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Astronomy & Physics Weekly News

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Sharjah Center for Astronomy & Space Sciences

Top News

Scientists confirm a structural similarity found in both human cells and neutron stars

Physicists demonstrate existence of new subatomic structure 2

Producing turbulence in a Bose-Einstein condensate yields cascade of wave-like excitations

Supercomputer comes up with a profile of dark matter: Standard Model extension predicts properties of candidate particle 3

GRAPES-3 indicates a crack in Earth's magnetic shield 4

Curiosity Mars rover checks odd-looking iron meteorite

Special Read:

Schiaparelli crash site in colour

Scientists set traps for atoms with single-particle precision

Physicists induce superconductivity in non-superconducting materials 5

Study confirms that stellar novae are the main source of lithium in the universe

Close galactic encounter leaves 'nearly naked' supermassive black hole 6

New Theory Explains How the Moon Got There

Relax, the expansion of the universe is still accelerating 7

This Week's Sky at a Glance, Nov. 05 -11

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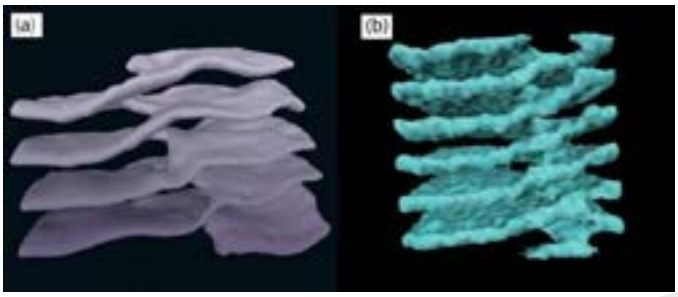
Scientists confirm a structural similarity found in both human cells and neutron stars



Similar shapes — structures consisting of stacked sheets connected by helical ramps — have been found in cell cytoplasm (left) and neutron stars (right). Credit: University of California - Santa Barbara

We humans may be more aligned with the universe than we realize. According to research published in the journal Physical Review C, neutron stars and cell cytoplasm have something in common: structures that resemble multistory parking garages.

In 2014, UC Santa Barbara soft condensed-matter physicist Greg Huber and colleagues explored the biophysics of such shapes—helices that connect stacks of evenly spaced sheets—in a cellular organelle called the endoplasmic reticulum (ER). Huber and his colleagues dubbed them Terasaki ramps after their discoverer, Mark Terasaki, a cell biologist at the University of Connecticut.

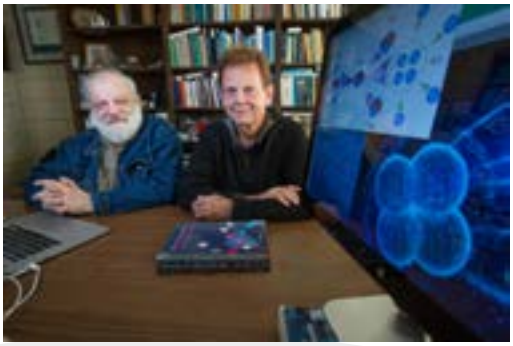
Huber thought these "parking garages" were unique to soft matter (like the interior of cells) until he happened upon the work of nuclear physicist Charles Horowitz at Indiana University. Using computer simulations, Horowitz and his team had found the same shapes deep in the crust of neutron stars.

"I called Chuck and asked if he was aware that we had seen these structures in cells and had come up with a model for them," said Huber, the deputy director of UCSB's Kavli Institute for Theoretical Physics (KITP). "It was news to him, so I realized then that there could be some fruitful interaction."

The resulting collaboration, highlighted in Physical Review C, explored the relationship between two very different models of matter.

Nuclear physicists have an apt terminology for the entire class of shapes they see in their high-performance computer simulations of neutron stars: nuclear pasta. These include tubes (spaghetti) and parallel sheets (lasagna) connected by helical shapes that resemble Terasaki ramps. "They see a variety of shapes that we see in the cell," Huber explained. "We see a tubular ...Read More...

Physicists demonstrate existence of new subatomic structure



James Vary, right, and coauthor Andrey Shirokov with an illustration of a tetraneutron. Credit: Christopher Gannon/Iowa State University

Iowa State University researchers have helped demonstrate the existence of a subatomic structure once thought unlikely to exist.

