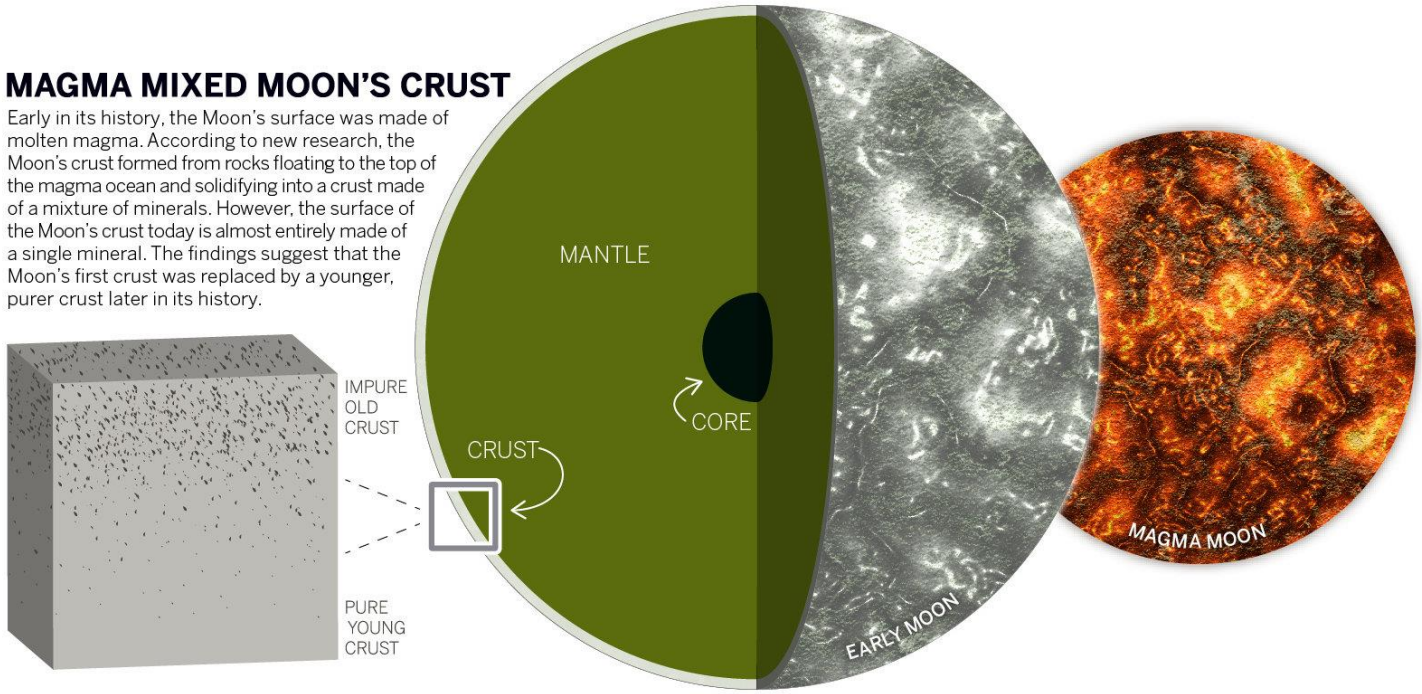
Space News Update

— November 28, 2017 —

Contents

1. Moon's Crust Underwent Resurfacing after Forming from Magma Ocean



Credit: The University of Texas at Austin/Jackson School of Geosciences

The Earth's Moon had a rough start in life. Formed from a chunk of the Earth that was lopped off during a planetary collision, it spent its early years covered by a roiling global ocean of molten magma before cooling and forming the serene surface we know today.

A research team led by The University of Texas at Austin Jackson School of Geosciences took to the lab to recreate the magmatic melt that once formed the lunar surface and uncovered new insights on how the modern moonscape came to be. Their study shows that the Moon's crust initially formed from rock floating to the surface of the magma ocean and cooling. However, the team also found that one of the great mysteries of the lunar body's formation – how it could develop a crust composed largely of just one mineral – cannot be explained by the initial crust formation and must have been the result of some secondary event.

The results were published on Nov. 21 in Geophysical Research Letters.

"It's fascinating to me that there could be a body as big as the Moon that was completely molten," said Nick Dygert, an assistant professor at the University of Tennessee, Knoxville who led the research while a postdoctoral researcher in the Jackson School's Department of Geological Sciences. "That we can run these simple experiments, in these tiny little capsules here on Earth and make first order predictions about how such a large body would have evolved is one of the really exciting things about mineral physics."

