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Space Image of the Week
1. NASA’s OSIRIS-REx Spots Target and Begins Asteroid Operations Campaign

On Aug. 17, the OSIRIS-REx spacecraft obtained the first images of its target asteroid Bennu. This is one of a cropped set of five images was obtained by the PolyCam camera over the course of an hour for calibration purposes and in order to assist the mission’s navigation team with optical navigation efforts. Bennu is visible as a moving object against the stars in the constellation Serpens. Credits: NASA/Goddard/University of Arizona

After an almost two-year journey, NASA’s asteroid sampling spacecraft, the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx), caught its first glimpse of asteroid Bennu last week and began the final approach toward its target. Kicking off the mission’s asteroid operations campaign on Aug. 17, the spacecraft’s PolyCam camera obtained the image from a distance of 1.4 million miles (2.2 million km).

OSIRIS-REx is NASA’s first mission to visit a near-Earth asteroid, survey the surface, collect a sample and deliver it safely back to Earth. The spacecraft has traveled approximately 1.1 billion miles (1.8 billion km) since its Sept. 8, 2016, launch and is scheduled to arrive at Bennu on Dec. 3.

“Now that OSIRIS-REx is close enough to observe Bennu, the mission team will spend the next few months learning as much as possible about Bennu’s size, shape, surface features, and surroundings before the spacecraft arrives at the asteroid,” said Dante Lauretta, OSIRIS-REx principal investigator at the University of Arizona, Tucson. “After spending so long planning for this moment, I can’t wait to see what Bennu reveals to us.”

As OSIRIS-REx approaches the asteroid, the spacecraft will use its science instruments to gather information about Bennu and prepare for arrival. The spacecraft’s science payload comprises the OCAMS camera suite (PolyCam, MapCam, and SamCam), the OTES thermal spectrometer, the OVIRS visible and infrared spectrometer, the OLA laser altimeter, and the REXIS x-ray spectrometer.

During the mission’s approach phase, OSIRIS-REx will:

- regularly observe the area around the asteroid to search for dust plumes and natural satellites, and study Bennu’s light and spectral properties;
• execute a series of four asteroid approach maneuvers, beginning on Oct. 1, slowing the spacecraft to match Bennu’s orbit around the Sun;

• jettison the protective cover of the spacecraft’s sampling arm in mid-October and subsequently extend and image the arm for the first time in flight; and

• use OCAMS to reveal the asteroid’s overall shape in late-October and begin detecting Bennu’s surface features in mid-November.

After arrival at Bennu, the spacecraft will spend the first month performing flybys of Bennu’s north pole, equator and south pole, at distances ranging between 11.8 and 4.4 miles (19 and 7 km) from the asteroid. These maneuvers will allow for the first direct measurement of Bennu’s mass as well as close-up observations of the surface. These trajectories will also provide the mission’s navigation team with experience navigating near the asteroid.

“Bennu’s low gravity provides a unique challenge for the mission,” said Rich Burns, OSIRIS-REx project manager at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. “At roughly 0.3 miles [500 meters] in diameter, Bennu will be the smallest object that any spacecraft has ever orbited.”

The spacecraft will extensively survey the asteroid before the mission team identifies two possible sample sites. Close examination of these sites will allow the team to pick one for sample collection, scheduled for early July 2020. After sample collection, the spacecraft will head back toward Earth before ejecting the Sample Return Capsule for landing in the Utah desert in Sept. 2023.

Source: NASA

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Landing Site on Asteroid Ryugu Chosen for Japan's Hayabusa2 Mission

We now know where a Japanese asteroid-sampling probe's lander will touch down this October. The Hayabusa2 spacecraft's Mobile Asteroid Surface Scout (MASCOT) will land at a site in the asteroid Ryugu's southern hemisphere dubbed MA-9, mission officials announced today (Aug. 23).

MA-9 won out over nine other finalists because it offered the best combination of scientific potential and accessibility, MASCOT team members said.

