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1. Rosetta Instrument Reignites Debate on Earth’s Oceans

The question about the origin of oceans on Earth is one of the most important questions with respect to the formation of our planet and the origin of life. The most popular theory is that water was brought by impacts of comets and asteroids. Data from the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) instrument aboard the European Space Agency’s Rosetta spacecraft indicate that terrestrial water did not come from comets like 67P/Churyumov-Gerasimenko. The findings were published today in the journal Science.

Researchers agree that water must have been delivered to Earth by small bodies at a later stage of the planet’s evolution. It is, however, not clear which family of small bodies is responsible. There are three possibilities: asteroid-like small bodies from the region of Jupiter; Oort cloud comets formed inside of Neptune’s orbit; and Kuiper Belt comets formed outside of Neptune’s orbit.

The key to determining where the water originated is in its isotopic “flavor.” That is, by measuring the level of deuterium – a heavier form of hydrogen. By comparing the ratio of deuterium to hydrogen in different objects, scientists can identify where in the solar system that object originated. And by comparing the D/H ratio, in Earth’s oceans with that in other bodies, scientists can aim to identify the origin of our water.

The ROSINA instrument on the Rosetta spacecraft has found that the composition of comet 67P/Churyumov-Gerasimenko’s water vapor is significantly different from that found on Earth.

The value for the D/H ratio on the comet is more than three times the terrestrial value. This is among the highest-ever-measured values in the solar system. That means it is very unlikely that comets like 67P/Churyumov-Gerasimenko are responsible for the terrestrial water.
The D/H ratio is the ratio of a heavier hydrogen isotope, called deuterium, to the most common hydrogen isotope. It can provide a signature for comparison across different stages of a planet’s history.

“We knew that Rosetta’s in situ analysis of this comet was always going to throw us surprises,” said Matt Taylor, Rosetta’s project scientist from the European Space Research and Technology Center, Noordwijk, the Netherlands. “The bigger picture of solar-system science, and this outstanding observation, certainly fuel the debate as to where Earth got its water.”

Almost 30 years ago (1986) the mass spectrometers on board the European Giotto mission to comet Halley could, for the first time, determine D/H ratio in a comet. It turned out to be twice the terrestrial ratio. The conclusion at that time was that Oort cloud comets, of which Halley is a member, cannot be the responsible reservoir for our water. Several other Oort cloud comets were measured in the next 20 years, all displaying very similar D/H values compared to Halley. Subsequently, models that had comets as the origin of the terrestrial water became less popular.

This changed when, thanks to the European Space Agency’s Herschel spacecraft, the D/H ratio was determined in comet Hartley 2, which is believed to be a Kuiper Belt comet. The D/H ratio found was very close to our terrestrial value -- which was not really expected. Most models on the early solar system claim that Kuiper Belt comets should have an even higher D/H ratio than Oort cloud comets because Kuiper Belt objects formed in a colder region than Oort cloud comets.

The new findings of the Rosetta mission make it more likely that Earth got its water from asteroid-like bodies closer to our orbit and/or that Earth could actually preserve at least some of its original water in minerals and at the poles.

“Our finding also disqualifies the idea that Jupiter family comets contain solely Earth ocean-like water,” said Kathrin Altwegg, principal investigator for the ROSINA instrument from the University of Bern, Switzerland, and lead author of the Science paper. “It supports models that include asteroids as the main delivery mechanism for Earth’s oceans.”

Comets are time capsules containing primitive material left over from the epoch when the sun and its planets formed. Rosetta’s lander obtained the first images taken from a comet’s surface and will provide analysis of the comet’s possible primordial composition. Rosetta will be the first spacecraft to witness at close proximity how a comet changes as it is subjected to the increasing intensity of the sun’s radiation. Observations will help scientists learn more about the origin and evolution of our solar system and the role comets may have played in seeding Earth with water, and perhaps even life.

Rosetta is an ESA mission with contributions from its member states and NASA. The Jet Propulsion Laboratory, Pasadena, California, a division of the California Institute of Technology in Pasadena, manages the U.S. contribution of the Rosetta mission for NASA’s Science Mission Directorate in Washington. JPL also built the MIRO instrument and hosts its principal investigator, Samuel Gulkis. The Southwest Research Institute (San Antonio and Boulder) developed the Rosetta orbiter’s IES and Alice instruments, and hosts their principal investigators, James Burch (IES) and Alan Stern (Alice).

For more information on the U.S. instruments aboard Rosetta, visit http://rosetta.jpl.nasa.gov.

More information about Rosetta is available at http://www.esa.int/rosetta.

Source: NASA
The momentum of certifying American space transportation systems capable of carrying astronauts to the International Space Station continued on pace as NASA took a comprehensive look at all of Boeing’s ground-based system designs. This Ground Segment Critical Design Review marks the second milestone in the company’s Commercial Crew Transportation Capability (CCtCap) contract, NASA’s Launch America initiative designed to return human spaceflight launches to the United States and end our reliance on Russia.