Dygert collaborated with Jackson School Associate Professor Jung-Fu Lin, Professor James Gardner and Ph.D. student Edward Marshall, as well as Yoshio Kono, a beamline scientist at the Geophysical Laboratory at the Carnegie Institution of Washington.

Large portions of the Moon's crust are made up almost entirely of a single mineral. In these sections, 98 percent of the crust is plagioclase. According to the prevailing theory, which this study calls into question, the purity is due to plagioclase floating to the surface of the magma ocean over hundreds of millions of years and

solidifying into the Moon's crust. This theory hinges on the magma ocean having a specific viscosity, a term related to the magma's "gooiness," that would allow plagioclase to separate from other dense minerals it crystallized with and rise to the top.

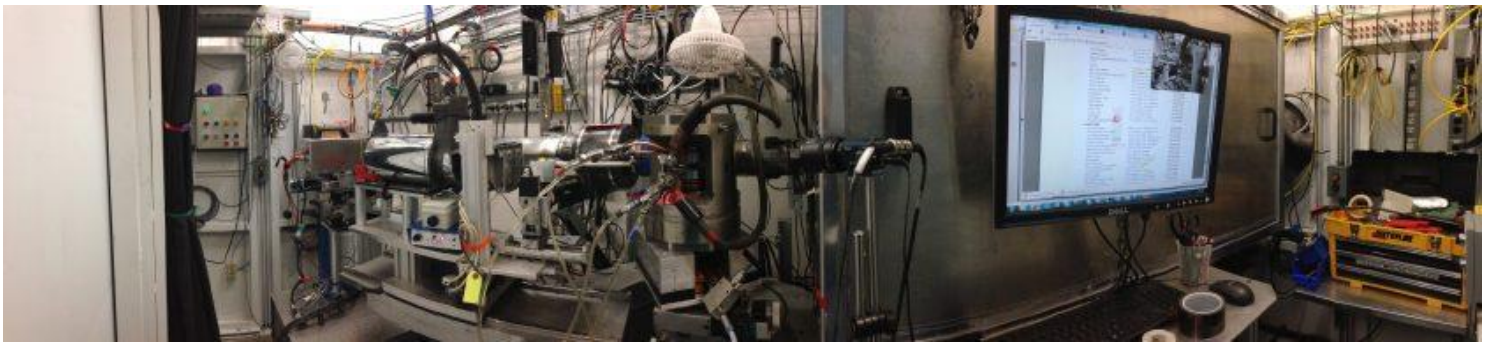
Dygert decided to test the plausibility of the theory by measuring the viscosity of lunar magma directly. The feat involved using a high-pressure apparatus called a synchrotron to shoot a concentrated beam of high-energy X-rays into a sample of mineral powders and flash melting them into magma. The researchers then measured the time it took for a melt-resistant sphere to sink through the magma.

"Previously, there had not been any laboratory data to support models," said Lin. "So this is really the first time we have reliable laboratory experimental results to understand how the Moon's crust and interior formed."

The experiment found that the magma melt had a very low viscosity, somewhere between that of olive oil and corn syrup at room temperature, a value that would have supported plagioclase flotation. However, it would have also led to mixing of plagioclase with the magma, a process that would trap other minerals in between the plagioclase crystals, creating an impure crust on the lunar surface. Because satellite-based investigations demonstrate that a significant portion of the crust on the Moon's surface is pure, a secondary process must have resurfaced the Moon, exposing a deeper, younger, purer layer of crust. Dygert said the results support a "crustal overturn" on the lunar surface where the old mixed crust was replaced with young, buoyant, hot deposits of pure plagioclase. The older crust could have also been eroded away by asteroids slamming into the Moon's surface.

Dygert said the study's results exemplify how small-scale experiments can lead to large-scale understanding of geological processes that build planetary bodies in our solar system and others.