James Vary, a professor of physics and astronomy, and Andrey Shirokov, a visiting scientist, together with an international team, used sophisticated supercomputer simulations to show the quasi-stable existence of a tetraneutron, a structure comprised of four neutrons (subatomic particles with no charge).

The new finding was published in Physical Review Letters, a publication of the American Physical Society, on October 28.

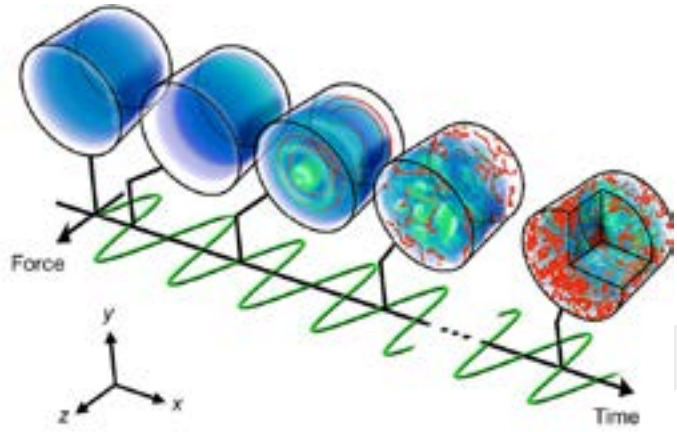
On their own, neutrons are very unstable and will convert into protons—positively charged subatomic particles—after ten minutes. Groups of two or three neutrons do not form a stable structure, but the new simulations in this research demonstrate that four neutrons together can form a resonance, a structure stable for a period of time before decaying.

For the tetraneutron, this lifetime is only 5×10^(-22) seconds (a tiny fraction of a billionth of a nanosecond). Though this time seems very short, it is long enough to study, and provides a new avenue for exploring the strong forces between neutrons.

"This opens up a whole new line of research," Vary said. "Studying the tetraneutron will help us understand inter-neutron forces including previously unexplored features of the unstable two-neutron and three-neutron systems."

The advanced simulations demonstrating the tetraneutron corroborate the first observational evidence of the tetraneutron earlier this year in an experiment performed at the RIKEN Radioactive Ion Beam Factory (RIBF), in Saitama, Japan. The tetraneutron structure has been sought for 40 years with little evidence supporting ...Read More...

Producing turbulence in a Bose-Einstein condensate yields cascade of wave-like excitations



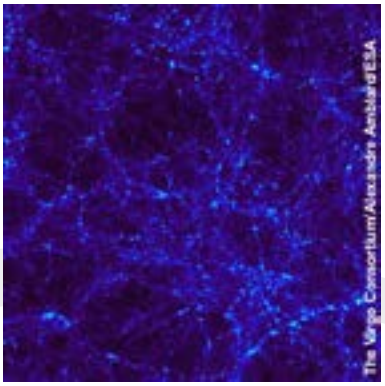
Gross-Pitaevskii simulations of a shaken, box-trapped Bose gas. The blue shading indicates the gas density; the red lines indicate vortices. Credit: (c) Nature (2016). DOI: 10.1038/nature20114

A team of researchers at the University of Cambridge has succeeded in creating turbulence in a Bose-Einstein condensate (BEC) and in the process, have possibly opened the door to a new avenue of research. In their paper published in the journal Nature, the team describes how they achieved this feat and the evidence they found for a cascade. Brian Anderson with the University of Arizona offers a News & Views piece describing the work done by the team in the same journal issue and offers a brief overview of the characteristic distribution of kinetic energy in turbulent fluids.

Scientists have learned a lot about the nature of turbulence in fluids over the past several hundred years, some of which surrounds the way kinetic energy is distributed among components that have different momenta—which can be seen in action, as Anderson notes, by stirring cream into a cup of coffee. But until now, no one had succeeded in producing turbulence in a BEC, in which a gas of bosons is cooled to near absolute zero causing them to occupy the lowest possible quantum state, thereby allowing for viewing quantum phenomena—Anderson calls them "microscopic droplets of atomic gasses."