The three-week-long review covered Boeing’s plans for constructing and processing its Crew Space Transportation System, called the CST-100, in a former orbiter processing facility at NASA’s Kennedy Space Center in Florida, where Boeing will process its CST-100. It also covered the development of a nearby mission control center that would be the hub of the company’s engineering operations.

“Along with facility designs, we looked at the operation processes,” said Dave Allega, a lead in the Ground and Mission Operations Office of NASA’s Commercial Crew Program. “How would they be using those facilities? What is the flow? How are they going to build up their new spacecraft, get it ready to fly, put it on the launch vehicle and then operate it once it is there? Then, after landing, how will they go recover it and turn it around to go and do it again?”

A few dozen engineers, along with safety and health and human performance experts, took a deep dive into the various elements here on the ground that would support a crew mission to the station. Even astronauts who could one day fly aboard the CST-100 participated in the review of these critical elements, such as how Boeing would test flight hardware, and assemble and integrate its spacecraft to the United Launch Alliance Atlas V rocket. They even looked at the equipment that would move the integrated stack to Cape Canaveral Air Force Station’s Space Launch Complex 41.
“ULA has a long history of successful uncrewed commercial launches, and now they are highlighting what is different about flying a crew,” said John Mulholland, Boeing Commercial Crew Program Manager.

Another critical piece of this review included how Boeing plans to train astronauts prior to missions and how the company will monitor crew members during all phases of the flight. For example, the CST-100 spacecraft simulator the company built at its Houston Product Support Center will start to see a lot of action as more pilot-in-the-loop demonstrations are performed and crew training begins.

“The CST-100 will be a more simple vehicle to operate than the space shuttle, but the automation is complicated in and of itself, so we need to understand that automation and so does the crew,” said Allega. “When Boeing trains our astronauts, they will have to balance simplicity, and giving the crew everything they need to know to manually operate the spacecraft just in case something goes wrong.”

As part of its Launch America initiative, NASA selected Boeing and SpaceX to finalize their respective space transportation system designs, then build and fly test flights with crews to the station over the next few years. For actual crew transportation missions to the ISS, the CCtCap contract requires crew handover to NASA within one hour of landing, which is why Boeing is looking at bringing the CST-100 home to land on terra-ferma in the Western United States using parachute and then utilizing airbags to soften the final touchdown. This means for the first time since the end of NASA’s Space Shuttle Program, agency managers, program managers and medical teams won’t need to leave the United States to greet astronauts returning from space.

“This critical design review was validation to the NASA team that all of Boeing’s ground segment plans are in place and are starting to match up to our certification requirements,” said Kathy Lueders, manager of NASA’s Commercial Crew Program. “This is a really good sign that we’re marching at a good pace to reach our goal of certifying the system to fly to the space station.”

Source: NASA
3. Scientists Find Possible Signal from Dark Matter

Could there finally be tangible evidence for the existence of dark matter in the Universe? After sifting through reams of X-ray data, scientists in EPFL’s Laboratory of Particle Physics and Cosmology (LPPC) and Leiden Univ. believe they may have identified the signal of a particle of dark matter. This substance, which up to now has been purely hypothetical, is run by none of the standard models of physics other than through the gravitational force. Their research will be published next week in Physical Review Letters.

When physicists study the dynamics of galaxies and the movement of stars, they are confronted with a mystery. If they only take visible matter into account, their equations simply don't add up: the elements that can be observed are not sufficient to explain the rotation of objects and the existing gravitational forces. There is something missing. From this they deduced that there must be an invisible kind of matter that does not interact with light, but does, as a whole, interact by means of the gravitational force. Called dark matter, this substance appears to make up at least 80 percent of the Universe.

Andromeda and Perseus revisited

Two groups have recently announced that they have detected the much sought after signal. One of them, led by EPFL scientists Oleg Ruchayskiy and Alexey Boyarsky, also a professor at Leiden Univ. in the Netherlands, found it by analyzing X-rays emitted by two celestial objects - the Perseus galaxy cluster and the Andromeda galaxy. After having collected thousands of signals from the ESA's XMM-Newton telescope and eliminated all those coming from known particles and atoms, they detected an anomaly that, even considering the possibility of instrument or measurement error, caught their attention.

The signal appears in the X-ray spectrum as a weak, atypical photon emission that could not be attributed to any known form of matter. Above all, "the signal’s distribution within the galaxy corresponds exactly to what we were expecting with dark matter, that is, concentrated and intense in the center of objects and weaker and diffuse on the edges," explains Ruchayskiy. "With the goal of verifying our findings, we then looked at data from our own galaxy, the Milky Way, and made the same observations," says Boyarsky.