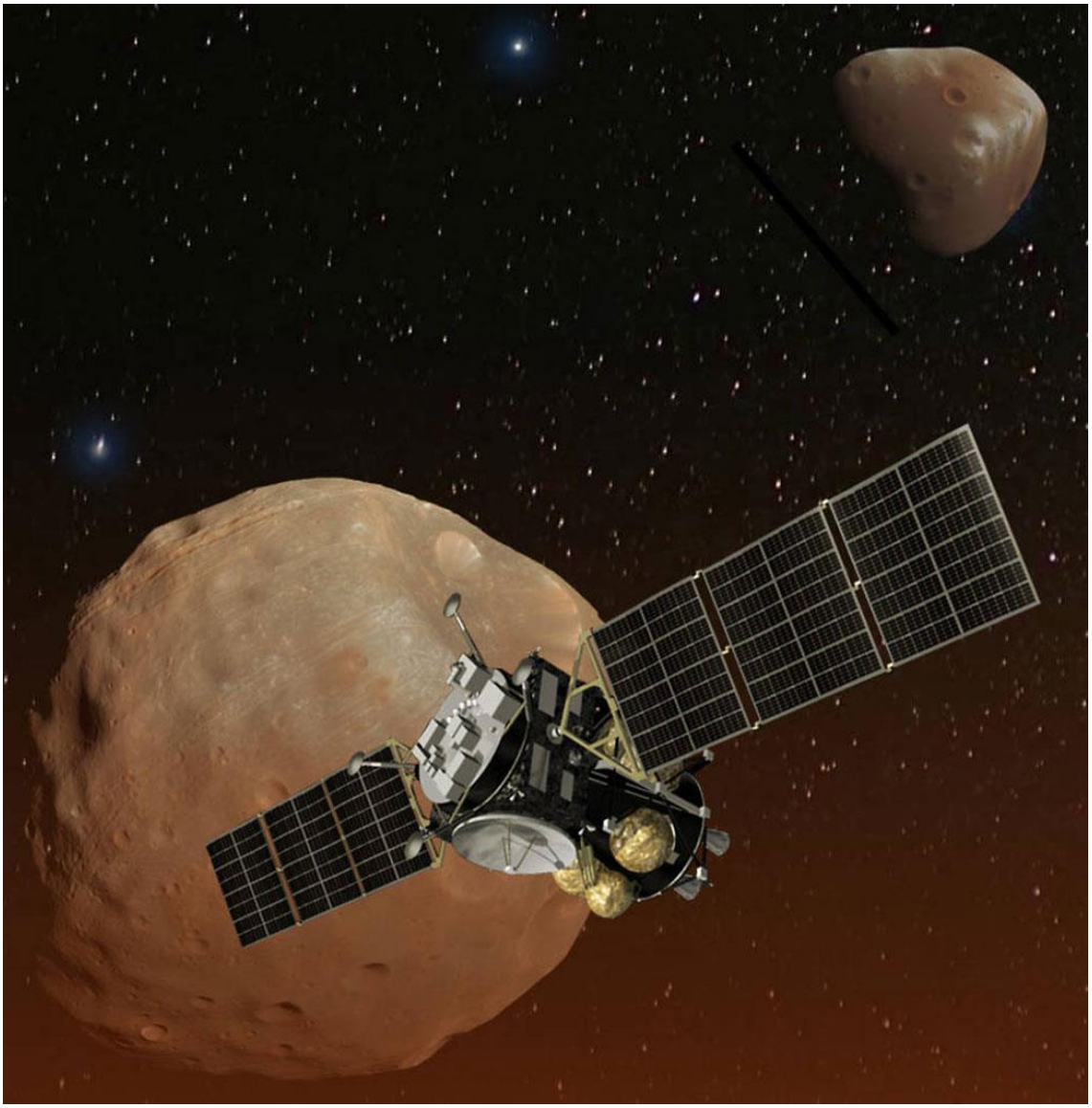
"I view the Moon as a planetary lab," Dygert said. "It's so small that it cooled quickly, and there's no atmosphere or plate tectonics to wipe out the earliest processes of planetary evolution. The concepts described here could be applicable to just about any planet."



The experimental apparatus in the synchrotron facility. The researchers used the machine to recreate moon magma in the lab. Credit: Nick Dygert.

Source: EurekAlert/University of Texas, Austin Return to Contents

2. NASA Confirms Contribution to Japanese-Led Mars Mission



Artist's concept of the MMX spacecraft at Phobos. Credit: JAXA/NASA

NASA announced Thursday it will fund development of a scientific instrument that will fly on Japan's Martian Moons Exploration mission, a robotic probe set for launch in 2024 to bring back the first samples from Mars' largest moon Phobos.

A neutron and gamma-ray spectrograph developed by a team led by David Lawrence of the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, will help officials decide where the Japanese spacecraft will pick up samples on Phobos.

Fitted with a souped-up propulsion module, landing legs and a sample carrier, the spacecraft will enter orbit around Mars, then rendezvous with Phobos before landing on the moon to core into its surface and gather rock fragments. The craft will take off from Phobos — an asteroid-like object with weak gravity — and make several flybys of the smaller moon Deimos before firing its engines to head back to Earth, arriving home in mid-2029.