In this new effort, the researchers conducted experiments designed to discover what might happen if turbulence were introduced to a BEC, in this case, one made of rubidium atoms captured in a laser-created virtual box—this type of setup provided uniform density of the atoms. The team then applied a timed magnetic field that served to shake up the cloud of atoms, which added energy to the system. They then determined the momentum distribution. For small time intervals, they found most of the atoms in the cloud were in a low-momentum mode—more shaking pushed the atoms into a higher momentum mode. After approximately two seconds, the researchers found evidence of a cascade of excitations by ...Read More...

Supercomputer comes up with a profile of dark matter: Standard Model extension predicts properties of candidate particle



Simulated distribution of dark matter approximately three billion years after the Big Bang (illustration not from this work). Credit: The Virgo Consortium/Alexandre Amblard/ESA

In the search for the mysterious dark matter, physicists have used elaborate computer calculations to come up with an outline of the particles of this unknown form of matter. To do this, the scientists extended the successful Standard Model of particle physics which allowed them, among other things, to predict the mass of so-called axions, promising candidates for dark matter. The German-Hungarian team of researchers led by Professor Zoltán Fodor of the University of Wuppertal, Eötvös University in Budapest and Forschungszentrum Jülich carried out its calculations on Jülich's supercomputer JUQUEEN (BlueGene/Q) and presents its results in the journal Nature.

"Dark matter is an invisible form of matter which until now has only revealed itself through its gravitational effects. What it consists of remains a complete mystery," explains co-author Dr Andreas Ringwald, who is based at DESY and who proposed the current research. Evidence for the existence of this form of matter comes, among other things, from the astrophysical observation of galaxies, which rotate far too rapidly to be held together only by the gravitational pull of the visible matter. High-precision measurements using the European satellite "Planck" show that almost 85 percent of the entire mass of the universe consists of dark matter. All the stars, planets, nebulae and other objects in space that are made of conventional matter account for no more than 15 percent of the mass of the universe.

"The adjective 'dark' does not simply mean that it does not emit visible light," says Ringwald. "It does not appear to give off any other wavelengths either - its interaction with photons must be very weak indeed." For decades, physicists have been searching for particles of this new type of matter. What is clear is that ...Read More...

GRAPES-3 indicates a crack in Earth's magnetic shield

The GRAPES-3 muon telescope, the largest and most sensitive cosmic ray monitor recorded a burst of galactic cosmic rays that indicated a crack in the Earth's magnetic shield Credit: TIFR

The GRAPES-3 muon telescope, the largest and most sensitive cosmic ray monitor recorded a burst of galactic cosmic rays that indicated a crack in the Earth's magnetic shield. The burst occurred when a giant cloud of plasma ejected from the solar corona struck Earth at a very high speed causing massive compression of the Earth's magnetosphere and triggering a severe geomagnetic storm.

The GRAPES-3 muon telescope located at TIFR's Cosmic Ray Laboratory in Ooty recorded a burst of galactic cosmic rays of about 20 GeV, on 22 June 2015 lasting for two hours.

The burst occurred when a giant cloud of plasma ejected from the solar corona, and moving with a speed of about 2.5 million kilometers per hour struck our planet, causing a severe compression of Earth's magnetosphere from 11 to 4 times the radius of Earth. It triggered a severe geomagnetic storm that generated aurora borealis, and radio signal blackouts in many high latitude countries.

Earth's magnetosphere extends over a radius of a million kilometers, which acts as the first line of defence, shielding us from the continuous flow of solar and galactic cosmic rays, thus protecting life on our planet from these high intensity energetic radiations. Numerical simulations performed by the GRAPES-3 collaboration on this event indicate that the Earth's magnetic shield temporarily cracked due to the occurrence of magnetic reconnection, allowing the lower energy galactic cosmic ray particles to enter our atmosphere. Earth's magnetic field bent these particles about 180 degree, from the day-side to the night-side of the Earth where it was detected as a burst by the GRAPES-3 muon telescope around mid-night on 22 June 2015. The data was analyzed and interpreted through extensive simulation over several weeks by using the 1280-core computing farm that was built in-house by the GRAPES-3 team of physicists and engineers at the Cosmic Ray Laboratory in Ooty.