The MA-9 site on the asteroid Ryugu, where the Hayabusa2 spacecraft’s MASCOT lander will touch down on Oct. 3, 2018.

Credit: JAXA/DLR

Source: Space.com

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2. Water-Worlds Are Common: Exoplanets May Contain Vast Amounts of Water

Scientists have shown that water is likely to be a major component of those exoplanets (planets orbiting other stars) which are between two to four times the size of Earth. It will have implications for the search of life in our Galaxy. The work is presented at the Goldschmidt conference in Boston.

The 1992 discovery of exoplanets orbiting other stars has sparked interest in understanding the composition of these planets to determine, among other goals, whether they are suitable for the development of life. Now a new evaluation of data from the exoplanet-hunting Kepler Space Telescope and the Gaia mission indicates that many of the known planets may contain as much as 50% water. This is much more than the Earth's 0.02% (by weight) water content.

"It was a huge surprise to realize that there must be so many water-worlds", said lead researcher Dr Li Zeng (Harvard University),

Scientists have found that many of the 4000 confirmed or candidate exoplanets discovered so far fall into two size categories: those with the planetary radius averaging around 1.5 that of the Earth, and those averaging around 2.5 times the radius of the Earth.

Now a group of International scientists, after analysing the exoplanets with mass measurements and recent radius measurements from the Gaia satellite, have developed a model of their internal structure.

"We have looked at how mass relates to radius, and developed a model which might explain the relationship", said Li Zeng. The model indicates that those exoplanets which have a radius of around x1.5 Earth radius tend
to be rocky planets (of typically x5 the mass of the Earth), while those with a radius of x2.5 Earth radius (with a mass around x10 that of the Earth) are probably water worlds”.

"This is water, but not as commonly found here on Earth", said Li Zeng. "Their surface temperature is expected to be in the 200 to 500 degree Celsius range. Their surface may be shrouded in a water-vapor-dominated atmosphere, with a liquid water layer underneath. Moving deeper, one would expect to find this water transforms into high-pressure ices before we reaching the solid rocky core. The beauty of the model is that it explains just how composition relates to the known facts about these planets”.

Li Zeng continued, "Our data indicate that about 35% of all known exoplanets which are bigger than Earth should be water-rich. These water worlds likely formed in similar ways to the giant planet cores (Jupiter, Saturn, Uranus, Neptune) which we find in our own solar system. The newly-launched TESS mission will find many more of them, with the help of ground-based spectroscopic follow-up. The next generation space telescope, the James Webb Space Telescope*, will hopefully characterize the atmosphere of some of them. This is an exciting time for those interested in these remote worlds”.

Professor Sara Seager, Professor of Planetary Science at Massachusetts Institute of Technology, and deputy science director of the recently-launched TESS (Transiting Exoplanet Survey Satellite) mission, which will search for exoplanets, said:

"It's amazing to think that the enigmatic intermediate-size exoplanets could be water worlds with vast amounts of water. Hopefully atmosphere observations in the future--of thick steam atmospheres---can support or refute the new findings”.

Source: EurekAlert/ Goldschmidt Conference

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Note: Kepler Spacecraft Update

Aug. 24 - The Kepler spacecraft went into sleep mode after successfully downloading Campaign 18 data. It is unclear how much fuel is still on board; NASA is looking into the health of the spacecraft and determining a full range of options and next steps.

Aug. 9 - The Kepler spacecraft has successfully downloaded Campaign 18 data to Earth. We are monitoring the spacecraft very closely and will provide more information when its status has been fully assessed.

Aug. 3 - Kepler made contact yesterday and is successfully downloading its store of science data from its last observation campaign, Campaign 18.

Source: NASA  

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Having worked around the clock since the launch of Aeolus on Wednesday, teams at ESA’s control centre in Germany have declared today (August 24th) that the critical first phase for Europe’s wind mission is complete.

