September 10, 2016 Dhu'l Hijjah 08, 1437 AH Volume 6, Issue 37

Astronomy & Physics Weekly News

Dept. of Applied Physics & Astronomy - **University of Sharjah**

Compiled by **Dr. Ilias Fernini**

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New research reveals hundreds of undiscovered black holes

Hubble Space Telescope Observation of the central region of the Galactic globular cluster NGC 6101: Compared to the majority of Galactic globular clusters, NGC 6101 shows a less concentrated distribution of observable stars. Credit: NASA

New research by the University of Surrey published today in the journal Monthly Notices of the Royal Astronomical Society has shone light on a globular cluster of stars that could host several hundred black holes, a phenomenon that until recently was thought impossible.

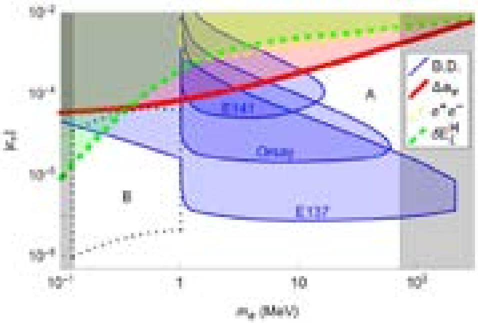
Globular clusters are spherical collections of stars which orbit around a galactic centre such as our Milky-way galaxy. Using advanced computer simulations, the team at the University of Surrey were able to see the un-see-able by mapping a globular cluster known as NGC 6101, from which the existence of black holes within the system was deduced. These black holes are a few times larger than the Sun, and form in the gravitational collapse of massive stars at the end of their lives. It was previously thought that these black holes would almost all be expelled from their parent cluster due to the effects of supernova explosion, during the death of a star.

"Due to their nature, black holes are impossible to see with a telescope, because no photons can escape", explained lead author Miklos Peuten of the University of Surrey. "In order to find them we look for their gravitational effect on their surroundings. Using observations and simulations we are able to spot the distinctive clues to their whereabouts and therefore effectively 'see' the un-seeable".

It is only as recently as 2013 that astrophysicists found individual black holes in globular clusters via rare phenomena in which a companion star donates material to the black hole. This work, which was supported by the European Research Council (ERC), has shown that in NGC 6101 there could be several hundred black holes, overturning old theories as to how black holes form.

Co-author Professor Mark Gieles, University of Surrey continued, "Our work is intended to help ...Read More...

Hypothetical new particle could solve two major problems in particle physics



Using constraints from previous experiments, the physicists identified two regions, A and B (dotted), to search for the new particle in proposed experiments. Credit: Liu et al. ©2016 American Physical Society

Although the Large Hadron Collider's enormous 13 TeV energy is more than sufficient to detect many particles that theorists have predicted to exist, no new particles have been discovered since the Higgs boson in 2012. While the absence of new particles is informative in itself, many physicists are still yearning for some hint of "new physics," or physics beyond the standard model.

In a new paper published in Physical Review Letters, physicists Yu-Sheng Liu, David McKeen, and Gerald A. Miller at the University of Washington in Seattle have hypothesized the existence of a new particle that looks very enticing because it could simultaneously solve two important problems: the proton radius puzzle and a discrepancy in muon anomalous magnetic moment measurements that differ significantly from standard model predictions.

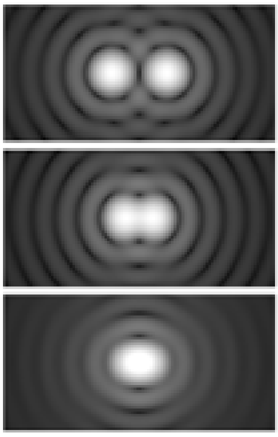
"The new particle can account for two seemingly unrelated problems," Miller told Phys.org. "We also point out several experiments that can further test our hypothesis."

The physicists describe the hypothetical new particle as an "electrophobic scalar boson." Currently there are five bosons in the standard model, only one of which is a scalar (the Higgs), meaning it has zero spin. All five bosons have been experimentally confirmed, and all are force carriers that play a role in holding matter together.

One of the distinct features of the new hypothetical particle is that, although it is predicted to bind to protons and neutrons, it would bind very weakly or not at all to electrons, making it "electrophobic." The scientists showed that this electrophobic property would allow the particle to solve both the proton and muon problems.

