSIRIS-Rex and Hayabusa2 asteroid explorers complete their missions to collect samples and return them to Earth for analysis. Hyabusa2 landed two mini robots on the asteroid known as Ryugu on September 21.

"The really cool thing is that this is a testable hypothesis, because the Japanese are developing a mission called MMX that is going to go to Phobos, collect a sample and bring it back to Earth for us to analyze," Glotch said.

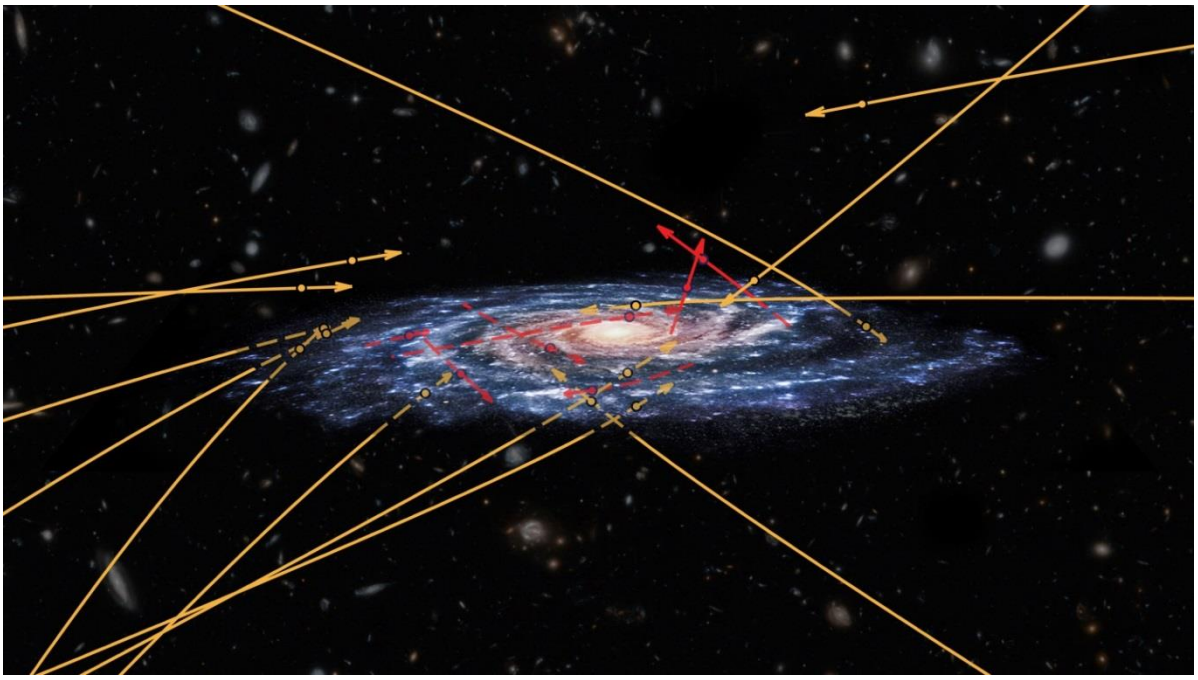


The new study compared mid-infrared spectra from a chip from the Tagish Lake meteoroid whole (right) and ground-up (left) to spectra collected from Phobos by the Mars Global Explorer spacecraft in 1998. *Credit: AGU*

Source: American Geophysical Union

Return to Contents

3. Gaia Spots Stars Flying Between Galaxies



The positions and reconstructed orbits of 20 high-velocity stars, represented on top of an artistic view of our Galaxy, the Milky Way. These stars were identified using data from the second release of ESA's Gaia mission. The seven stars shown in red are sprinting away from the Galaxy and could be travelling fast enough to eventually escape its gravity. Surprisingly, the study revealed also thirteen stars, shown in orange, that are racing towards the Milky Way: these could be stars from another galaxy, zooming right through our own.

A team of astronomers using the latest set of data from ESA's Gaia mission to look for high-velocity stars being kicked out of the Milky Way were surprised to find stars instead sprinting inwards – perhaps from another galaxy.

In April, ESA's stellar surveyor Gaia released an unprecedented catalogue of more than one billion stars. Astronomers across the world have been working ceaselessly over the past few months to explore this extraordinary dataset, scrutinizing the properties and motions of stars in our Galaxy and beyond with never before achieved precision, giving rise to a multitude of new and intriguing studies.