This work has recently been published in Physical Review Letters. ...Read More...

Curiosity Mars rover checks odd-looking iron meteorite

The dark, golf-ball-size object in this composite, colorized view from the ChemCam instrument on NASA's Curiosity Mars rover is a nickel-iron meteorite, as confirmed by analysis using laser pulses from ChemCam on Oct. 30, 2016. The grid of bright spots on the rock resulted from the laser pulses. Credit: NASA/JPL-Caltech/LANL/CNES/IRAP/LPGNantes/CNRS/IAS/MSSS

Laser-zapping of a globular, golf-ball-size object on Mars by NASA's Curiosity rover confirms that it is an iron-nickel meteorite fallen from the Red Planet's sky.

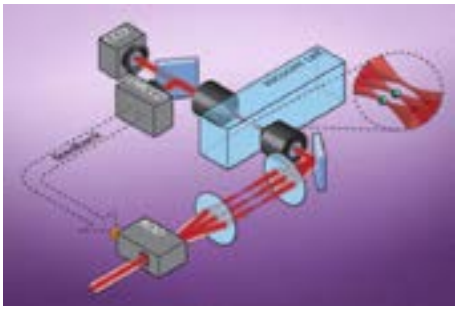
Iron-nickel meteorites are a common class of space rocks found on Earth, and previous examples have been seen on Mars, but this one, called "Egg Rock," is the first on Mars examined with a laser-firing spectrometer. To do so, the rover team used Curiosity's Chemistry and Camera (ChemCam) instrument.

Scientists of the Mars Science Laboratory (MSL) project, which operates the rover, first noticed the odd-looking rock in images taken by Curiosity's Mast Camera (Mastcam) at at a site the rover reached by an Oct. 27 drive.

"The dark, smooth and lustrous aspect of this target, and its sort of spherical shape attracted the attention of some MSL scientists when we received the Mastcam images at the new location," said ChemCam team member Pierre-Yves Meslin, at the Research Institute in Astrophysics and Planetology (IRAP), of France's National Center for Scientific Research (CNRS) and the University of Toulouse, France.

ChemCam found iron, nickel and phosphorus, plus lesser ingredients, in concentrations still being determined through analysis of the spectrum of light produced from dozens of laser pulses at nine spots on the object. The enrichment in both nickel and phosphorus at some of the same points suggests the presence of an iron-nickel-phosphide mineral that is rare except in iron-nickel meteorites, Meslin said. Iron meteorites typically originate as core material of asteroids that melt, allowing the molten metal fraction of the asteroid's composition to sink to the center and form a core. ...Read More...

Scientists set traps for atoms with single-particle precision



This image shows the basic setup that enables researchers to use lasers as optical "tweezers" to pick individual atoms out from a cloud and hold them in place. The atoms are imaged onto a camera, and the traps are generated by a laser that is split into many different focused laser beams. This allows a single atom to be trapped at each focus. Credit: Massachusetts Institute of Technology

Atoms, photons, and other quantum particles are often capricious and finicky by nature; very rarely at a standstill, they often collide with others of their kind. But if such particles can be individually corralled and controlled in large numbers, they may be harnessed as quantum bits, or qubits—tiny units of information whose state or orientation can be used to carry out calculations at rates significantly faster than today's semiconductor-based computer chips.

In recent years, scientists have come up with ways to isolate and manipulate individual quantum particles. But such techniques have been difficult to scale up, and the lack of a reliable way to manipulate large numbers of atoms remains a significant roadblock toward quantum computing.

Now, scientists from Harvard and MIT have found a way around this challenge. In a paper published today in the journal Science, the researchers report on a new method that enables them to use lasers as optical "tweezers" to pick individual atoms out from a cloud and hold them in place. As the atoms are "trapped," the scientists use a camera to create images of the atoms and their locations. Based on these images, they then manipulate the angle of the laser beams, to move individual atoms into any number of different configurations.

The team has so far created arrays of 50 atoms and manipulated them into various defect-free patterns, with single-atom control. Vladan Vuletic, one of the paper's authors and the Lester Wolfe Professor of Physics at MIT, likens the process to "building a small crystal of atoms, from the bottom, up."