In the proton radius puzzle, the problem is that the proton radius seems to have a different size depending on what type of particle is orbiting it. Experiments have found that the proton radius is slightly larger when it ...Read More...

Quantum mechanics technique allows for pushing past 'Rayleigh's curse'



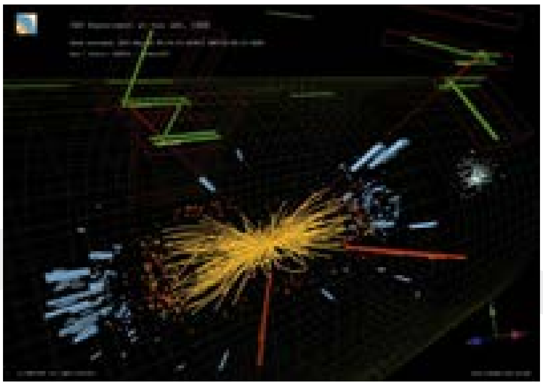
The Rayleigh criterion states that in direct imaging, two light sources are only discernable when the centers of their diffraction patterns, or peaks of their point spread functions, are farther apart than their widths. (Top) The sources are farther apart than the Rayleigh criterion distance. (Middle) The sources meet the Rayleigh criterion distance. (Bottom) The sources are closer than the Rayleigh criterion distance. Tsang and collaborators used quantum metrology techniques to show that the Rayleigh criterion is not a fundamental limitation, finding that the separation between two objects can always be estimated with a precision that is independent of the size of the separation. Credit: Wikimedia Commons/Spencer Blevin, via Physics

A team of researchers with the National University of Singapore has found a way to get around what they describe as 'Rayleigh's curse'—a phenomenon that happens when two light sources appear to coalesce as they grow closer together, limiting the ability to measure the distance between them. In their paper published in the journal Physical Review Letters, the team describes how they applied a quantum mechanics technique to solve the problem.

For many years, scientists working in a variety of fields studying the stars through a telescope or objects through a microscope have been limited by the same problem—diffraction interfering with light sources that are very close together—the wave-like nature of light causes spreading, which in turn can cause an overlap of photons striking a surface meant to be used to measure the difference between two sources. Back in the late 1800's, John William Strutt, Lord Rayleigh, laid down the criterion to describe such limitations and it now bears his name. In this new effort, the researchers report on a new technique they have developed that gets around this problem, allowing for measuring the distance between light sources regardless of how far apart they are.

To address the diffraction problem, the researchers applied quantum metrology and quantum optics techniques, using a hybrid of quantum mechanics and a type of statistical theory—it involves working out which measurements are likely to give the most information when measuring sources of light—even when they violate ...Read More...

Scientists predict the existence of a new boson: New Madala boson might assist in the understanding of dark matter



Real CMS proton-proton collisions events in which 2 high energy electrons and two high energy muons are observed. Credit: Taylor L; McCauley T/CERN

Scientists at the High Energy Physics Group (HEP) of the University of the Witwatersrand in Johannesburg predict the existence of a new boson that might aid in the understanding of Dark Matter in the Universe.

Using data from a series of experiments that led to the discovery and first exploration of the Higgs boson at the European Organization for Nuclear Research (CERN) in 2012, the group established what they call the Madala hypothesis, in describing a new boson, named as the Madala boson. The experiment was repeated in 2015 and 2016, after a two-and-a-half year shut-down of the Large Hadron Collider (LHC) at CERN. The data reported by the LHC experiments in 2016 have corroborated the features in the data that triggered the Madala hypothesis in the first place.

"Based on a number of features and peculiarities of the data reported by the experiments at the LHC and collected up to the end of 2012, the Wits HEP group in collaboration with scientists in India and Sweden formulated the Madala hypothesis," says Professor Bruce Mellado, team leader of the HEP group at Wits.

The Wits Madala project team consists of approximately 35 young South African and African students and researchers who are currently contributing to the understanding of the data coming out of the LHC experiments, along with phenomenological investigations from theorists such as Prof. Alan Cornell and Dr. Mukesh Kumar and support in the area of detector instrumentation from Prof. Elias Sideras-Haddad (all from Wits University).

The hypothesis describes the existence of a new boson and field, similar to the Higgs boson. However, where the Higgs boson in the Standard Model of ...Read More...