The Milky Way contains over a hundred billion stars. Most are located in a disc with a dense, bulging centre, at the middle of which is a supermassive black hole. The rest are spread out in a much larger spherical halo.

Stars circle around the Milky Way at hundreds of kilometers per second, and their motions contain a wealth of information about the past history of the Galaxy. The fastest class of stars in our Galaxy is called hypervelocity stars, which are thought to start their life near the Galactic center to be later flung towards the edge of the Milky Way via interactions with the black hole.

Only a small number of hypervelocity stars have ever been discovered, and Gaia's recently published second data release provides a unique opportunity to look for more of them.

Several groups of astronomers jumped into the brand-new dataset in search of hypervelocity stars immediately after the release. Among them, three scientists at Leiden University, the Netherlands, were in for a big surprise.

For 1.3 billion stars, Gaia measured positions, parallaxes – an indicator of their distance – and 2D motions on the plane of the sky. For seven million of the brightest ones, it also measured how quickly they move towards or away from us.

"Of the seven million Gaia stars with full 3D velocity measurements, we found twenty that could be travelling fast enough to eventually escape from the Milky Way," explains Elena Maria Rossi, one of the authors of the new study.

Elena and colleagues, who had already discovered a handful of hypervelocity stars last year in an exploratory study based on data from Gaia's first release, were pleasantly surprised, as they were hoping to find at most one star breaking loose from the Galaxy among these seven million. And there is more.

"Rather than flying away from the Galactic center, most of the high velocity stars we spotted seem to be racing towards it," adds co-author Tommaso Marchetti. "These could be stars from another galaxy, zooming right through the Milky Way."

It is possible that these intergalactic interlopers come from the Large Magellanic Cloud, a relatively small galaxy orbiting the Milky Way, or they may originate from a galaxy even further afield.

If that is the case, they carry the imprint of their site of origin, and studying them at much closer distances than their parent galaxy could provide unprecedented information on the nature of stars in another galaxy – similar in a way to studying martian material brought to our planet by meteorites.

"Stars can be accelerated to high velocities when they interact with a supermassive black hole," Elena explains. "So the presence of these stars might be a sign of such black holes in nearby galaxies. But the stars may also have once been part of a binary system, flung towards the Milky Way when their companion star exploded as a supernova. Either way, studying them could tell us more about these kinds of processes in nearby galaxies."

An alternative explanation is that the newly identified sprinting stars could be native to our Galaxy's halo, accelerated and pushed inwards through interactions with one of the dwarf galaxies that fell towards the Milky Way during its build-up history. Additional information about the age and composition of the stars could help the astronomers clarify their origin.

"A star from the Milky Way halo is likely to be fairly old and mostly made of hydrogen, whereas stars from other galaxies could contain lots of heavier elements," says Tommaso. "Looking at the colors of stars tells us more about what they are made of."

New data will help nail down the nature and origin of these stars with more certainty, and the team will use ground-based telescopes to find out more about them. In the meantime, Gaia continues to make observations of the full sky, including the stars analysed in this study.

While investigating the nature of these possible stellar interlopers, the team is also busy digging into the full dataset from Gaia's second release, searching for more high-speed stars and looking forward to the future. At least two more Gaia data releases are planned in the 2020s, and each will provide both more precise and new information on a larger set of stars.

"We eventually expect full 3D velocity measurements for up to 150 million stars," explains co-author Anthony Brown, chair of the Gaia Data Processing and Analysis Consortium Executive.

"This will help find hundreds or thousands of hypervelocity stars, understand their origin in much more detail, and use them to investigate the Galactic centre environment as well as the history of our Galaxy," he adds.

"This exciting result shows that Gaia is a true discovery machine, providing the ground for completely unexpected discoveries about our Galaxy," concludes Timo Prusti, Gaia project scientist at ESA.

Source: ESA Return to Contents

The Night Sky

Tuesday, October 2

• Last-quarter Moon (exact at 5:45 a.m. on this date). Tonight, the Moon rises around midnight or 1 a.m. in Gemini. Before dawn Wednesday morning, you'll find it shining high with Pollux and Castor to its upper left and Procyon farther to its lower right.