The ambitious mission, known as MMX, will follow Japan's Hayabusa and Hayabusa 2 asteroid sample return projects. Hayabusa brought microscopic asteroid specimens back to Earth in 2010, and Hayabusa 2 is set to arrive at its target — asteroid Ryugu — next year to collect samples for return to Earth in 2020.

MMX is the first of three "strategic" space missions planned by the Japan Aerospace Exploration Agency in the 2020s. Two astronomy missions, named LiteBIRD and SPICA, could follow later in the decade.

JAXA's strategic missions are expected to cost approximately $300 million, not including international contributions.

The planned Phobos sample return mission aims to return the first material directly from the surface of Phobos.

A Russian mission named Phobos-Grunt launched in 2011 had the same objective, but a rocket mishap stranded the probe in orbit around the Earth before it could depart for the red planet. Russian scientists have developed plans for another Phobos mission, but the project has not been formally approved, and if given the go-ahead would likely launch after MMX.

The NASA-funded instrument — named MEGANE, meaning "eyeglasses in Japanese — will measure the elemental composition of Phobos by detecting neutrons and gamma-rays emitted from the small moon, scientists said.

A major science goal of the MMX mission is to determine the origin of the Martian moons. Theories suggest Phobos and Deimos were either asteroids captured by Martian gravity, or they coalesced from rocky debris generated from an ancient impact on Mars.

Phobos has an average diameter of about 14 miles, or 22 kilometers.

"Solving the riddle of how Mars' moons came to be will help us better understand how planets formed around our Sun and, in turn, around other stars," said Thomas Zurbuchen, associate administrator for NASA's science mission directorate. "International partnerships like this provide high-quality science with high-impact return."

"We'll see the composition of the region from which MMX collects its sample," said Thomas Statler, program scientist for MMX at NASA Headquarters in Washington. "This will help us better understand what we discover in the laboratory when the mission returns the sample to Earth for analysis."

NASA selected the MEGANE instrument from proposals submitted by multiple U.S. science teams. Managed under NASA's Discovery program as a mission of opportunity, the MEGANE instrument has a cost cap of $15 million.

JAXA and the French space agency CNES announced in April their partnership on the MMX mission.

French scientists committed to build an infrared camera and spectrometer named MacrOmega to fly on the MMX spacecraft. Like MEGANE, the CNES-provided instrument will help scientists locate the best place to collect a sample.

French engineers will also study the possibility of adding a miniature rover to the MMX mission, and provide flight dynamics and navigation expertise to the Japanese team.

Source: SpaceflightNow Return to Contents

3. The Lost LED Revolution: Light Pollution Is Increasing

Changes in the color of Milan, Italy, at night between 2012 (left) and 2015 (right), between which the outdoor lighting in its urban core was transitioned from high-pressure sodium vapor to white LED. Credit: International Dark-Sky Association / NASA

The transition from sodium lights to LEDs, the so-called "lighting revolution", was supposed to reduce energy consumption and bring back starry skies, but new satellite data indicate it's not working out that way.

When scientists are disappointed with their results, it's usually because they were following a different hypothesis than where their data leads. In the case of the switch from sodium lights to LEDs, though, it's more than that.

"Honestly, I had thought, assumed, and hoped that with LEDs we were turning the corner," says Christopher Kyba (German Research Center for Geosciences). Kyba researches the spread of artificial lights and how it affects our nights, and as a former member of the board of directors of the International Dark Sky Association, he also advocates the use of improved lighting practices.

But in the November 22nd *Science Advances*, Kyba and colleagues show that we are farther from the goal of dark, starry skies than ever.

The team used the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Suomi National Polar-orbiting Partnership weather satellite to measure the change in global light emissions between October 2012 and October 2016. The VIIRS instrument is the first-ever calibrated satellite radiometer designed to measure nighttime lights – earlier investigations were often based on uncalibrated sensors on military satellites.

VIIRS observes the Day/Night band (DNB), which picks up visible through near-infrared wavelengths. Each pixel covers ½ square kilometer, a higher spatial resolution than previous instruments, which enables scientists to investigate neighborhood-scale changes, rather than city or national, for the first time.

The researchers' findings will not please astronomers: Earth's nights are becoming brighter.

Between 2012 and 2016, the artificially lit outdoor area on our planet grew by 9.1%, an annual increase of roughly 2.2%. Additionally, already lit areas also got brighter by 2.2% per year. Only very few places show a decrease in lighting (mostly war-torn countries like Syria and Yemen), while some of the already brightest-lit countries remained stable, among them Spain, Italy and the United States. With few exceptions, all countries in Asia, Africa, and South America emit significantly more light now than they used to five years ago.

