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Top News

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Discovery of Water Ice on the Moon Thrills Lunar Scientists

This image shows the distribution of surface ice at the moon's south pole (left) and north pole (right), as detected by NASA's Moon Mineralogy Mapper instrument, which flew aboard India's Chandrayaan-1 spacecraft. Credit: NASA

Scientists who study the moon are beaming about the new discovery of exposed water ice in lunar polar regions.

Using data from NASA's Moon Mineralogy Mapper (M3) spectrometer experiment, a team of researchers — led by HI Li iof the University of Hawaii and Brown University — found direct evidence of water ice on the lunar surface, in permanently shadowed areas in polar craters.

M3 flew aboard the Indian Space Research Organization's Chandrayaan-1 spacecraft, which studied the moon from orbit in 2008 and 2009. Previous data could not confirm the existence of water ice on the moon's surface, but Li et al. provide esolid evidence for its presencee in their study, which was published online this week in the journal Proceedings of the National Academy of Sciences.

"This is a critical paper, as it demonstrates that we have four independent lines of evidence that there are surface ice exposures at the lunar poles," explained Clive Neal, a leading lunar expert at the University of Notre Dame.

"With the neutron data, we also know that these deposits extend into the subsurface. Therefore, we now have great maps that we can use to target prospecting surface rovers," Neal, who was not involved with the new study, told Inside Outer Space.

Key details about these lunar ice deposits still need to be worked out, Neal stressed. For example, researchers don't yet know the deposits' size and purity, or thee geomechanical properties of the regolith in which they lie. Such information could be gathered on the ground by robotic explorers.nl.

"It is time to get to the surface of the moon and start prospecting!" Neal said.

North and south poles

Angel Abbud-Madrid, Director of the Center for Space Resources at the Colorado School of Mines in Goldeno, also found the new research exciting. ..Read More...

A galaxy 11.3 billion light-years away appears filled with dark matter

Using the telescopes of the Atacama Large Millimeter/submillimeter Array in Chile (shown), astronomers discovered the most distant yet galaxy that appears to be filled with dark matter.

A distant galaxy appears filled with dark matter.

The outermost stars in the Cosmic Seagull, a galaxy 11.3 billion light-years away, race too fast to be propelled by the gravity of the galaxy's gas and stars alone. Instead, they move as if urged on by an invisible force, indicating the hidden presence of dark matter, astrophysicist Verónica Motta of the University of Valparaíso in Chile and her colleagues report August 8 at arXiv.org.

"In our nearby universe, you see these halos of dark matter around galaxies like ours," Motta says. "So we should expect that in the past, that halo was there, too."

Motta and her colleagues used radio telescopes at the Atacama Large Millimeter/submillimeter Array (ALMA) to measure the speed of gas across the Cosmic Seagull's disk, from the center out to about 9,800 light-years. They found that the galaxy's stars speed up as they get farther from the galaxy's center.

That's a strange setup for most orbiting objects — when planets orbit a star, for instance, the most distant planets move slowest. But it can be explained if the galaxy's far reaches are dominated by dark matter that speeds things along. Similar measurements of the Milky Way and neighboring galaxies provided one of the first signs that dark matter may exist, although physicists are still trying to detect the proposed particle directly.

Her team's finding contrasts with a recent claim that such distant galaxies are oddly lacking in dark matter. That idea comes from a 2017 study by astronomer Reinhard Genzel of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, and his colleagues, who found more than 100 distant galaxies keep their slower stars at the edges and faster stars closer in — little to no dark matter required. ..Read More...

The Galaxy Is Soaked with Water-Rich Alien Planets

This artist's conception shows habitable-zone planets with similarities to Earth. From left: Kepler-22b, Kepler-69c, Kepler-452b, Kepler-62f and Kepler-186f. Last in line is Earth itself. Credit: NASA/Ames/JPL-Caltech

"Water worlds" are incredibly common throughout the Milky Way galaxy, a new study suggests.

Midsize alien planets — those two to four times larger than Earth — tend to harbor huge amounts of water, according to the research. Indeed, some of these exotic worlds are probably up to 50 percent water by weight. (Our seemingly wet Earth, by contrast, is just 0.02 percent water by weight.)

"Our data indicate that about 35 percent of all known exoplanets which are bigger than Earth should be water-rich," study leader Li Zeng, a postdoctoral fellow in the Department of Earth and Planetary Sciences at Harvard University, said in a statement. "It was a huge surprise to realize that there must be so many water worlds."