"We have demonstrated a reconfigurable array of traps for single atoms, where we can prepare up to 50 individual atoms in separate traps deterministically, for future use in quantum information processing, quantum simulations, or precision measurements," says Vuletic, who is also a member of MIT's Research Laboratory of Electronics. "It's like Legos of atoms that you build up, and ...Read More...

Physicists induce superconductivity in non-superconducting materials

Paul C.W. Chu. Credit: University of Houston

Researchers at the University of Houston have reported a new method for inducing superconductivity in non-superconducting materials, demonstrating a concept proposed decades ago but never proven.

The technique can also be used to boost the efficiency of known superconducting materials, suggesting a new way to advance the commercial viability of superconductors, said Paul C.W. Chu, chief scientist at the Texas Center for Superconductivity at UH (TcSUH) and corresponding author of a paper describing the work, published Oct. 31 in the Proceedings of the National Academy of Sciences.

"Superconductivity is used in many things, of which MRI (magnetic resonance imaging) is perhaps the best known," said Chu, the physicist who holds the TLL Temple Chair of Science at UH. But the technology used in health care, utilities and other fields remains expensive, in part because it requires expensive cooling, which has limited widespread adoption, he said.

The research, demonstrating a new method to take advantage of assembled interfaces to induce superconductivity in the non-superconducting compound calcium iron arsenide, offers a new approach to finding superconductors that work at higher temperatures.

Superconducting materials conduct electric current without resistance, while traditional transmission materials lose as much as 10 percent of energy between the generating source and the end user. That means superconductors could allow utility companies to provide more electricity without increasing the amount of fuel used to generate electricity.

"One way that has long been proposed to achieve enhanced Tcs (critical temperature, or the temperature at which a material becomes superconducting) is to take advantage of artificially or naturally assembled interfaces," the researchers wrote. "The present work clearly demonstrates that high Tc superconductivity in ...Read More...

Study confirms that stellar novae are the main source of lithium in the universe

Artist's concept of a binary system similar to the one that originated the nova Sagittarii 2015 N.2. Credit: David A. Hardy y PPARC

Lithium, the lightest solid element, is created during astrophysical phenomena, but its origin has been elusive. Recently, a group of researchers detected enormous quantities of beryllium-7, an unstable element that decays into lithium in 53.2 days, inside nova Sagittarii 2015 N.2, which suggests that novae are the main source of lithium in the galaxy.

Practically every chemical element has an astronomical origin. Light elements were formed between 10 seconds and 20 minutes after the Big Bang, including hydrogen (75%), helium (25%) and a very small amount of lithium and beryllium.

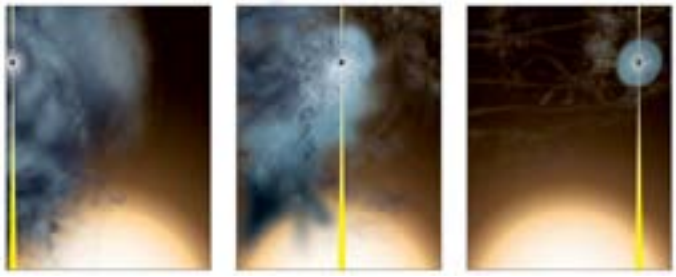
The remaining chemical elements were formed in stars, either through fusion of other elements inside the nucleus, which begins with the fusion of hydrogen into helium, and produces increasingly heavy elements until iron forms. Other processes such as supernovae explosions or reactions in the atmospheres of giant stars produce gold, lead and copper, among others. Those elements were in turn recycled into new stars and planets, until the present time.

Luca Izzo, researcher at the Institute of Astrophysics of Andalusia (IAA-CSIC), says, "But lithium posed a problem: We knew that 25 percent of existing lithium comes from primordial nucleosynthesis, but we were not able to trace the origins of the remaining 75 percent."

Solution to the lithium enigma

The solution to the enigma of the origin of lithium lies, according to this study, in the novae, explosive phenomena occurring in binary star systems in which one of the stars is a white dwarf. The white dwarf can nab material from its twin star and form a superficial layer of hydrogen which, when it reaches a certain density, will trigger a nova, which can increase the brightness of the star up to 100 thousand times. After a few weeks, the system stabilizes and the process starts again. ...Read More...