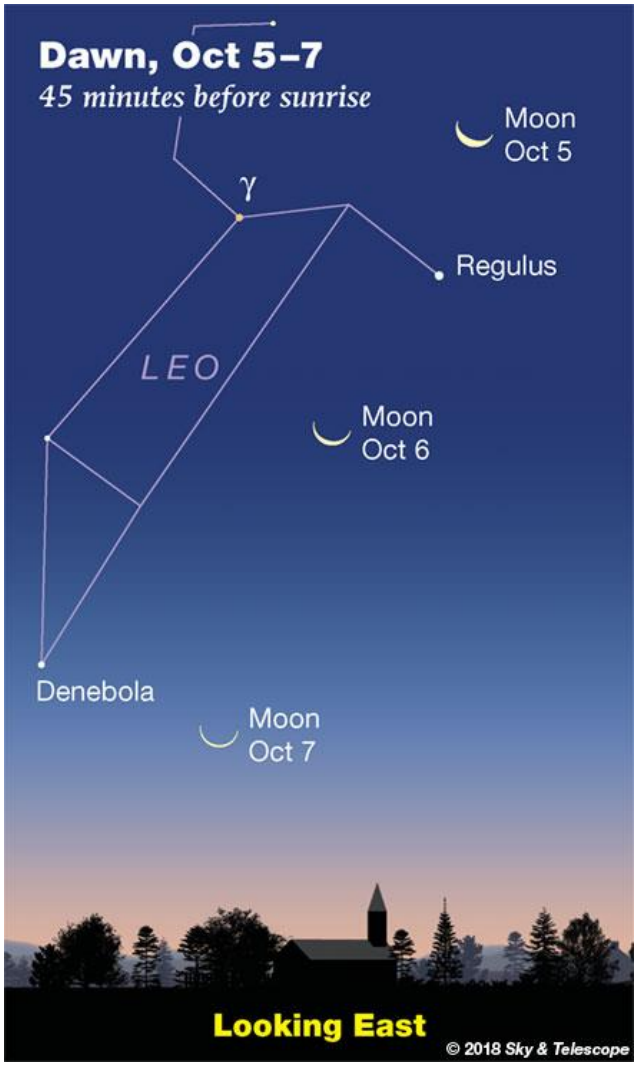
Wednesday, October 3

• Cygnus floats high overhead these evenings. Its brightest stars form the big Northern Cross. When you face southwest and crane your head overhead, the cross appears oriented upright. It's about two fists at arm's length tall.

The bottom star of the cross is Albireo, not very bright. It's a fine double star for 10x binoculars, but how well you can resolve it in binoculars depends on their optical quality and how steady you can brace them.

Thursday, October 4

• After dark, look just above the northeast horizon — far below high Cassiopeia — for bright Capella on the rise. How soon Capella rises, and how high you'll find it, depends on your latitude. The farther north you are, the sooner and higher.



The waning crescent Moon passes Leo in early dawn.

Friday, October 5

• These evenings the Great Square of Pegasus stands high in the east, still tipped onto one corner. It's a little larger than your fist held at arm's length.

From its left corner runs the line of three similarly bright stars marking the main line of Andromeda.

As evening grows late, the Square's upper-right side points far down to Fomalhaut on the rise (four or five fists distant).

Saturday, October 6

• Vega is the brightest star very high in the west right after nightfall. Arcturus, equally bright, is getting low in the west-northwest. The brightest star in the vast expanse between them, about a third of the way from Arcturus up toward Vega, is Alphecca, magnitude 2.2 — the crown jewel of Corona Borealis. Alphecca is a 17-day eclipsing binary, but its brightness dips are too slight for the eye to see reliably.