That in itself isn't unexpected — artificial lighting has long been an indicator for growing wealth and population. What's surprising is that the ongoing transition to LEDs isn't having a contrary effect.

"While we know that LEDs save energy in specific projects, for example when a city transitions all of its street lighting from sodium lamps to LED," Kyba explains, "when we look at our data at the national and the global level, it indicates that these savings are being offset by either new or brighter lights in other places."

It's a rebound effect: Cheaper lights lead not to savings in energy consumption, but to more light. And that's not just bad news for astronomers.

"Since the first emergence of life, the biological world was organized to a large extent by natural cycles of variation in light," explains Franz Hölker (Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany). "From an evolutionary perspective, artificial light at night is a very new stressor."

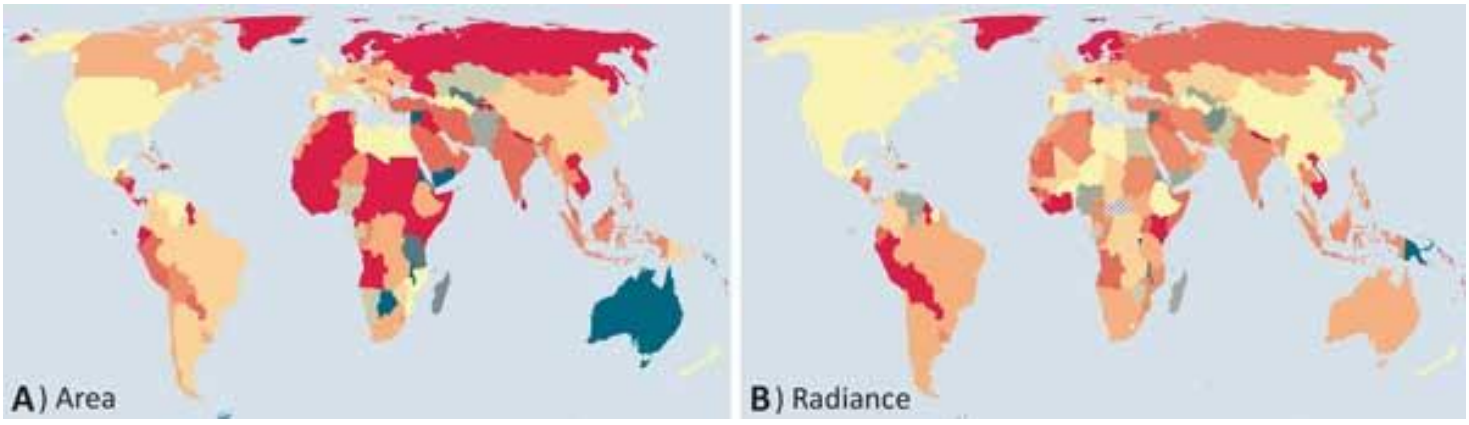
Because electricity brings light to places, times, and intensities at which it doesn't naturally occur, many organisms have no chance to adapt. Their natural light cycles are fundamentally disrupted. About 30% of vertebrates and more than 60% of invertebrates on our planet are nocturnal, but outdoor artificial light also affects plants and microorganisms, and scientist are only beginning to learn about its possible negative effects on human health.

Blue vs. Amber LEDs

To make matters worse, the DNB is insensitive to wavelengths below 0.5 microns — blue light, which the atmosphere scatters more than other visible wavelengths. Unfortunately, many popular LED lights peak at these wavelengths.

It doesn't have to be this way. "One of the really huge advantages of LEDs is that it's possible to make very many different colors," Kyba insists. "Cities can buy lamps that are not white, that have this blue component completely removed." However these "PC Amber" or "True Amber" lights are so far used almost exclusively in designated dark-sky places.

Nevertheless, Kyba and his colleagues remain open to working with cities, local governments, and industry partners to reverse this trend: "The real dream is that we have great vision on the streets, never really experience an uncomfortably dark place inside of a city, but because the light is used much more efficiently, would have more stars to see in the sky."



World maps showing the rates of change of the lit area of the world (left) and the measured brightness of each country (right) during 2012–2016. Warmer colors in each map correspond to higher rates of change. Note that Australia is an odd case: wildfires increased the country's lit area, but this effect was not included in the radiance analysis. Credit: Kyba et al. / Science Advances

Source: Sky and Telescope Return to Contents

The Night Sky

Tuesday, November 28

- After dark this evening, look below the waxing gibbous Moon for Beta Ceti and above it for the Great Square of Pegasus.