Close galactic encounter leaves 'nearly naked' supermassive black hole



Artist's conception of how the "nearly naked" supermassive black hole originated. Credit: Bill Saxton, NRAO/AUI/NSF.

Astronomers using the super-sharp radio vision of the National Science Foundation's Very Long Baseline Array (VLBA) have found the shredded remains of a galaxy that passed through a larger galaxy, leaving only the smaller galaxy's nearly-naked supermassive black hole to emerge and speed away at more than 2,000 miles per second.

The galaxies are part of a cluster of galaxies more than 2 billion light-years from Earth. The close encounter, millions of years ago, stripped the smaller galaxy of nearly all its stars and gas. What remains is its black hole and a small galactic remnant only about 3,000 light-years across. For comparison, our Milky Way Galaxy is approximately 100,000 light-years across.

The discovery was made as part of a program to detect supermassive black holes, millions or billions of times more massive than the Sun, that are not at the centers of galaxies. Supermassive black holes reside at the centers of most galaxies. Large galaxies are thought to grow by devouring smaller companions. In such cases, the black holes of both are expected to orbit each other, eventually merging.

"We were looking for orbiting pairs of supermassive black holes, with one offset from the center of a galaxy, as telltale evidence of a previous galaxy merger," said James Condon, of the National Radio Astronomy Observatory. "Instead, we found this black hole fleeing from the larger galaxy and leaving a trail of debris behind it," he added.

"We've not seen anything like this before," Condon said.

The astronomers began their quest by using the VLBA to make very high resolution images of more than 1,200 galaxies, previously identified by large-scale sky surveys done with infrared and radio telescopes. Their VLBA observations showed that the supermassive black holes of nearly all these galaxies were at the centers of the galaxies.

However, one object, in a cluster of galaxies called ZwCl 8193, did not fit that pattern. Further studies showed that this object, called B3 1715+425, is a supermassive black hole surrounded by a galaxy much smaller ...Read More...

New Theory Explains How the Moon Got There

File Image.

Earth's moon is an unusual object in our solar system, and now there's a new theory to explain how it got where it is, which puts some twists on the current "giant impact" theory. The work is published Oct. 31 in the journal Nature.

The moon is relatively big compared to the planet it orbits, and it's made of almost the same stuff, minus some more volatile compounds that evaporated long ago. That makes it distinct from every other major object in the solar system, said Sarah Stewart, professor of earth and planetary sciences at the University of California, Davis, and senior author on the paper.

"Every other body in the solar system has different chemistry," she said.

The textbook theory of lunar formation goes like this: Late in the formation of the solar system came the "giant impact" phase, when hot, planet-sized objects collided with each other. A Mars-sized object grazed what would become Earth, throwing off a mass of material from which the moon condensed. This impact set the angular momentum for the Earth-moon system, and gave the early Earth a five-hour day. Over millennia, the moon has receded from the Earth and the rotation has slowed to our current 24-hour day.

Scientists have figured this out by looking at the moon's current orbit, working out how rapidly angular momentum of the Earth-moon system has been transferred by the tidal forces between the two bodies, and working backward.

But there are a couple of problems with the textbook theory. One is the moon's surprisingly Earth-like composition. Another is that if the moon condensed from a disk of material rotating around Earth's equator, it should be in orbit over the equator. But the moon's current orbit is tilted 5 degrees off the equator, meaning some more energy must have been put in to move it. ...Read More...

Relax, the expansion of the universe is still accelerating

The expanding universe. Credit: Shutterstock/suns butterfly

There's been a whirlwind of commentary of late speculating that the acceleration of the expanding universe might not be real after all.

It follows the publication this month of a new look at supernovae in our universe, which the researchers say give only a "marginal detection" of the acceleration of the universe.

This seems to be a big deal, because the 2011 Nobel Prize was awarded to the leaders of two teams that used supernovae to discover that the expansion of the universe is speeding up.

But never have I seen such a storm in a teacup. The new analysis, published in Scientific Reports, barely changes the original result, but puts a different (and in my opinion misleading) spin on it.

So why does this new paper claim that the detection of acceleration is "marginal?"