The Aeolus satellite was launched on a Vega rocket in the evening of 22 August from Europe’s Spaceport in Kourou, French Guiana. With a launch mass of 1360 kg, including 266 kg of fuel, Aeolus will be the first-ever satellite to directly measure Earth’s winds from space.

Carrying one of the most sensitive instruments ever put into orbit — Aladin, a Doppler wind lidar — Aeolus will provide vital information on wind speeds around the globe. This information is expected to improve weather forecasting as wind plays a complex and pivotal role in global weather systems.

**Gone with the wind** -- Originally planned to be launched on 21 August, liftoff was delayed by 24 hours, as, ironically, high winds meant it was unsafe to launch the satellite.

Scarce wind observations around the launch site near the Southern Caribbean Ocean mean forecasts in the region are less accurate than in more populated regions, highlighting the need for more advanced wind models.

Despite the delay, Aeolus was delivered into orbit at the desired altitude of 320 km by a Vega rocket, just 54 minutes and 57 seconds after liftoff.

Once in orbit, Aeolus separated from the Vega launcher and began its free-flying journey, unfolding its solar arrays, turning its radio antenna toward Earth and sending signals to ground stations in Australia and Antarctica to signify that all is well.
An initial radio signal from Aeolus was picked up at 00:15 CEST on 23 August by a special launcher tracking dish, dubbed NNO-2, at ESA’s New Norcia station in Australia — the newest in the Agency’s network of communication antennas.

This first, simple, ‘hello’ was followed just 15 minutes later by the official data link that was established at the Norwegian Troll Satellite Station in Antarctica. With this full data link, mission teams at ESOC became able to send commands to the satellite and receive the data it will go on to collect.

**Decisive days** -- Following separation, the critical ‘Launch and Early Orbit Phase’ (LEOP) ensued, in which flight controllers, satellite engineers and experts in flight dynamics worked 24-hours a day as they gradually switched on the satellite’s various control systems and verified its health.

“The satellite is uniquely vulnerable during LEOP; it is on its way to becoming fully functional but still needs to be responsive to the hazards of space,” says flight director Pier Paolo Emanuelli.

“Any marauding space debris in Aeolus’ orbit would have the potential to trigger a sudden collision avoidance manoeuvre – a complex operation at the best of times but even more so in these very early days in space.”

Paolo Ferri, Head of Mission Operations at ESA, describing this important stage, says: “The end of the risky Launch and Early Orbit Phase and the transition into in-orbit commissioning marks a vital chapter in Aeolus’ life.”

“These crucial steps mean that the spacecraft will soon be ready to measure wind on Earth from space, transmitting this precious and much-needed data back to scientists on Earth.”

Flight control teams guided the satellite through this tense period, working to ensure Aeolus was safely configured and ready for its next milestone: in-orbit commissioning.

**Commissioning the wind mission** -- During the commissioning phase of a satellite, controllers nudge it slightly to optimise its position in orbit, and perform tests to ensure the health of its instruments. This step is unique for every satellite, and for Aeolus it is expected to last for several months.

The main commissioning objective of Aeolus is to fully check out, calibrate and understand the behaviour of all systems onboard the spacecraft now that has taken up its new residence in space. The absolute centrepiece of this, ESA’s newest satellite, will be the switch-on and first light of the hypermodern Aladin lidar instrument.

Once this is done, the real challenge will be to fully calibrate, characterise and tune the instrument, finally making it able to get to work measuring Earth’s winds.

Source: [European Space Agency](https://www.esa.int/esaMO/)  
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Tuesday, August 28

• After nightfall this week, Arcturus and the Big Dipper shine equally high in the west and northwest, respectively.

Wednesday, August 29

• Summer’s end approaches. Soon after dark now, Cassiopeia has risen as high in the northeast as the Big Dipper has sunk down to in the northwest. Find Polaris a little above the midpoint between them.