Wednesday, November 29

- The five brightest stars of Cassiopeia are usually called a W, but now Cas is turning over to become a wide M, riding very high in the north by late evening.

Thursday, November 30

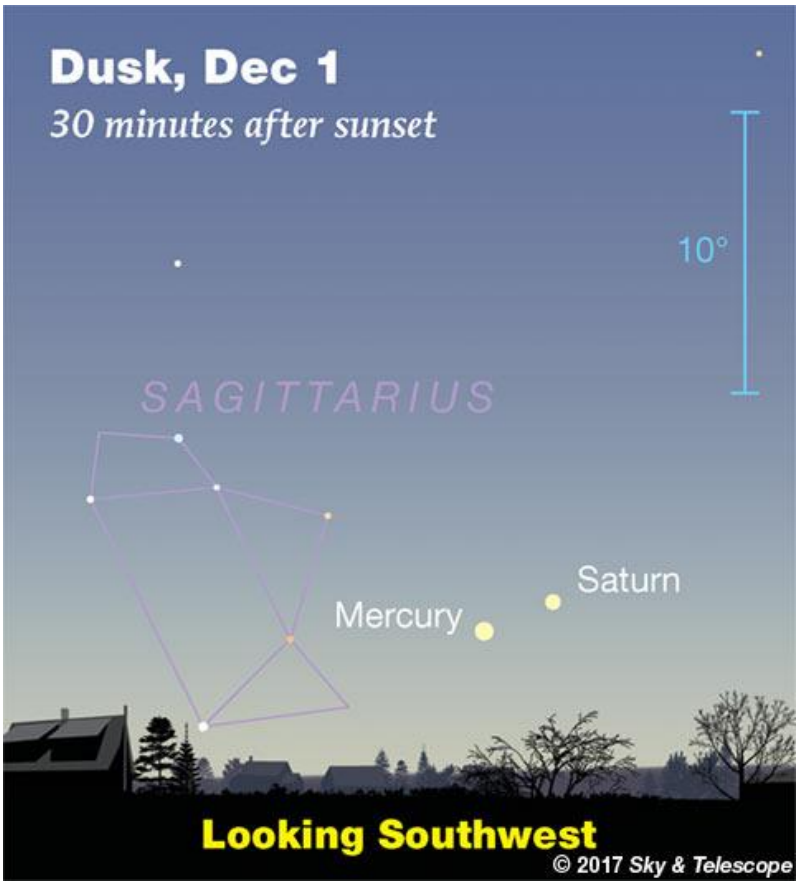
- Bright Vega still shines well up in the west-northwest after dark. The brightest star above it is Deneb, the head of the big Northern Cross, which is formed by the brightest stars of Cygnus. At nightfall the shaft of the cross extends lower left from Deneb. By about 11 or midnight, the cross plants itself more or less upright on the northwest horizon.

Friday, December 1

- The bright waxing gibbous Moon shines in the east this evening. Look upper right of it for the two brightest stars of Aries, left of it for the little Pleiades cluster, and below the Pleiades for orange Aldebaran.

Saturday, December 2

- The nearly-full Moon shines in Taurus this evening, upper right of Aldebaran and below or lower right of the Pleiades.
- Does the Moon look just a trace bigger than usual? You're right! Tomorrow's full Moon is a "supermoon," in fact the closest full Moon of the year.
- Now that the Pleiades and Aldebaran are up in due east, can Orion be far behind? Orion's entire iconic figure, formed by its brightest seven stars, takes about an hour and a quarter to cross the horizon below them. By 10 p.m. Orion is well up in fine pre-winter view, under the Moon.



By Friday December 1st, Mercury and Saturn are just 3° apart in the sunset glow.

Source: Sky and Telescope

Return to Contents

ISS Sighting Opportunities (from Denver)

Date	Visible	Max Height	Appears	Disappears
Tue Nov 28, 5:58 PM	3 min	84°	29° above SW	37° above NE
Wed Nov 29, 5:05 PM	5 min	47°	19° above SSW	11° above ENE
Wed Nov 29, 6:42 PM	1 min	21°	15° above WNW	21° above NW
Thu Nov 30, 5:50 PM	3 min	36°	23° above W	21° above NNE
Fri Dec 1, 4:59 PM	4 min	66°	43° above W	10° above NE
Fri Dec 1, 6:35 PM	1 min	14°	10° above NW	14° above NNW

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

NASA-TV Highlights (all times Eastern Time Zone)