Zeng and his colleagues analyzed data gathered by NASA's Kepler space telescope, which has discovered about 70 percent of the 3,800 known exoplanets to date, and the European Space Agency's Gaia spacecraft. The study's researchers used this information to develop a model explaining the relationship between an exoplanet's mass and its radius.

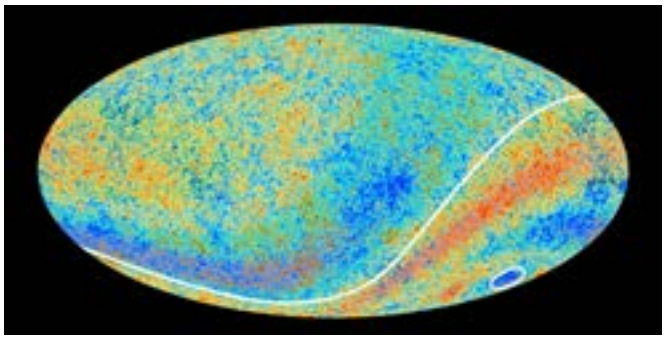
"The beauty of the model is that it explains just how composition relates to the known facts about these planets," said Zeng, who presented the results in Boston Friday (Aug. 17) at the Goldschmidt Conference, a high-profile annual geochemistry meeting.

The team's model suggests that alien worlds about 1.5 times the size of Earth or smaller tend to be rocky, whereas those that are a bit bigger are generally water worlds. (The planets in the next size class up are primarily gaseous. For example, Neptune, the smallest gas giant in our solar system, is about four times wider than Earth.)

But these alien water worlds are not just flooded versions of a pumped-up Earth.

"This is water, but not as [it is] commonly found here on Earth," Zeng said. "Their surface ...Read More...

Physicists Think They've Spotted the Ghosts of Black Holes from Another Universe



An image of the cosmic microwave background. Credit: ESA and the Planck Collaboration

We are not living in the first universe. There were other universes, in other eons, before ours, a group of physicists has said. Like ours, these universes were full of black holes. And we can detect traces of those long-dead black holes in the cosmic microwave background (CMB) — the radiation that is a remnant of our universe's violent birth.

At least, that's the somewhat eccentric view of the group of theorists, including the prominent Oxford University mathematical physicist Roger Penrose (also an important Stephen Hawking collaborator). Penrose and his acolytes argue for a modified version of the Big Bang.

In Penrose and similarly-inclined physicists' history of space and time (which they call conformal cyclic cosmology, or CCC), universes bubble up, expand and die in sequence, with black holes from each leaving traces in the universes that follow. And in a new paper released Aug. 6 in the preprint journal arXiv, Penrose, along with State University of New York Maritime College mathematician Daniel An and University of Warsaw theoretical physicist Krzysztof Meissner, argued that those traces are visible in existing data from the CMB.

"If the universe goes on and on and the black holes gobble up everything, at a certain point, we're only going to have black holes," he told Live Science. According to Hawking's most famous theory, black holes slowly lose some of their mass and energy over time through radiation of massless particles called gravitons and photons. If this Hawking radiation exists, "then what's going to happen is that these black holes will gradually, gradually shrink."

At a certain point, those black holes would disintegrate entirely, An said, leaving the universe a massless soup of photons and gravitons.

"The thing about this period of time is that massless gravitons and photons don't really experience time or space," he said.

Gravitons and photons, massless light speed travelers, don't experience time and space the ..Read More...

A rogue star may explain why the outer solar system is so odd

An illustration of a protoplanetary disk of the sort that scientists believe gave way to our solar system. Universal History Archive / Getty Images

Scientists have a new explanation for Pluto's tilted orbit and other idiosyncrasies.

s recently as two decades ago, we thought our solar system was "normal." That was pretty accurate as long as you didn't look at it too closely. But now we know our system has some remarkable idiosyncrasies, which are especially obvious if you look at the dim spaces beyond Neptune. A prime example is Pluto's oddball orbit, which is tilted by 17 degrees to the disk-shaped plane known as the "ecliptic" in which all the other planets travel around the sun.

Pluto's orbit is also much more egg-shaped than the orbits of Earth and the other planets. This dwarf ice ball takes 248 years to revolve around the sun but spends 20 of those years closer to Sol than Neptune ever is. It's as if one of the horses on a carousel were to weave in and out of the path of an adjacent steed. The dwarf planet Sedna, which is roughly twice as far away as Pluto, has a similarly wacko orbit.