Thursday, August 30

• Now that the waning Moon doesn't rise until nearly an hour after dark, you have a window of darkness to explore the telescopic double stars and open clusters in high Lacerta, the Lizard. Do you know why the 17th-century creator of Lacerta also named it Stellio? Hint: not real stars.*

Friday, August 31

• Look for bright Vega passing the zenith as it Vega goes right through your zenith if you're at latitude 39° north (near Baltimore, Kansas City, Lake Tahoe, Sendai, Beijing, Athens, Lisbon).

Then Deneb follows two hours behind. For Deneb to pass exactly through your zenith you need to be a little farther north, at latitude 45°: near Bangor, Montreal, Minneapolis, mid-Oregon, northernmost Japan, Bucharest, Milan.

Saturday, September 1

• As twilight fades this evening, spot Venus very low in the west-southwest as shown here. Upper right of it by just 1.3° is Spica, a 1st-magnitude star but less than 1% as bright as Venus. Can you see Spica naked-eye through the twilight? They’re about a finger-width at arm’s length apart. Or, try binoculars.

• After dark as August nears its end, the Great Square of Pegasus looms up in the east, balancing on one corner. Its stars are only 2nd and 3rd magnitude. Extending leftward from the Square's left corner is the main line of the constellation Andromeda. It's made of three stars (including the corner) that are about as bright as the others forming the Square.

Source: Sky and Telescope

*Hint: not real stars.*
ISS Sighting Opportunities (from Denver)

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

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

**August 28, Tuesday**

- 10:25 a.m. – Space Station In-Flight Interview with Sky Sports in London and Space Station Commander Drew Feustel of NASA (All Channels)

**August 30, Thursday**

- 9:30 a.m. – Space Station In-Flight Educational Event with the Kranz Junior High School in Dickinson, Texas, and NASA astronaut Serena Aunon-Chancellor (All Channels)

Watch NASA TV online by going to the [NASA website](https://www.nasa.gov/).  

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Space Calendar

- Aug 28 - Comet 125P/Spacewatch Perihelion (1.520 AU)
- Aug 28 - Comet C/2017 P2 (PANSTARRS) Closest Approach To Earth (2.895 AU)
- Aug 28 - Comet 81P/Wild At Opposition (3.832 AU)
- Aug 28 - Aten Asteroid 2016 GK135 Near-Earth Flyby (0.043 AU)
- Aug 28 - Apollo Asteroid 358744 (2008 CR118) Near-Earth Flyby (0.099 AU)
- Aug 28 - Apollo Asteroid 12711 Tukmit Closest Approach To Earth (0.652 AU)
- Aug 28 - Asteroid 9622 Terryjones Closest Approach To Earth (1.424 AU)
- Aug 28 - Colloquium: Prospects for Unseen Planets Beyond Neptune, Tucson, Arizona
- Aug 28-31 - IAU Symposium 348: 21st Century Astrometry - Crossing the Dark and Habitable Frontiers, Vienna, Austria
- Aug 28-31 - CoDyCE-LIO International Workshop on Fundamental Theories for BSM and Cosmology, Lyon, France
- Aug 28-Sep 01 - Invisibles18 School, Burghausen, Germany
- Aug 29 - Comet P/1996 R2 (Lagerkvist) Closest Approach To Earth (1.767 AU)
- Aug 29 - Comet C/2015 V1 (PANSTARRS) Closest Approach To Earth (3.872 AU)
- Aug 29 - Comet P/2004 WR9 (LINEAR) At Opposition (4.091 AU)
- Aug 29 - Aten Asteroid 1998 SD9 Near-Earth Flyby (0.011 AU)
- Aug 29 - Aten Asteroid 2016 NF23 Near-Earth Flyby (0.034 AU)
- Aug 29 - Asteroid 1193 Africa Closest Approach To Earth (1.729 AU)
- Aug 29 - Asteroid 51823 Rickhusband Closest Approach To Earth (1.862 AU)
- Aug 29 - Asteroid 1691 Oort Closest Approach To Earth (1.929 AU)
- Aug 29 - Asteroid 10463 Bannister Closest Approach To Earth (2.045 AU)
- Aug 29 - Asteroid 3688 Navajo Closest Approach To Earth (3.752 AU)
- Aug 29-31 - Workshop: Star Cluster Formation - Mapping the First Few Myrs, Grenoble, France
- Aug 30 - Comet 245P/WISE At Opposition (1.673 AU)
- Aug 30 - Comet C/2017 U7 At Opposition (6.085 AU)
- Aug 30 - Apollo Asteroid 2018 DE1 Near-Earth Flyby (0.039 AU)
- Aug 30 - Apollo Asteroid 2018 PH21 Near-Earth Flyby (0.067 AU)
- Aug 30 - Asteroid 31556 Shatner Closest Approach To Earth (1.117 AU)
- Aug 30 - Asteroid 6143 Pythagoras Closest Approach To Earth (1.652 AU)
- Aug 30 - Kuiper Belt Object 408706 (2004 NT33) At Opposition (38.293 AU)
- Aug 30 - Lecture: Extraordinary Upwelling and Overturning in the Midlatitidue Ionosphere, Ithaca, New York
- Aug 30-31 - Dawn IV Workshop: Global Strategies for Gravitational Wave Astronomy, Amsterdam, The Netherlands
- Aug 31 - Comet C/2018 O1 (ATLAS) Perihelion (1.558 AU)
- Aug 31 - Comet 266P/Christensen At Opposition (2.880 AU)
- Aug 31 - Comet P/2009 WX51 (Catalina) At Opposition (4.237 AU)
- Aug 31 - Aten Asteroid 136818 Selqet Closest Approach To Earth (0.290 AU)