Well, it is marginal if you only use a single data set. After all, most big discoveries are initially marginal. If they were more obvious, they would have been discovered sooner.

The evidence, so far

The supernova data alone could, at only a slight stretch, be consistent with a universe that neither accelerates nor decelerates. This has been known since the original discovery, and is not under dispute.

But if you also add one more piece of information - for example, that matter exists - then there's nothing marginal about it. New physics is clearly required.

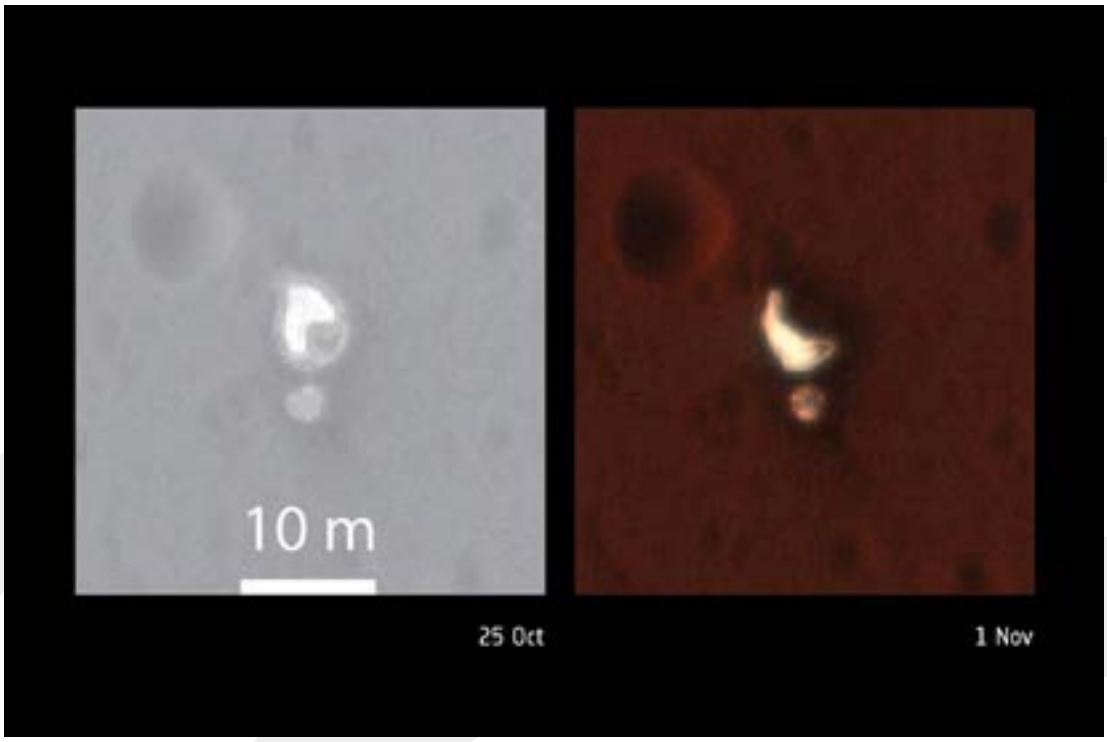
In fact, if the universe didn't accelerate or decelerate at all, which is an old proposal revisited in this new paper, new physics would still be required.

These days the important point is that if you take all of the supernova data and throw it in the ...Read More...

This Week's Sky at a Glance
Nov. 05 - 11

Nov 05	Taurid meteor shower
Nov 07	First Quarter Moon (23:51)
Nov 09	Moon at descending node (19:57)

Schiaparelli crash site in colour



A comparison of the 25 October image taken by NASA's Mars Reconnaissance Orbiter HiRISE camera with that taken on 1 November. In the week that elapsed, the outline of Schiaparelli's parachute on the martian surface has apparently changed, which is interpreted as movement due to local wind. The parachute has a maximum diameter of 12 m, and it is attached to the rear heat-shield, which measures about 2.4 m across. Aside from the obvious difference of the 1 November being in colour, the images have slightly different projections: in the colour image north is about 7° west of straight up. In addition, the 25 October image was looking to the east, while the 1 November image was taken looking slightly to the west. Credit: NASA/JPL-Caltech/University of Arizona

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