A new era

The signal comes from a very rare event in the Universe: a photon emitted due to the destruction of a hypothetical particle, possibly a "sterile neutrino." If the discovery is confirmed, it will open up new avenues of research in particle physics.

Apart from that, "It could usher in a new era in astronomy," says Ruchayskiy. "Confirmation of this discovery may lead to construction of new telescopes specially designed for studying the signals from dark matter particles," adds Boyarsky. "We will know where to look in order to trace dark structures in space and will be able to reconstruct how the Universe has formed."

Source: Laboratory Equipment
The Night Sky

Friday, December 12

This is the time of year when, around 8 or 9 p.m., Cassiopeia stands very high in the north as a flattened letter M. When will you see it perfectly level? This mostly depends on how far east or west you are in your time zone.

Saturday, December 13

The Geminid meteor shower should be at its strongest late tonight and late tomorrow night. Bundle up even more warmly than you think you'll need, find a dark, shadowed site with an open view overhead, lie back in a reclining lawn chair, and watch the stars. Be patient.

Under a fairly dark sky you may see a meteor every minute or two. You know it's a Geminid if its path, traced far enough backward across the sky, would pass close to Castor and Pollux in Gemini. The Moon, at last quarter, rises around 11 or midnight depending on your location, brightening the sky somewhat. See article.

Sunday, December 14

The Geminid meteors late tonight should still be near maximum activity; see above. The Moon rises an hour later than it did last night at your location.

Monday, December 15

Double shadow transit on Jupiter! Both Io and Europa are casting their tiny black shadows onto the face of Jupiter from 1:12 to 2:02 a.m. Tuesday morning Eastern Standard Time (10:12 to 11:02 p.m. Monday evening Pacific Standard Time).

Europa itself starts crossing Jupiter at 1:18 a.m. EST, and Europa starts crossing the disk at 2:15 a.m. EST. For all about the doings on and around Jupiter for amateur telescopes this month, see "Action at Jupiter" in the December Sky & Telescope, page 52.

Algol is near its minimum light this evening, magnitude 3.4 instead of its usual 2.1, for a couple hours centered on 10:22 p.m. EST (7:22 p.m. PST). It takes several additional hours to fade and to rebrighten. Comparison-star chart.

Source: Sky & Telescope
ISS Sighting Opportunities

For Denver:

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

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**NASA-TV Highlights**

*(all times Eastern Daylight Time)*

**Monday, December 15**

9:55 a.m., ISS Expedition 42 In-Flight Event for ESA with Flight Engineer Samantha Cristoforetti of ESA (all channels)

Watch NASA TV on the Net by going to the [NASA website](https://www.nasa.gov/).
• Dec 12 - [Dec 11] NROL-35 Atlas 5 Launch
• Dec 12 - Asteroid 3414 Champollion Closest Approach To Earth (0.991 AU)
• Dec 12 - 10th Anniversary (2004), Scott Sheppard, et al's Discovery of Saturn Moons Fornjot, Farbauti, Aegir, Bebhionn, Hati & Bergeimir
• Dec 12 - 10th Anniversary (2004), Sheppard/Jewitt/Kleyna's Discovery of Saturn Moon Hyrrokkin
• Dec 12 - Cassini, Orbital Trim Maneuver #398 (OTM-398)
• Dec 13 - Geminids Meteor Shower Peak
• Dec 13 - Comet C/2013 U1 (Catalina) At Opposition (3.361 AU)
• Dec 13 - [Dec 05] Asteroid 2014 UV210 Near-Earth Flyby (0.018 AU)
• Dec 13 - Asteroid 13609 Lewicki Closest Approach To Earth (1.544 AU)
• Dec 13 - Galaxy Forum Japan 2014, Tokyo, Japan
• Dec 13 - 10th Anniversary (2004), Scott Sheppard, et al's Discovery of Saturn Moons Fenrir & Bestla
• Dec 14 - Comet 304P/Ory Closest Approach To Earth (0.936 AU)
• Dec 14 - Comet C/2014 U3 (Kowalski) At Opposition (1.952 AU)
• Dec 14 - Comet P/2012 T2 (PANSTARRS) At Opposition (4.177 AU)
• Dec 14 - [Dec 12] Asteroid 2014 XB6 Near-Earth Flyby (0.019 AU)
• Dec 14 - Asteroid 204131 (2003 YL) Near-Earth Flyby (0.069 AU)
• Dec 14 - Asteroid 30857 Parsec Closest Approach To Earth (0.884 AU)
• Dec 14 - Asteroid 231307 Peterfalk Closest Approach To Earth (1.781 AU)
• Dec 14 - Asteroid 3992 Wagner Closest Approach To Earth (2.163 AU)
• Dec 14 - Asteroid 4255 Spacewatch Closest Approach To Earth (3.594 AU)
• Dec 14 - Asteroid 39415 Janeausten Closest Approach To Earth (3.655 AU)
• Dec 14 - Asteroid 3317 Paris Closest Approach To Earth (4.902 AU)
• Dec 14 - Pluto 55638 (2002 VE95) At Opposition (28.236 AU)
• Dec 14 - 15th Anniversary (1999), Dunbogan Meteorite Fall (Hit House in Australia)
• Dec 15 - Comet 251P/LINEAR At Opposition (4.170 AU)
• Dec 15 - [Dec 11] Asteroid 2014 WD497 Near-Earth Flyby (0.041 AU)
• Dec 15 - Asteroid 3173 McNaught Closest Approach To Earth (1.584 AU)
• Dec 15 - Asteroid 218998 Navi Closest Approach To Earth (1.751 AU)
• Dec 15 - 30th Anniversary (1984), Vega 1 Launch (Soviet Venus/Comet Halley Mission)
• Dec 15 - Charles Augustus Young's 180th Birthday (1834)
Food for Thought
How Buckyballs Form in Interstellar Space