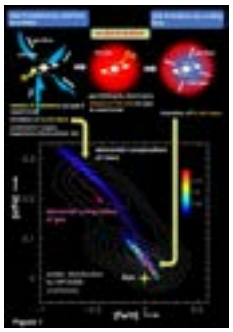
Explanations old and new

So what gives? Why doesn't the sun's retinue of worlds have near-circular orbits, all in the ecliptic? That would be normal.

The usual explanation has been that these distant and generally small objects were tossed around billions of years ago by the shifting gravitational forces of bully worlds such as Neptune. But earlier this month a group of researchers headed by Susanne Pfalzner of the Max Planck Institute for Radio Astronomy in Bonn, Germany, published a study in The Astrophysical Journal that offers another explanation for our solar system's idiosyncrasies — one that's far more dramatic.

Their hypothesis is that long, long ago another star — as big as the sun — passed close to the nascent disk of dust and gas that would become the worlds of our solar system. Its gravity stirred things up, dooming the objects that would eventually form to erratic behavior ...Read More...

Stars memorize rebirth of our home galaxy



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).

The Milky Way galaxy has died once before, and we are now in what is considered its second life. Calculations by Masafumi Noguchi (Tohoku University) have revealed previously unknown details about the Milky Way. These were published in the July 26 edition of Nature.

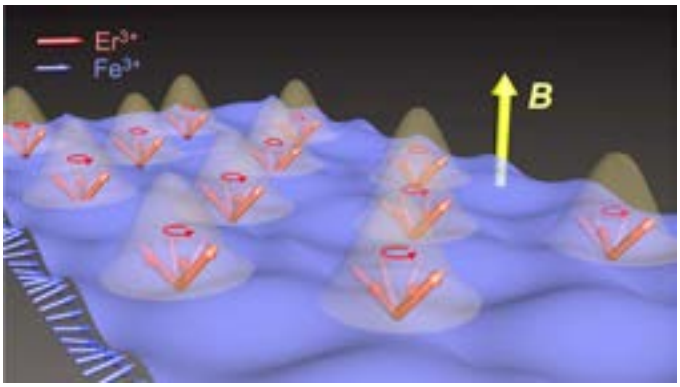
Stars in the Milky Way formed in two different epochs through different mechanisms. There was a long dormant period in between, when star formation ceased. Our home galaxy has turned out to have a more dramatic history than was originally thought.

In calculating the evolution of the Milky Way over a 10 billion-year period, Noguchi included the concept of "cold flow accretion," a new idea proposed by Avishai Dekel (The Hebrew University) and colleagues. It describes how galaxies collect surrounding gas during their formation. Although the two-stage formation was suggested for much more massive galaxies by Yuval Birnboim (The Hebrew University) and colleagues, Noguchi has been able to confirm that the same picture applies to our own Milky Way.

The history of the Milky Way is inscribed in the elemental composition of stars, because stars inherit the composition of the gas from which they are formed—in effect, stars "memorize" the element abundance in gas at the time they are formed.

There are two groups of stars in the solar neighborhood with different compositions. One group is rich in α-elements such as oxygen, magnesium and silicon. The other contains a lot of iron. Recent observations by Misha Haywood (Observatoire de Paris) and colleagues revealed that this phenomenon prevails over a vast region of the Milky Way. The origin of this dichotomy was unclear. Noguchi's model provides an answer to this long-..Read More...

Research team finds evidence of matter-matter coupling



Rice University scientists observed Dicke cooperativity in a magnetic crystal in which two types of spins, in iron (blue arrows) and erbium (red arrows), interacted with each other. The iron spins were excited to form a wave-like object called a spin wave; the erbium spins precessing in a magnetic field (B) behaved like two-level atoms. Credit: Xinwei Li

After their recent pioneering experiments to couple light and matter to an extreme degree, Rice University scientists decided to look for a similar effect in matter alone. They didn't expect to find it so soon.

Rice physicist Junichiro Kono, graduate student Xinwei Li and their international colleagues have discovered the first example of Dicke cooperativity in a matter-matter system, a result reported in Science this week.

The discovery could help advance the understanding of spintronics and quantum magnetism, Kono said. On the spintronics side, he said the work will lead to faster information processing with lower power consumption and will contribute to the development of spin-based quantum computing. The team's findings on quantum magnetism will lead to a deeper understanding of the phases of matter induced by many-body interactions at the atomic scale.