Source: JPL Space Calendar
Food for Thought

We’re in the Milky Way’s Second Life. Star Formation was Shut Down for Billions of Years

Since the birth of modern astronomy, scientists have sought to determine the full extent of the Milky Way galaxy and learn more about its structure, formation and evolution. According to current theories, it is widely believed that the Milky Way formed shortly after the Big Bang (roughly 13.51 billion years ago). This was the result of the first stars and star clusters coming together, as well as the accretion of gas directly from the Galactic halo.

Since then, multiple galaxies are thought to have merged with the Milky Way, which triggered the formation of new stars. But according to a new study by a team of Japanese researchers, our galaxy has had a more turbulent history than previously thought. According to their findings, the Milky Way experienced a dormant era between two periods of star formation that lasted for billions of years, effectively dying before coming back to life again.

Schematic diagram showing two stages of star formation in the Milky Way galaxy according to Noguchi. In upper illustration, blue (cold) and red (hot) indicate gas. The color map in bottom panel shows distribution of the elemental composition of stars calculated by Noguchi’s model with the purple line indicating how the elemental composition of the gas changes over time (Credit: M. Noguchi, courtesy of Nature). Overlaid contours show the distribution of solar neighborhood stars observed by APOGEE, a spectroscopic device attached to the 2.5 m telescope of the Alfred P. Sloan Foundation at Apache Point Observatory in New Mexico (Credit: M. Haywood et al. A&A, 589, 66 (2016), reproduced with permission © ESO).
Their study, titled "The formation of solar-neighborhood stars in two generations separated by 5 billion years", recently appeared in the scientific journal Nature. The study was conducted by Masafumi Noguchi, an astronomer from the Astronomical Institute at Tohoku University, Japan. Using a new idea known as “cold flow accretion”, Noguchi calculated the evolution of the Milky Way over a 10 billion year period.

This idea of cold gas accretion was first proposed by Avishai Dekel – the Andre Aisenstadt Chair of Theoretical Physics at The Hebrew University in Jerusalem – and his colleagues to explain how galaxies accrete gas from surrounding space during their formation. The concept of two-stage formation has also been suggested in the past by Yuval Birnboim – a senior lecturer at The Hebrew University – and colleagues to account for the formation of more massive galaxies in our Universe.