Best Picture Yet Of Milky Way's Formation 13.5 Billion Years Ago

This dazzling infrared image from NASA's Spitzer Space Telescope shows hundreds of thousands of stars crowded into the swirling core of our spiral Milky Way galaxy. Credit: NASA/JPL-Caltech

Maybe we take our beloved Milky Way galaxy for granted. As far as humanity is concerned, it's always been here. But how did it form? What is its history?

Our Milky Way galaxy has three recognized stellar components. They are the central bulge, the disk , and the halo. How these three were formed and how they evolved are prominent, fundamental questions in astronomy. Now, a team of researchers have used the unique property of a certain type of star to help answer these fundamental questions.

The type of star in question is called the blue horizontal-branch star (BHB star), and it produces different colors depending on its age. It's the only type of star to do that. The researchers, from the University of Notre Dame, used this property of BHB's to create a detailed chronographic (time) map of the Milky Way's formation.

This map has confirmed what theories and models have predicted for some time: the Milky Way galaxy formed through mergers and accretions of small haloes of gas and dust. Furthermore, the oldest stars in our galaxy are at the center, and younger stars and galaxies joined the Milky Way over billions of years, drawn in by the galaxy's growing gravitational pull.

The team who produced this study includes astrophysicist Daniela Carollo, research assistant professor in the Department of Physics at the University of Notre Dame, and Timothy Beers, Notre Dame Chair of Astrophysics. Research assistant professor Vinicius Placco, and other colleagues rounded out the team.

"We haven't previously known much about the age of the most ancient component of the Milky Way, which is the Halo System," Carollo said. "But now we have demonstrated conclusively for the first time that ...Read More...

NASA Searches for Big Idea from Students for In-Space Assembly of Spacecraft

NASA's Game Changing Development Program, managed by the agency's Space Technology Mission Directorate, and the National Institute of Aerospace are seeking novel and robust concepts for in-space assembly of spacecraft - particularly tugs, propelled by solar electric propulsion, that transfer payloads from low earth orbit to a lunar distant retrograde orbit. Image courtesy Analytical Mechanics Associates.

In the 2017 Breakthrough, Innovative, and Game-changing (BIG) Idea Challenge, NASA is engaging university-level students in its quest to reduce the cost of deep space exploration. NASA's Game Changing Development Program (GCD), managed by the agency's Space Technology Mission Directorate, and the National Institute of Aerospace (NIA) are seeking novel and robust concepts for in-space assembly of spacecraft - particularly tugs, propelled by solar electric propulsion (SEP), that transfer payloads from low earth orbit (LEO) to a lunar distant retrograde orbit (LDRO).

"GCD initiated the BIG Idea Challenge in 2016 as a unique approach to finding top talent for NASA, and it proved to be more successful than we had hoped," said Mary E. Wusk, acting GCD program manager at NASA's Langley Research Center in Hampton, Virginia.

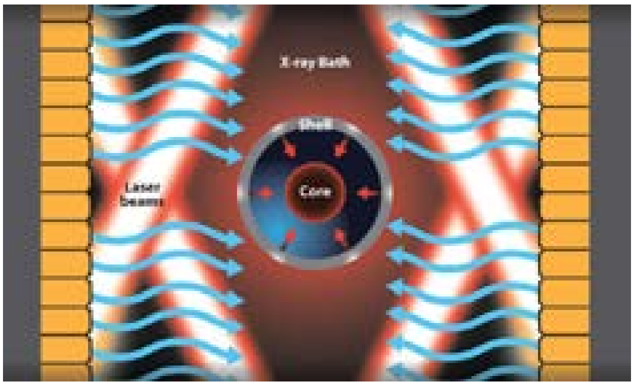
"In last year's challenge, students from across the nation proposed innovative solutions to the technology challenge of controlling a heat shield upon reentry, Wusk said.

"The 2016 BIG Idea Challenge finalists are now interning at NASA Langley where they are building prototypes of their designs under the mentorship of experts in the field. These students bring new ideas, new perspectives, new tools and unlimited energy to solving real world challenges that NASA is working on. It is a win-win for NASA and the students. I am excited to kick off our second Challenge which will address our ability to make in-space assembly a reality."

Why is this important? Think: 'Reduce, Reuse, Recycle.' Combined with advances in robotic technology, SEP tugs (i.e., transportation systems) enable NASA to move toward the use of more modular space systems that can be assembled into functional space craft hundreds of thousands of miles from Earth. The modular design also allows for upgrades, replacement of components, and reconfigurations for new mission application.