Instead of using light to trigger interactions in a quantum well, a system that produced new evidence of ultrastrong light-matter coupling earlier this year, the Kono lab at Rice used a magnetic field to prompt cooperativity among the spins within a crystalline compound made primarily of iron and erbium.

"This is an emerging subject in condensed matter physics," Kono said. "There's a long history in atomic and molecular physics of looking for the phenomenon of ultrastrong cooperative coupling. In our case, we'd already found a way to make light and condensed matter interact and hybridize, but what we're reporting here is more exotic."

Dicke cooperativity, named for physicist Robert Dicke, happens when incoming radiation causes a collection of atomic dipoles to couple, like gears in a motor that don't actually touch. Dicke's early work set the stage for the invention of lasers, the discovery of cosmic background radiation in the universe and the development of ..Read More...

Scientists create a mineral in the lab that captures carbon dioxide

It takes thousands of years for this mineral to form naturally. Now researchers have found a way to make magnesite, or magnesium carbonate, in the lab in just a few months.

Scientists are one step closer to a long-sought way to store carbon dioxide in rocks.

A new technique speeds up the formation of a mineral called magnesite that, in nature, captures and stores large amounts of the greenhouse gas CO2. And the process can be done at room temperature in the lab, researchers reported August 14 at the Goldschmidt geochemistry conference, held in Boston. If the mineral can be produced in large quantities, the method could one day help fight climate change.

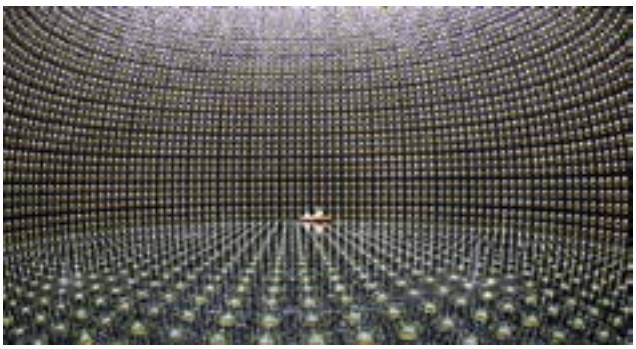
"A lot of carbon on Earth is already stored within carbonate minerals, such as limestone," says environmental geoscientist Ian Power of Trent University in Peterborough, Canada, who presented the research. "Earth knows how to store carbon naturally and does this over geologic time. But we're emitting so much CO2 now that Earth can't keep up."

Researchers have been seeking ways to boost the planet's capacity for CO2 storage (SN: 6/5/10, p. 16). One possible technique: Sequester the CO2 gas by converting it to carbonate minerals. Magnesite, or magnesium carbonate, is a stable mineral that can hold a lot of CO2 naturally: A metric ton of magnesite can contain about half a metric ton of the greenhouse gas.

But magnesite isn't quick to make — at least, not at Earth's surface. Previous researchers have considered pumping CO2 deep into Earth's interior, where high temperatures and pressures can speed up the gas's reaction with a magnesium-bearing upper mantle rock called olivine. But many barriers remain to making this idea commercial, including finding the right locations to insert the CO2 to produce large amounts of magnesite and the costs of transportation and storage for the gas.

Another option is to try to make magnesite in the laboratory — but at room temperature, that can take a very long time. One place where magnesite ...Read More...

Ghostly antineutrinos could help ferret out nuclear tests



The Super-Kamiokande detector (shown) in Hida, Japan, could catch antineutrinos from a powerful nuclear blast about 100 kilometers away, scientists calculated.

But building detectors up to the task would be a huge undertaking. Rogue nations that want to hide nuclear weapons tests may one day be thwarted by antineutrinos.

Atomic blasts emit immense numbers of the lightweight subatomic particles, which can travel long distances through the Earth. In general, the particles — the antimatter twins of neutrinos — are notoriously difficult to spot. But a large antineutrino detector located within a few hundred kilometers of a powerful nuclear explosion could glimpse a handful of the particles, scientists report in the August Physical Review Applied.

An antineutrino detector wouldn't spot an explosion solely on its own, but would use seismic activity picked up by existing sensors to trigger a search for particles arriving from a suspected blast. It's "a very smart and clever idea," says physicist Patrick Huber of Virginia Tech in Blacksburg.

A global network of sensors already gathers detailed information about nuclear explosions by monitoring for telltale seismic activity and radioactive isotopes. In recent years, those sensors have revealed details of North Korean nuclear tests performed underground. .