Source: Sky and Telescope

Return to Contents

ISS Sighting Opportunities (from Denver)

Date	Visible	Max Height	Appears	Disappears
Tue Oct 2, 7:35 PM	1 min	10°	10° above NNW	10° above N
Wed Oct 3, 8:19 PM	1 min	13°	10° above NNW	13° above N
Thu Oct 4, 7:28 PM	2 min	11°	10° above NNW	10° above NNE
Thu Oct 4, 9:03 PM	< 1 min	12°	10° above NW	12° above NNW
Fri Oct 5, 8:12 PM	2 min	18°	10° above NNW	18° above N

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

NASA-TV Highlights (all times Eastern Time Zone)

October 2, Tuesday

- 11:05 a.m. – Space Station Expedition 56 In-Flight Educational Event to Wrap Up the "Year of Education on Station" with astronaut Ricky Arnold of NASA (All Channels)

October 3, Wednesday

- 8:35 a.m. - Space Station Expedition 56 In-Flight Event for the European Space Agency with the International Astronautical Congress in Bremen, Germany and Flight Engineer Alexander Gerst of ESA (Public Channel with interpretation; Media Channel in native language)
- 10:10 a.m. - Space Station Expedition 56/57 Change of Command Ceremony; Drew Feustel hands over command of the International Space Station to Alexander Gerst (All Channels)
- 4 p.m. – Space Station Expedition 57-58 Crew's Pre-Launch Activities at the Baikonur Cosmodrome in Kazakhstan (includes material recorded from Sept. 25-Oct. 3) – Johnson Space Center via Baikonur, Kazakhstan (Media Channel)

October 4, Thursday

- 12:30 a.m. - Space Station Expedition 56 Crew Farewells and Soyuz MS-08 Hatch Closure Coverage; hatch closure scheduled at approximately 12:55 a.m. ET (All Channels)
- 3:30 a.m. - Space Station Expedition 56/Soyuz MS-08 Undocking Coverage; scheduled at 3:57 a.m. ET (All Channels)
- 6:30 a.m. – Space Station Expedition 56/Soyuz MS-08 Deorbit Burn and Landing Coverage (Deorbit burn scheduled at 6:51 a.m. ET; landing near Dzhezkazgan, Kazakhstan scheduled at 7:45 a.m. ET) - Johnson Space Center via Korolev, Russia and Kazakhstan (All Channels)
- 11 a.m. - Space Station Expedition 56/Soyuz MS-08 Hatch Closure, Undocking, Landing and Post-Landing Activities (Media Channel)

October 5, Friday

- 11 a.m. – Space Station Expedition 56/Soyuz MS-08 Post-Landing Crew Activities in Karaganda, Kazakhstan (may include post-landing interviews with Station Commander Drew Feustel and astronaut engineer Ricky Arnold of NASA (Media Channel)

Watch NASA TV online by going to the NASA website.

Return to Contents

Space Calendar

- Oct 02 - Comet 26P/Grigg-Skjellerup Perihelion (1.082 AU)
- Oct 02 - Comet C/2018 R4 (Fuls) At Opposition (2.134 AU)
- Oct 02 - Atira Asteroid 2012 VE46 Closest Approach To Earth (0.277 AU)
- Oct 02 - Asteroid 4523 MIT Closest Approach To Earth (2.030 AU)
- Oct 02 - Kuiper Belt Object 2015 RR245 At Opposition (61.997 AU)
- Oct 02-03 - Meeting: Time-Domain Astrophysics with Swift III, Clemson, South Carolina
- Oct 02-04 - Global Geodetic Observing System (GGOS) Days 2018, Tsukuba, Japan
- Oct 02-04 - APSCC 2018 Satellite Conference & Exhibition, Jakarta, Indonesia
- Oct 02-05 - 3rd Bienneial Workshop on Dark Interactions: Perspective from Theory and Experiment (di2018), Upton, New York
- Oct 02-05 - 39th ESA Antenna Workshop: Multibeam and Reconfigurable Antennas for Space Applications, Noordwijk, The Netherlands
- Oct 02-05 - ForestSAT 2018 Conference, College Park, Maryland
- **Oct 03 - Hayabusa 2, Hopping Lander Lands on Asteroid Ryugu**
- **Oct 03 - Parker Solar Probe, 1st Venus flyby**
- Oct 03 - Comet 64P/Swift-Gehrels At Opposition (0.484 AU)
- Oct 03 - Amor Asteroid 2018 RS1 Near-Earth Flyby (0.054 AU)
- Oct 03 - Amor Asteroid 2009 TK Near-Earth Flyby (0.073 AU)
- Oct 03 - Apollo Asteroid 469219 (2016 HO3) Closest Approach To Earth (0.155 AU)
- Oct 03 - Asteroid 13681 Monty Python Closest Approach To Earth (2.032 AU)
- Oct 03 - Alexander Macmillan's 200th Birthday (1818)
- Oct 03-11 - School for Astroparticle Physics, Obertrubach-Barnfels, Germany
- **Oct 04 - Soyuz Return To Earth (International Space Station)**
- Oct 04 - Comet P/2007 T4 (Gibbs) Closest Approach To Earth (2.375 AU)
- Oct 04 - Apollo Asteroid 2018 SP1 Near-Earth Flyby (0.039 AU)
- Oct 04 - Asteroid 10867 Lima Closest Approach To Earth (1.638 AU)
- Oct 04 - Asteroid 6677 Renoir Closest Approach To Earth (1.970 AU)
- Oct 04 - Lecture: Advanced Rapid Imaging and Analysis (ARIA) - Rapid Disaster Response Using Space Geodesy, Pasadena, California
- Oct 04 - Lecture: Pulsar Timing Arrays - The Next Window to Open on the Gravitational-Wave Universe, Ithaca, New York
- Oct 04-10 - World Space Week
- Oct 05 - Comet P/2001 R6 (LINEAR-Skiff) Perihelion (2.191 AU)
- Oct 05 - Comet C/2018 N2 (ASASSN) At Opposition (4.254 AU)
- Oct 05 - Asteroid 7394 Xanthomalitia Occults HIP 31277 (5.6 Magnitude Star)
- Oct 05 - Amor Asteroid 2018 RZ1 Near-Earth Flyby (0.100 AU)
- Oct 05 - Binary Apollo Asteroid 69230 Hermes Closest Approach To Earth (0.529 AU)
- Oct 05 - Asteroid 951 Gaspra Closest Approach To Earth (0.836 AU)