The 2017 BIG Idea Challenge invites teams and their faculty advisors to work together to design and analyze potential modular concepts and systems that provide the ability to construct large SEP tugs in space. Concepts can employ: ...Read More...

A first for direct-drive fusion



In the indirect-drive method of inertial confinement fusion, laser beams are converted to x-rays. Credit: Michael Osadwic/University of Rochester.

Scientists at the University of Rochester have taken a significant step forward in laser fusion research.

Experiments using the OMEGA laser at the University's Laboratory of Laser Energetics (LLE) have created the conditions capable of producing a fusion yield that's five times higher than the current record laser-fusion energy yield, as long as the relative conditions produced at LLE are reproduced and scaled up at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory in California.

The findings are the result of multiple experiments conducted by LLE scientists Sean Regan, Valeri Goncharov, and collaborators, whose paper was published in Physical Review Letters. Arijit Bose, a doctoral student in physics at Rochester working with Riccardo Betti, a professor of engineering and physics, interpreted those findings in a paper published as Rapid Communications in the journal Physical Review E (R).

Bose reports that the conditions at LLE would produce over 100 kilojoules (kJ) of fusion energy if replicated on the NIF. While that may seem like a tiny flicker in the world's ever-expanding demand for energy, the new work represents an important advance in a long-standing national research initiative to develop fusion as an energy source. The 100 kJ is the energy output of a 100-watt light for about 20 minutes, but in a fusion experiment at NIF, that energy would be released in less than a billionth of a second and enough to bring the fuel a step closer to the ignition conditions.

"We have compressed thermonuclear fuel to about half the pressure required to ignite it. This is the result of a team effort involving many LLE scientists and engineers," said Regan, the leader of the LLE experimental group.

If ignited, thermonuclear fuel would unleash copious amounts of fusion energy, much greater than the input energy to the fuel. ...Read More...

Sound-proof metamaterial inspired by spider webs

Different vibration mode shapes of the spider-web-inspired acoustic metamaterial. Credit: M. Miniaci et al. ©2016 AIP Publishing

Spider silk is well-known for its unusual combination of being both lightweight and extremely strong—in some cases, stronger than steel. Due to these properties, researchers have been developing spider-silk-inspired materials for potential applications such as durable yet lightweight clothing, bullet-proof vests, and parachutes.

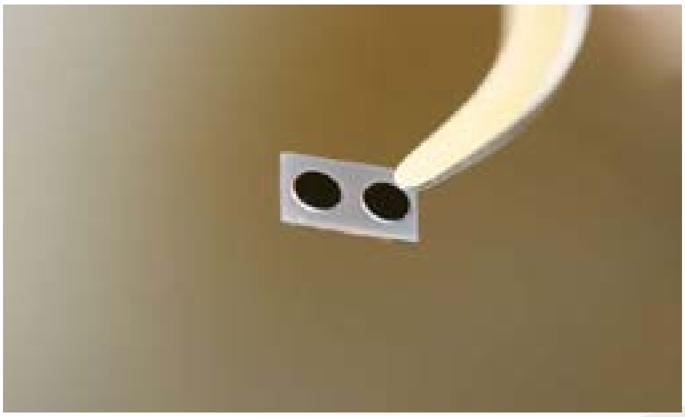
But so far, the acoustic properties of spider webs have not yet been explored. Now in a new study, a team of researchers from Italy, France and the UK has designed an acoustic metamaterial (which is a material made of periodically repeating structures) influenced by the intricate spider web architecture of the golden silk orb-weaver, also called the Nephila spider.

"There has been much work in the field of metamaterials in recent years to find the most efficient configurations for wave attenuation and manipulation," coauthor Federico Bosia, a physicist at the University of Torino in Italy, told Phys.org. "We have found that the spider web architecture, combined with the variable elastic properties of radial and circumferential silk, is capable of attenuating and absorbing vibrations in wide frequency ranges, despite being lightweight."

By modeling different versions of the new spider-web-inspired acoustic metamaterial, the researchers demonstrated that the new design is more efficient at inhibiting low-frequency sound and is more easily tuned to different frequencies than other sound-controlling materials. Combined with the stiffening mechanical properties and the heterogeneity of spider silk, the tunable acoustic properties demonstrated here suggest that spider-web-inspired metamaterials could lead to a new class of applications for controlling vibrations. Possibilities include earthquake protection for suspended bridges and buildings, noise reduction, sub-wavelength imaging, and acoustic cloaking.

