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SCASS Participation at the 11th UoS Annual Research Forum
Solving one of nature’s great puzzles: What drives the accelerating expansion of the universe?

Credit: NASA

UBC physicists may have solved one of nature’s great puzzles: what causes the accelerating expansion of our universe?

PhD student Qingdi Wang has tackled this question in a new study that tries to resolve a major incompatibility issue between two of the most successful theories that explain how our universe works: quantum mechanics and Einstein’s theory of general relativity.

The study suggests that if we zoomed in-way in-on the universe, we would realize it’s made up of constantly fluctuating space and time.

“Space-time is not as static as it appears, it’s constantly moving,” said Wang. “This is a new idea in a field where there hasn’t been a lot of new ideas that try to address this issue,” said Bill Unruh, a physics and astronomy professor who supervised Wang’s work.

In 1998, astronomers found that our universe is expanding at an ever-increasing rate, implying that space is not empty and is instead filled with dark energy that pushes matter away.

The most natural candidate for dark energy is vacuum energy. When physicists apply the theory of quantum mechanics to vacuum energy, it predicts that there would be an incredibly large density of vacuum energy, far more than the total energy of all the particles in the universe. If this is true, Einstein’s theory of general relativity suggests that the energy would have a strong gravitational effect and most physicists think this would cause the universe to explode.

Fortunately, this doesn’t happen and the universe expands very slowly. But it is a problem that must be resolved for fundamental physics to progress.

Unlike other scientists who have tried to modify the theories of quantum mechanics or general relativity to resolve the issue, Wang and his colleagues.

Nano fiber feels forces and hears sounds made by cells

Engineers at the University of California San Diego have developed a miniature device that’s sensitive enough to feel the forces generated by swimming bacteria and hear the beating of heart muscle cells.

The device is a nano-sized optical fiber that’s about 100 times thinner than a human hair. It can detect forces down to 160 femtonewtons—about ten trillion times smaller than a newton—when placed in a solution containing live Helicobacter pylori bacteria, which are swimming bacteria found in the gut. In cultures of beating heart muscle cells from mice, the nano fiber can detect sounds down to -30 decibels—a level that’s one thousand times below the limit of the human ear.

“This work could open up new doors to track small interactions and changes that couldn’t be tracked before,” said nanoengineering professor Donald Sirbuly at the UC San Diego Jacobs School of Engineering, who led the study.

Some applications, he envisions, include detecting the presence and activity of a single bacterium; monitoring bonds forming and breaking; sensing changes in a cell’s mechanical behavior that might signal it becoming cancerous or being attacked by a virus; or a mini stethoscope to monitor cellular acoustics in vivo.

The work is published in Nature Photonics on May 15.

The optical fiber developed by Sirbuly and colleagues is at least 10 times more sensitive than the atomic force microscope (AFM), an instrument that can measure infinitesimally small forces generated by interacting molecules. And while AFMs are bulky devices, this optical fiber is only several hundred nanometers in diameter. “It’s a mini AFM with the sensitivity of an optical tweezer,” Sirbuly said.

The device is made from an extremely thin fiber of tin dioxide, coated with a thin layer of a polymer, called polyethylene glycol, and studded with gold nanoparticles. To use the device, researchers dip the nano optical fiber into a solution of cells, send a beam of light.
NASA Mission Uncovers Dance of Electrons in Space

As MMS flew around Earth, it passed through an area of a moderate strength magnetic field where electric currents run in the same direction as the magnetic field. Such areas are known as intermediate guide fields. While inside the region, the instruments recorded a curious interaction of electrons with the current sheet, the thin layer through which the current travels.

You can’t see them, but swarms of electrons are buzzing through the magnetic environment - the magnetosphere - around Earth. The electrons spiral and dive around the planet in a complex dance dictated by the magnetic and electric fields. When they penetrate into the magnetosphere close enough to Earth, the high-energy electrons can damage satellites in orbit and trigger auroras.