Scientists from Leiden University have shown in the laboratory how Buckyballs -- molecular soccer balls -- form in space.

The experiments are special, as these are based on a new chemical concept -- top-down, from big to small -- transferring large aromatic species into interstellar graphene, fullerenes and carbon cages.

C60 Buckminsterfullerenes were discovered in space in 2010, nearly 15 years after the Nobel Prize was awarded for their discovery in the laboratory. With this discovery, C60 also became the largest identified molecule in the interstellar medium. Unclear, however, was how such a complex molecule could form. Because of the highly dilute nature of matter in space, it is very unlikely that it forms in a series of sequential steps, building up from smaller species. An answer to this question has been found in the Laboratory for Astrophysics at Leiden Observatory. The results have been accepted for publication in the Astrophysical Journal Letters.

Dying stars expel large amounts of so called PAHs, polycyclic aromatic hydrocarbons. These are the same particles that are emitted on Earth by cars, contributing to air pollution. A PAH comprises of a generally flat carbon skeleton with H-atoms at the edges. They are expected to be omnipresent in space as their spectral fingerprints are visible everywhere in the universe.

In Leiden a new setup has been constructed -- iPOP (I nstrument to study the Photodynamics of PAHs) that is used to catch very large PAHs in a molecular trap. The scientists at Leiden Observatory subsequently irradiated the PAHs with light and discovered that once a PAH is put into the spotlights, it starts with a molecular
striptease, stripping off H-atoms one by one, until the naked carbon skeleton is left over. This is nothing else than a graphene flake.

Lead author Dr. Junfeng Zhen and PhD students Pablo Castellanos Nash and Daniel Paardekooper explain: "The experiment starts with a GRAND-PAH, a very large PAH, for example C66H26, then the molecule is ionized, and trapped in an ion trap. The trapped species are irradiated by light and fragment. Once the trap is opened, a sensitive mass spectrometer is used to visualize which species have been formed. We find all steps from the precursor species up to the fully stripped molecule, as well as new reaction products."

The principal investigators, Profs. Xander Tielens and Harold Linnartz, are very enthusiastic about the fact that among the reaction products also C60 can be found. "The experiments show that it is possible to transfer PAHs into molecular soccer balls, and this can explain why we find C60 in space. The experiments also show that the chemical complexity in the interstellar medium not necessarily has to be explained by merging smaller components, the fragmentation of a large precursor may be equally important," according to Tielens.

It is very well possible that the researchers have dug into a goldmine. The new experiments make it possible to generate exotic molecules, carbon cages, fullerenes and graphene flakes, species that so far could not be investigated under isolated conditions. Space may be littered with these exotic species. Indeed, meanwhile also C70 -- a molecule in the form of a rugby ball -- has been identified in the interstellar medium, and also here lab data hint for a formation from even larger PAHs. Linnartz: "We now wait for the detection of interstellar graphene."


Source: Spaceref.com
Crystals on Mars

**Explanation:**  This extreme close-up, a mosaic from the Mars Hand Lens Imager (MAHLI) on the Curiosity rover, spans a breathtaking 5 centimeters. It captures what appear to be elongated crystal shapes formed by the precipitation of minerals dissolved in water, a likely result of the evaporation of ancient lake or river from the Martian surface. Brushed by a dust removal tool and illuminated by white LEDs, the target rock named Mojave was found on the Pink Cliffs outcrop of the Pahrump Hills at the base of Mount Sharp. The MAHLI images were acquired on Curiosity's sol 809, known on planet Earth as November 15, 2014. Of course, the inset 1909 Lincoln Cent image is provided for a comparison scale. Covered with Mars dust itself, the penny is a MAHLI calibration target attached to the rover.

**Image Credit:** NASA, JPL-Caltech, MSSS

Source: Astronomy Picture of the Day