The acoustic advantages of the spider web arise, at least in part, from the concentric circles, or "rings," of the web. These rings resonate at a particular ...Read More...

New breed of optical soliton wave discovered



Optical microcavities in which the solitons were created. Credit: Qi-Fan Yang/Caltech

pplied scientists led by Caltech's Kerry Vahala have discovered a new type of optical soliton wave that travels in the wake of other soliton waves, hitching a ride on and feeding off of the energy of the other wave.

Solitons are localized waves that act like particles: as they travel across space, they hold their shape and form rather than dispersing as other waves do. They were first discovered in 1834 when Scottish engineer John Scott Russell noted an unusual wave that formed after the sudden stop of a barge in the Union Canal that runs between Falkirk and Edinburgh. Russell tracked the resulting wave for one or two miles, and noted that it preserved its shape as it traveled, until he ultimately lost sight of it.

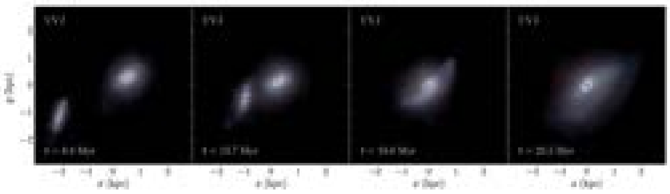
He dubbed his discovery a "wave of translation." By the end of the century, the phenomenon had been described mathematically, ultimately giving birth to the concept of the soliton wave. Under normal conditions, waves tend to dissipate as they travel through space. Toss a stone into a pond, and the ripples will slowly die down as they spread out away from the point of impact. Solitons, on the other hand, do not.

In addition to water waves, solitons can occur as light waves. Vahala's team studies light solitons by having them recirculate indefinitely in micrometer-scale circular circuits called optical microcavities. Solitons have applications in the creation of highly accurate optical clocks, and can be used in microwave oscillators that are used for navigation and radar systems, among other things.

But despite decades of study, a soliton has never been observed behaving in a dependent—almost parasitic—manner.

"This new soliton rides along with another soliton—essentially, in the other soliton's wake. It also syphons energy off of the other soliton so that it is self-sustaining. It can eventually grow larger than its host," says Vahala, Ted and Ginger Jenkins Professor of ...Read More...

First Gravitational Waves form After 10 Million Years



This simulation shows how two galaxies merge over a period of 15 million years. The red and the blue dots illustrate the two black holes. Image courtesy Astrophysical Journal.

In his general theory of relativity, Albert Einstein predicted gravitational waves over a century ago; this year, they were detected directly for the first time: The American Gravitational Wave Observatory LIGO recorded such curvatures in space from Earth, which were caused by the merging of two massive black holes.

And the research on gravitational waves - and thus the origin of the universe - continues: From 2034 three satellites are to be launched into space in a project headed by the European Space Agency (ESA) to measure gravitational waves at even lower frequency ranges from space using the Evolved Laser Interferometer Space Antenna (eLISA).

Until now, however, it was not possible to conclusively predict the point at which gravitational waves are triggered and spread throughout space when galaxies merge. An international team of astrophysicists from the University of Zurich, the Institute of Space Technology Islamabad, the University of Heidelberg and the Chinese Academy of Sciences has now calculated this for the first time using an extensive simulation.

Much Faster Than Previously Assumed

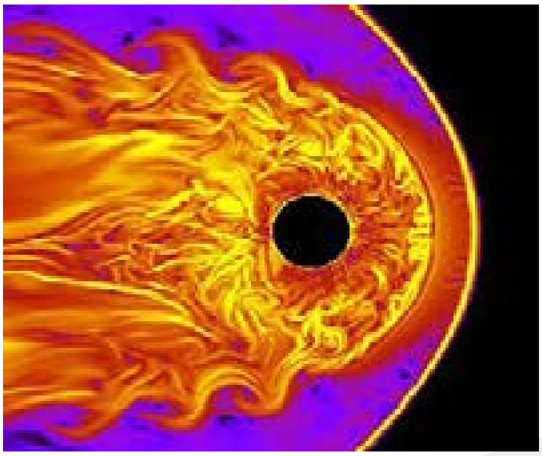
Every galaxy has a supermassive black hole at its core, which can exhibit millions or even billions of solar masses. In a realistic simulation of the universe, the merging of two roughly 3-billion-year-old galaxies lying relatively close to one another was simulated. With the aid of supercomputers, the researchers calculated the time the two central black holes with around 100 million solar masses needed to emit strong gravitational waves after the galaxies collided.