Wednesday, November 29

- 8:30 a.m. - ISS Expedition 53 In-Flight Event for ESA with the Mission X Competition and Flight Engineer Paolo Nespoli of the European Space Agency (Starts at 8:40 a.m.) (all channels)
- 12 p.m. - Video File of the ISS Expedition 54-55 Crew First Soyuz Qualification Training at the Gagarin Cosmonaut Training Center in Star City, Russia (Recorded on November 28-29; Shkaplerov, Tingle, Kanai) (NTV-3 (Media))

Thursday, November 30

- 4 p.m. - Replay of the ISS Expedition 54-55 Crew News Conference at the Gagarin Cosmonaut Training Center in Star City, Russia (Shkaplerov, Tingle, Kanai) (all channels)
- 4:45 p.m. - Video File of the ISS Expedition 54-55 Crew's Ceremonial Visit to the Gagarin Museum at the Gagarin Cosmonaut Training Center and Visit to Red Square and the Kremlin in Moscow (Shkaplerov, Tingle, Kanai) (NTV-3 (Media))

Friday, December 1

- 5:30 a.m. - Video B-Roll Feed of Training of ISS Expedition 54-55 Flight Engineer Scott Tingle of NASA (all channels)
- 6 a.m. - Live Interviews with Expedition 54-55 Flight Engineer Scott Tingle of NASA from the Gagarin Cosmonaut Training Center in Star City, Russia (all channels)

Watch NASA TV online by going to the NASA website. Return to Contents

Space Calendar

- Nov 28 - 50th Anniversary (1967), Discovery of 1st Pulsar by Jocelyn Bell & Antony Hewish
- Nov 28 - Mercury Passes 3.0 Degrees From Saturn
- Nov 28 - Comet 73P-AY/Schwassmann-Wachmann At Opposition (3.240 AU)
- Nov 28 - Comet 73P-AZ/Schwassmann-Wachmann At Opposition (3.241 AU)
- Nov 28 - Apollo Asteroid 2017 WK1 Near-Earth Flyby (0.020 AU)
- Nov 28 - Apollo Asteroid 11066 Sigurd Closest Approach To Earth (0.807 AU)
- Nov 28 - Apollo Asteroid 2009 BD Closest Approach To Earth (1.963 AU)
- Nov 28 - Kuiper Belt Object 386723 (2009 YE7) At Opposition (49.823 AU)
- Nov 28 - Colloquium: Physical Properties of the Trans-Neptunian Objects, Tucson, Arizona
- Nov 28-29 - 4th Defense Strategies Institute (DSI) Space Resiliency Summit, Alexandria, Virginia
- Nov 28-30 - 2017 Conference on Big Data from Space (BiDS'17), Toulouse, France
- Nov 28-Dec 01 - Workshop: Unlocking the Climate Record Stored within Mars' Polar Layered Deposits - Part II, Pasadena, California
- Nov 28-Dec 01 - ESAC Data Analysis and Statistics Workshop 2017, Madrid, Spain
- Nov 29 - Comet 229P/Gibbs Closest Approach To Earth (1.937 AU)
- Nov 29 - Comet C/2017 S7 (Lemmon) Closest Approach To Earth (6.764 AU)
- Nov 29 - Aten Asteroid 2010 VD139 Near-Earth Flyby (0.013 AU)
- **Nov 29 - Apollo Asteroid 2017 WF16 Near-Earth Flyby (0.010 AU)**
- Nov 29 - Apollo Asteroid 2017 WN15 Near-Earth Flyby (0.019 AU)
- Nov 29 - Apollo Asteroid 2017 WS Near-Earth Flyby (0.052 AU)
- Nov 29 - Amor Asteroid 2017 VQ14 Near-Earth Flyby (0.080 AU)
- Nov 29 - Asteroid 11947 Kimclijsters Closest Approach To Earth (2.370 AU)
- Nov 29 - Apollo Asteroid 1863 Antinous Closest Approach To Earth (2.692 AU)
- Nov 29 - Kuiper Belt Object 145453 (2005 RR43) At Opposition (38.580 AU)
- Nov 29 - Lecture: Kepler, K2, and Beyond - The Era of Exoplanets Has Arrived!, Menlo Park, California
- Nov 29-30 - RAMS Awareness Workshop on Human Spaceflight and Robotic Exploration (PA3), Cologne, Germany
- Nov 29-30 - Meeting: Review of the Draft Fourth National Climate Assessment, Washington DC
- Nov 29-Dec 01 - Meeting: Review of Progress Toward Implementing the Decadal Survey Vision and Voyages for Planetary Sciences, Irvine, California
- Nov 29-Dec 02 - Symposium: The Origin of Galaxies, Stars, and Planets in the Era of ALMA, Pasadena, California
- Nov 30 - 6th International Cosmic Day
- Nov 30 - Comet C/2017 F1 (Lemmon) Perihelion (4.500 AU)
- Nov 30 - Apollo Asteroid 2017 WH2 Near-Earth Flyby (0.016 AU)
- Nov 30 - Apollo Asteroid 10563 Izhdubar Closest Approach To Earth (1.096 AU)
- Nov 30 - Apollo Asteroid 2013 EC20 Closest Approach To Earth (1.681 AU)
- **Dec 01 - Cosmos (Lotos N2 803) Soyuz-2.1b Launch**