Source: JPL Space Calendar Return to Contents

Food for Thought

NASA Is Taking a New Look at Searching for Life Beyond Earth

A zoom into the Hubble Space Telescope photograph of an enormous, balloon-like bubble being blown into space by a super-hot, massive star. Astronomers trained the iconic telescope on this colorful feature, called the Bubble Nebula, or NGC 7635. Credits: NASA, ESA, and the Hubble Heritage Team (STScI/AURA), F. Summers, G. Bacon, Z. Levay, and L. Frattare (Viz 3D Team, STScI)

Since the beginning of civilization, humanity has wondered whether we are alone in the universe. As NASA has explored our solar system and beyond, it has developed increasingly sophisticated tools to address this fundamental question. Within our solar system, NASA's missions have searched for signs of both ancient and current life, especially on Mars and soon, Jupiter's moon Europa. Beyond our solar system, missions, such as Kepler and TESS, are revealing thousands of planets orbiting other stars.

The explosion of knowledge of planets orbiting other stars, called exoplanets, and the results of decades of research on signatures of life - what scientists call biosignatures - have encouraged NASA to address, in a scientifically rigorous way, whether humanity is alone. Beyond searching for evidence of just microbial life, NASA now is exploring ways to search for life advanced enough to create technology.

Technosignatures are signs or signals, which if observed, would allow us to infer the existence of technological life elsewhere in the universe. The best known technosignature are radio signals, but there are many others that have not been explored fully.

In April 2018, new interest arose in Congress for NASA to begin supporting the scientific search for technosignatures as part of the agency's search for life. As part of that effort, the agency hosted the NASA Technosignatures Workshop in Houston on Sept. 26-28, 2018, with the purpose of assessing the current state of the field, the most promising avenues of research in technosignatures and where investments could be made to advance the science. A major goal is to identify how NASA could best support this endeavor through partnerships with private and philanthropic organizations.

What are Technosignatures? -- The term technosignatures has a broader meaning than the historically used "search for extraterrestrial intelligence," or SETI, which has generally been limited to communication signals. Technosignatures like radio or laser emissions, signs of massive structures or an atmosphere full of pollutants could imply intelligence.

In recent decades, the private and philanthropic sectors have carried out this research. They have used such methods as searching for patterns in low-band radio frequencies using radio telescopes. Indeed, humanity's own radio and television broadcasts have been drifting into space for a number of years. NASA's SETI program was ended in 1993 after Congress, operating under a budget deficit and decreased political support, cancelled funding for a high-resolution microwave survey of the skies. Since then, NASA's efforts have been directed towards furthering our fundamental understanding of life itself, its origins and the habitability of other bodies in our solar system and galaxy.