"The result is surprising," explains Lucio Mayer from the Institute for Computational Science of the University of Zurich: "The merging of the two black holes already triggered the first gravitational waves after 10 million years - around 100 times faster than previously assumed."

Year-Long Supercomputer Calculation

The computer simulation, which took more than a year, was conducted in China, Zurich and Heidelberg. The project required an innovative computational approach with various numerical codes on different ...Read More...

Space Plasma Hurricanes Suggest New Sources of Energy



File Image.

A new study by researchers at Embry-Riddle Aeronautical University, funded by the National Science Foundation, has identified for the first time a process by which the solar wind is heated along extended regions of the Earth's magnetic shield as it penetrates through this barrier. The process may have parallels to the unsolved problem in astrophysics of how the solar corona is heated. It may also be helpful for understanding the cross-scale transport of energy in man-made plasma devices that may lead to the creation of practical fusion power.

In 2011, Ph.D. student Thomas W. Moore, at that time a master's student, began working with Dr. Katariina Nykyri, a Professor of Physics in the Physical Sciences Department and member of Embry-Riddle's Center for Space and Atmospheric Research in Daytona Beach, analyzing data gathered from four European Space Agency Cluster spacecraft.

The team, including post-doctoral researcher Andrew Dimmock, created numerical simulations that aid in understanding the signatures in the spacecraft data and utilized multi-spacecraft techniques for plasma wave mode identification. For 16 years, these four satellites have been investigating the Earth's magnetic environment and its interaction with the solar wind in three dimensions.

"In space, the fast streaming plasma (solar wind) originating from the Sun creates large 'space hurricanes,' called Kelvin-Helmholtz (KH) waves, at the boundary of Earth's magnetic barrier," said Nykyri. "The KH waves typically have wavelengths in range of 20,000-40,000 km and a 1-3 minute period, and as they steepen and roll-up like ocean waves they can transport solar wind plasma into the magnetosphere."

The KH waves are a direct result of the way our planet fits into the larger solar system. Planet Earth is a gigantic magnet and its magnetic influence extends outward in a large bubble called a magnetosphere. A constant flow of particles from the Sun (solar wind) blows by the magnetosphere - not unlike wind blowing ...Read More...

NASA launches first asteroid dust-retrieval mission

The US space agency Thursday launched its first mission to collect dust from an asteroid, the kind of cosmic body that may have delivered life-giving materials to Earth billions of years ago.

The unmanned spacecraft, known as OSIRIS-REx, blasted off at 7:05 pm (23:05 GMT) atop an Atlas V rocket in Cape Canaveral, Florida.

The $800 million mission will travel for two years on a journey to Bennu, a near-Earth asteroid about the size of a small mountain.

Bennu was chosen from the some 500,000 asteroids in the solar system because it orbits close to Earth's path around the sun, it is the right size for scientific study, and it is one of the oldest asteroids known to NASA.

"For primitive, carbon-rich asteroids like Bennu, materials are preserved from over four and a half billion years ago," explained Christina Richey, OSIRIS-REx deputy program scientist at NASA.

These "may be the precursors to life in Earth or elsewhere in our solar system."

OSIRIS-REx's main goal is to gather dirt and debris from the surface of the asteroid and return it to Earth by 2023 for further study.

Learning more about the origins of life and the beginning of the solar system are key objectives for the SUV-sized OSIRIS-REx, which stands for Origins, Spectral Interpretation, Resource Identification and Security-Regolith Explorer.

The mission should also shed light on how to find precious resources such as water and metals in asteroids, a field that has generated increasing interest worldwide.

"We are going to map this brand-new world that we have never seen before," said Dante Lauretta, OSIRIS-REx principal investigator and professor at the University of Arizona, Tucson. ...Read More...

This Week's Sky at a Glance, Sep. 10-16

Sep 13	Mercury at inferior conjunction (Local Time: 03:39)
Sep 16	Moon at descending node (Local Time: 03:55)
Sep 16	Penumbral lunar eclipse (Local Time: 22:50)
Sep 16	Full Moon (23:04) - Meridian passage (00:20) – Altitude: 62°

Memories of John Ellis's Visit to SCASS/UoS - Sep. 06-07, 2016