But if those sensors were unable to confirm that a nuclear explosion occurred, spotting antineutrinos would eliminate doubt, says study coauthor and physicist Adam Bernstein of Lawrence Livermore National Laboratory in California. "If you see a burst of antineutrinos, there's really no other way you could have gotten that," he says, aside from an exploding star in the Milky Way. Those stellar bursts are rare events unlikely to coincide with a seismic signature.

And while stealthy bomb makers might be able to contain an explosion's radioactive isotopes or mask some of its seismic signals, there's no way to stop antineutrinos from escaping. Neutrinos could also provide information about how powerful the explosion was and what type of nuclear weapon was used.

None of the existing antineutrino detectors, however, are big enough and in the right location to monitor North Korea. One of the biggest is the Super- ...Read More...

Researchers discover link between magnetic field strength and temperature

The team created their sensor from a silicon carbide chip synthesized at the Ioffe Physical-Technical Institute. Credit: Andrey Anisimov

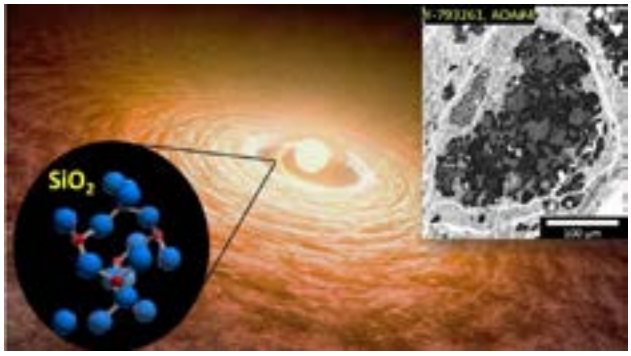
Researchers recently discovered that the strength of the magnetic field required to elicit a particular quantum mechanical process, such as photoluminescence and the ability to control spin states with electromagnetic (EM) fields, corresponds to the temperature of the material. Based on this finding, scientists can determine a sample's temperature to a resolution of one cubic micron by measuring the field strength at which this effect occurs. Temperature sensing is integral in most industrial, electronic and chemical processes, so greater spatial resolution could benefit commercial and scientific pursuits. The team reports their findings in AIP Advances.

In diamonds, nitrogen atoms can replace carbon atoms; when this occurs next to vacancies in the crystal lattice, it produces useful quantum properties. These vacancies can have a negative or neutral charge. Negatively charged vacancy centers are also photoluminescent and produce a detectable glow when exposed to certain wavelengths of light. Researchers can use a magnetic field to manipulate the spins of the electrons in the vacancies, which alters the intensity of the photoluminescence.

A team of Russian and German researchers created a system that can measure temperatures and magnetic fields at very small resolutions. The scientists produced crystals of silicon carbide with vacancies similar to the nitrogen-vacancy centers in diamonds. Then, they exposed the silicon carbide to infrared laser light in the presence of a constant magnetic field and recorded the resulting photoluminescence.

Stronger magnetic fields make it easier for electrons in these vacancies to transfer between energy spin states. At a specific field strength, the proportion of electrons with spin 3/2 quickly changes, in a process called anticrossing. The brightness of the photoluminescence depends on the proportion of electrons in various spin states, so the researchers could gauge the strength of the magnetic field by monitoring the change in brightness. Additionally, the luminescence abruptly changes when electrons in these vacancies undergo cross-relaxation ...Read More...

Crystalline silica in meteorite brings scientists closer to understanding solar evolution



The solar protoplanetary nebula. Credit: NASA/JPL-Caltech

A multi-institutional team of researchers has discovered silica mineral quartz in a primitive meteorite, comprising direct evidence of silica condensation within the solar protoplanetary disk, and offering new clues to understanding solar formation and evolution. Though previous infrared spectroscopic observations have suggested the existence of silica in young and newly formed T Tauri stars as well as in asymptotic giant branch (AGB) stars in their last phase of life, no evidence of gas-solid condensation of silica had been found in other primitive meteorites from the early stages of the solar system.

The scientists studied the primitive meteorite Yamato-793261 (Y-793261), a carbonaceous chondrite collected from an ice field near the Yamato Mountains during the 20th Japan Antarctic Research Expedition in 1979.

"The degree of crystallinity of organic matter in Y-793261 shows that it did not undergo thermal metamorphism," explains Timothy Jay Fagan, professor of geochemistry at Waseda University. "This confirms that Y-793261 preserves minerals and textures of its nebular origin, providing us with records of the early solar system."