However, after constructing a model of the Milky Way using composition data of its stars, Noguchi concluded that our own galaxy also experienced two stages of star formation. According to his study, the history of the Milky Way can be discerned by looking at the elemental compositions of its stars, which are the result of the composition of the gas from which they are formed.

When looking at the stars in the Solar neighborhood, many astronomical surveys have noted that there are two groups that have different chemical compositions. One is rich in elements like oxygen, magnesium and silicon (alpha-elements) while the the other is rich in iron. The reason for this dichotomy has been a long-standing mystery, but Noguchi’s model provides a possible answer.

According to this model, the Milky Way began when cold gas streams accreted into the galaxy and led to the formation of the first generation of stars. This gas contained alpha-elements as a result of short-lived type II supernovae – where a star undergoes core collapse at the end of its life cycle and then explodes – releasing these elements into the intergalactic medium. This led to the first generation of stars being rich in alpha-elements.

Then, about 7 billion years ago, shock waves appeared that heated the gas to high temperatures. This caused the cold gas to stop flowing into our galaxy, causing star formation to cease. A two-billion year period of dormancy continued in our galaxy. During this time, long-lived type Ia supernovae – which occur in binary systems where a white dwarf gradually siphons material from its companion – injected iron into the intergalactic gas and changed its elemental composition.

Over time, the intergalactic gas began to cool by emitting radiation and started flowing back into the galaxy 5 billion years ago. This led to a second generation of star formation, which included our Sun, that were rich in iron. Although the two-stage formation has suggested for much more massive galaxies in the past, Noguchi has been able to confirm that the same picture applies to our own Milky Way.

What’s more, other studies have indicated that the same may be the case for the Milky Way’s closest neighbor, the Andromeda Galaxy. In short, Noguchi’s model predicts that massive spiral galaxies experience a gap in star formation, whereas smaller galaxies make stars continuously.

In the future, observations by existing and next-generation telescopes are likely to provide additional evidence of this phenomena and tell us a great deal more about galaxy formation. From this, astronomers will also be able to construct increasingly accurate models of how our Universe evolved over time.

Source: Universe Today

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**Space Image of the Week**

**Just Another Day on Aerosol Earth**  
Image Credit: NASA/Joshua Stevens/Adam Voiland

**Explanation:** Take a deep breath. Even if the air looks clear, it is nearly certain that you will inhale millions of solid particles and liquid droplets. These ubiquitous specks of matter are known as aerosols, and they can be found in the air over oceans, deserts, mountains, forests, ice and every ecosystem in between.

If you have ever watched smoke billowing from a wildfire, ash erupting from a volcano or dust blowing in the wind, you have seen aerosols. Satellites like NASA’s Earth-observing satellites, Terra, Aqua, Aura and Suomi NPP, “see” them as well, though they offer a completely different perspective from hundreds of kilometers above Earth’s surface. A version of a NASA model called the Goddard Earth Observing System Forward Processing (GEOS FP) offers a similarly expansive view of the mishmash of particles that dance and swirl through the atmosphere.

The visualization above highlights GEOS FP model output for aerosols on August 23, 2018. On that day, huge plumes of smoke drifted over North America and Africa, three different tropical cyclones churned in the Pacific Ocean, and large clouds of dust blew over deserts in Africa and Asia. The storms are visible within giant swirls of sea salt aerosol (blue), which winds loft into the air as part of sea spray. Black carbon particles (red) are among the particles emitted by fires; vehicle and factory emissions are another common source. Particles the model classified as dust are shown in purple. The visualization includes a layer of night light data collected by the day-night band of the Visible Infrared Imaging Radiometer Suite (VIIRS) on Suomi NPP that shows the locations of towns and cities.

Source: [NASA](https://www.nasa.gov)