Source: JPL Space Calendar Return to Contents

Food for Thought

Interstellar Space Probes: Where's the brakes?!

Source: Space.com

With a miniaturized space probe capable of being accelerated to a quarter of the speed of light, we could reach Alpha Centauri, our nearest star, in 20 to 50 years. However, without a mechanism to slow it down, the space probe could only collect data from the star and its planets as it zoomed past. A theoretical physicist at Goethe University Frankfurt has now examined whether interstellar spacecraft can be decelerated using "magnetic sails".

For a long time, the idea of sending unmanned space probes through the depths of interstellar space to distant stars was purely utopian. Recent research on new concepts - amongst others within the "Breakthrough Starshot" project - has shown that miniaturized space probes could be accelerated by means of powerful lasers. Slowing them down again seems more challenging, since they cannot be fitted with braking systems for weight reasons. However, according to Professor Claudius Gros from the Institute for Theoretical Physics at Goethe University Frankfurt, it would be possible to decelerate at least comparatively slow space probes with the help of magnetic sails.

"Slow would mean in this case a travel velocity of 1,000 kilometers per second, which is only 0.3 percent of the speed of light but nevertheless about 50 times faster than the Voyager spacecraft," explains Gros. According to Gros' calculations, what is needed is a magnetic sail in order to transfer the spacecraft's momentum to the interstellar gas. The sail consists of a large, superconducting loop with a diameter of about 50 kilometers. A lossless current induced in this loop then creates a strong magnetic field. The ionized hydrogen in the interstellar medium is then reflected off the probe's magnetic field, slowing it down gradually. This concept works, as Gros was able to show, despite the extremely low particle density of interstellar space (0.005 to 0.1 particles per cubic centimeter).

Gros' research shows that magnetic sails can decelerate 'slow' spacecraft weighing up to 1,500 kilograms. However, the journey would take historical periods of time, for example about 12,000 years to reach the seven known planets of the TRAPPIST-1 system. Surprisingly, slower cruising probes the size of a car could be launched by the same laser which would make it possible to send, according to current planning, high-speed space probes weighing just a few grams to Alpha Centauri.

Missions to distant stars that would take thousands of years are out of the question for exploratory missions. But the situation is quite different in cases where cruising time is irrelevant, such as missions that open up alternative possibilities for terrestrial life. Such missions, like Gros proposed in 2016 under the name of 'The Genesis Project', would carry single-celled organisms, either as deep-frozen spores or encoded in a miniaturized gene laboratory. For a Genesis probe, it is not the time of arrival which is important, but the possibility to decelerate and then orbit the target planet.

Source: Eureka Alert/Goethe University Return to Contents

Space Image of the Week

Jovian Tempest

Image: NASA/JPL-Caltech/SwRI/MSSS/Gerald Eichstädt/Seán Doran.

Explanation: This color-enhanced image of a massive, raging storm in Jupiter's northern hemisphere was captured by NASA's Juno spacecraft during its ninth close flyby of the gas giant planet.

The image was taken on 24 October 2017 at 1732 GMT when the spacecraft was about 10,108 kilometers (6,281 miles) from the tops of the clouds of Jupiter at a latitude of 41.84 degrees. The spatial scale in this image is 6.7 kilometers/pixel (4.2 miles/pixel).

The storm is rotating counter-clockwise with a wide range of cloud altitudes. The darker clouds are expected to be deeper in the atmosphere than the brightest clouds. Within some of the bright "arms" of this storm, smaller clouds and banks of clouds can be seen, some of which are casting shadows to the right side of this picture (sunlight is coming from the left). The bright clouds and their shadows range from approximately 7 to 12 kilometers (4 to 8 miles) in both widths and lengths. These appear similar to the small clouds in other bright regions Juno has detected and are expected to be updrafts of ammonia ice crystals possibly mixed with water ice.

Citizen scientists Gerald Eichstädt and Seán Doran processed this image using data from the JunoCam imager.

Source: AstronomyNow

Return to Contents