A major component of chondrites includes refractory inclusions, which form at high temperatures and are the oldest solar system solids dated. Refractory inclusions can be subdivided into calcium-aluminum-rich inclusions (CAIs) and amoeboid olivine aggregates (AOAs). The research team found an AOA in Y-793261 containing typical AOA minerals and ultra-refractory (very high temperature) scandium- and zirconium-bearing minerals, along with the quartz (which forms at comparatively lower temperature). "Such variety in minerals implies that the AOA condensed from nebular gas to solid over a wide temperature range from approximately 1500-900°C," Professor Fagan says.S "This aggregate is the first of its kind to be found in our solar system."

They also found that the quartz in the AOA has an oxygen isotopic composition close to the sun's. This isotopic composition is typical of refractory inclusions in general, which indicates that refractory inclusions formed close to the protosun (approximately 0.1 AU, or 1/10 ...Read More...

Light from ancient quasars helps confirm quantum entanglement

The quasar dates back to less than one billion years after the big bang. Credit: NASA/ESA/G.Bacon, STScI

Last year, physicists at MIT, the University of Vienna, and elsewhere provided strong support for quantum entanglement, the seemingly far-out idea that two particles, no matter how distant from each other in space and time, can be inextricably linked, in a way that defies the rules of classical physics.

Take, for instance, two particles sitting on opposite edges of the universe. If they are truly entangled, then according to the theory of quantum mechanics their physical properties should be related in such a way that any measurement made on one particle should instantly convey information about any future measurement outcome of the other particle—correlations that Einstein skeptically saw as "spooky action at a distance."

In the 1960s, the physicist John Bell calculated a theoretical limit beyond which such correlations must have a quantum, rather than a classical, explanation.

But what if such correlations were the result not of quantum entanglement, but of some other hidden, classical explanation? Such "what-ifs" are known to physicists as loopholes to tests of Bell's inequality, the most stubborn of which is the "freedom-of-choice" loophole: the possibility that some hidden, classical variable may influence the measurement that an experimenter chooses to perform on an entangled particle, making the outcome look quantumly correlated when in fact it isn't.

Last February, the MIT team and their colleagues significantly constrained the freedom-of-choice loophole, by using 600-year-old starlight to decide what properties of two entangled photons to measure. Their experiment proved that, if a classical mechanism caused the correlations they observed, it would have to have been set in motion more than 600 years ago, before the stars' light was first emitted and long before the actual experiment was even conceived.

Now, in a paper published today in Physical Review Letters, the same team has vastly extended the case for quantum entanglement and further ...Read More...

Special Read:

Lockheed Martin gives first look into where astronauts may live on missions to deep space

Credit: Lockheed Martin

A massive cylindrical habitat may one day house up to four astronauts as they make the trek to deep space.

Lockheed Martin gave a first look at what one of these habitats might look like Thursday at the Kennedy Space Center, where the aerospace giant is under contract with NASA to build a prototype of the living quarters.

Lockheed is one of six contractors—the others are Boeing, Sierra Nevada Corp.'s Space Systems, Orbital ATK, NanoRacks and Bigelow Aerospace—that NASA awarded a combined $65 million to build a habitat prototype by the end of the year. The agency will then review the proposals to reach a better understanding of the systems and interfaces that need to be in place to facilitate living in deep space.

Lockheed's design uses the Donatello Multi-Purpose Logistics Module, a refurbished module dating back to the space shuttle era that was once destined to transfer cargo to the International Space Station. But Donatello was never sent into space, and the module has now instead been transformed into Lockheed's prototype.

At about 15 feet wide and nearly 22 feet long, the cylindrical capsule is roughly the size of a small bus. But it'll be a tight fit if four astronauts reside in it for 30 to 60 days, as Bethesda, Md.-based Lockheed envisions.

The capsule is designed to house racks for science, life support systems, sleep stations, exercise machines and robotic work stations, said Bill Pratt, the program's manager.

"You think of it as an RV in deep space," he said during a tour of the prototype. "When you're in an RV, your table becomes your bed and things are always moving around, so you have to be really efficient with the space. That's a lot of what we are testing here."

The team used augmented reality headsets, which overlay real hardware with simulations, to visualize the layout of the capsule—saving time and helping Lockheed catch errors early on.

Another cost-saving measure: the reuse of Donatello.

"We want to get to the moon and to Mars as quickly as possible, and we feel like we actually have a lot of stuff that we can use to do that," Pratt said, adding that repurposing materials has become a big theme at Lockheed. . ..Read More...

This Week's Sky at a Glance - Aug. 25-31, 2018

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