History of the Search for Technological Life -- Efforts to detect technologically advanced life predates the space age as early 20th century radio pioneers first foresaw the possibility of interplanetary communication. Theoretical work postulating the possibility of carrying signals on radio and microwave bands across vast distances in the galaxy with little interference led to first "listening" experiments in the 1960s.

Thanks to NASA's Kepler mission's discovery of thousands of planets beyond our solar system, including some with key similarities to Earth, it's now possible to not just imagine the science fiction of finding life on other worlds, but to one day scientifically prove life exists beyond our solar system.

As NASA's 2015 Astrobiology Strategy states: "Complex life may evolve into cognitive systems that can employ technology in ways that may be observable. Nobody knows the probability, but we know that it is not zero." As we consider the environments of other planets, "technosignatures" could be included in the possible interpretations of data we get from other worlds.

Debate about the probability of finding signals of advanced life varies widely. In 1961, astronomer Frank Drake created a formula estimating the number of potential intelligent civilizations in the galaxy, called the Drake equation, and calculated an answer of 10,000. Most of the variables in the equation continue to be rough estimates, subject to uncertainties. Another famous speculation on the subject called the Fermi paradox, posited by Italian physicist Enrico Fermi, asserted that if another intelligent life form was indeed out there, we would have met it by now.

NASA's SETI work began with a 1971 proposal by biomedical researcher John Billingham at NASA's Ames Research Center for a 1,000-dish array of 100-meter telescopes that could pick up television and radio signals from other stars. "Project Cyclops" was not funded, but in 1976, Ames established a SETI branch to continue research in this area. NASA's Jet Propulsion Laboratory (JPL) also began SETI work.

In 1988, NASA Headquarters in Washington formally endorsed the SETI program leading to development of the High Resolution Microwave Survey. Announced on Columbus Day in 1992 - 500 years after Columbus landed in North America - this 10-year, $100 million project included a targeted search of stars led by Ames using the 300-meter radio telescope in Arecibo, Puerto Rico, and an all-sky survey led by JPL using its Deep Space Network dish. The program lasted only a year before political opposition eliminated the project and effectively ended NASA's research efforts in SETI.

Why Start Looking at Technosignatures Now? -- Fueled by the discovery that our galaxy is teeming with planets, interest in detecting signs of technologically-advanced life is again bubbling up. Kepler's discovery in 2015 of irregular fluctuations in brightness in what came to be known as Tabby's Star led to speculation of an alien megastructure, though scientists have since concluded that a dust cloud is the likely cause. However, Tabby's Star has demonstrated the potential usefulness of looking for anomalies in data collected from space, as signs of technologically-advanced life may appear as aberrations from the norm.

Source: NASA Return to Contents

Space Image of the Week

Opportunity Emerges in a Dusty Picture

Credits: NASA/JPL-Caltech/Univ. of Arizona

Explanation: NASA still hasn't heard from the Opportunity rover, but at least we can see it again. A new image produced by HiRISE, a high-resolution camera aboard NASA's Mars Reconnaissance Orbiter (MRO), shows a small object on the slopes of the Red Planet's Perseverance Valley. That object is Opportunity, which was descending into the Martian valley when a dust storm swept over the region a little more than 100 days ago.

The storm was one of several that stirred up enough dust to enshroud most of the Red Planet and block sunlight from reaching the surface. The lack of sunlight caused the solar-powered Opportunity to go into hibernation. The rover's team at NASA's Jet Propulsion Laboratory in Pasadena, California, hasn't heard from it since. On Sept. 11, JPL began increasing the frequency of commands it beams to the 14-year-old rover.

The tau -- a measurement of how much sunlight reaches the surface -- over Opportunity was estimated to be a little higher than 10 during some points during the dust storm. The tau has steadily fallen in the last several months. On Thursday, Sept. 20, when this image was taken, tau was estimated to be about 1.3 by MRO's Mars Color Imager camera.

This image was produced from about 166 miles (267 kilometers) above the Martian surface. The white box marks a 154-foot-wide (47-meter-wide) area centered on the rover.

Updates about Opportunity can be found here: https://mars.nasa.gov/mer/mission/status.html

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