Scientists with NASA’s Magnetospheric Multiscale, or MMS, mission study the electrons’ dynamics to better understand their behavior. A new study, published in Journal of Geophysical Research revealed a bizarre new type of motion exhibited by these electrons.

Electrons in a strong magnetic field usually exhibit a simple behavior: They spin tight spirals along the magnetic field. In a weaker field region, where the direction of the magnetic field reverses, the electrons go free style - bouncing and wagging back and forth in a type of movement called Speiser motion. New MMS results show for the first time what happens in an intermediate strength field.

Then these electrons dance a hybrid, meandering motion - spiraling and bouncing about before being ejected from the region. This motion takes away some of the field’s energy and it plays a key role in magnetic reconnection, a dynamic process, which can explosively release large amounts of stored magnetic energy.

“MMS is showing us the fascinating reality of magnetic reconnection happening out there,” said Li-Jen Chen, lead author of the study and MMS scientist at NASA’s Goddard Space Flight Center in Greenbelt, Maryland.

As MMS flew around Earth, it passed through an area of a moderate strength magnetic field where electric currents run in the same direction as the magnetic field. Such areas are known as intermediate guide fields. While inside the region, the instruments recorded a curious interaction of electrons with the current sheet, the thin layer through which the current travels.

Hubble spots moon around third largest dwarf planet

Moon orbiting the third largest dwarf planet, catalogued as 2007 OR10. Credit: NASA, ESA, C. Kiss (Konkoly Observatory), and J. Stansberry (STScI).

The combined power of three space observatories, including NASA’s Hubble Space Telescope, has helped astronomers uncover a moon orbiting the third largest dwarf planet, catalogued as 2007 OR10. The pair resides in the frigid outskirts of our solar system called the Kuiper Belt, a realm of icy debris left over from our solar system’s formation 4.6 billion years ago.

With this discovery, most of the known dwarf planets in the Kuiper Belt larger than 600 miles across have companions. These bodies provide insight into how moons formed in the young solar system.

“The discovery of satellites around all of the known large dwarf planets - except for Sedna - means that at the time these bodies formed billions of years ago, collisions must have been more frequent, and that's a constraint on the formation models,” said Csaba Kiss of the Konkoly Observatory in Budapest, Hungary. He is the lead author of the science paper announcing the moon’s discovery. “If there were frequent collisions, then it was quite easy to form these satellites.”

The objects most likely slammed into each other more often because they inhabited a crowded region. “There must have been a fairly high density of objects, and some of them were massive bodies that were perturbing the orbits of smaller bodies,” said team member John Stansberry of the Space Telescope Science Institute in Baltimore, Maryland. “This gravitational stirring may have nudged the bodies out of their orbits and increased their relative velocities, which may have resulted in collisions.”

But the speed of the colliding objects could not have been too fast or too slow, according to the astronomers. If the impact velocity was too fast, the smash-up would have created lots of debris that could have escaped from the system; too slow and the collision would have produced only an impact crater.

Collisions in the asteroid belt, for example, are destructive because objects are traveling fast when...
Stars as random number generators could test foundations of physics

The proposed Bell test uses stars and quasars as random number generators to address the freedom-of-choice loophole and show that the quantum world does not obey local realism. Credit: Wu et al. ©2017 American Physical Society

Stars, quasars, and other celestial objects generate photons in a random way, and now scientists have taken advantage of this randomness to generate random numbers at rates of more than one million numbers per second. Generating random numbers at very high rates has a variety of applications, such as in cryptography and computer simulations.

But the researchers in the new study are also interested in using these cosmic random number generators for another purpose: to test the foundations of physics by progressively addressing another loophole in the Bell tests. While Bell tests show that quantum particles are correlated in ways that cannot be explained by classical physics, the results may not be reliable if parts of these tests manage to take advantage of any kind of loophole.

The researchers, led by Jian-Wei Pan, at the University of Science and Technology of China in Shanghai, have published a paper on using cosmic sources to generate random numbers in a recent issue of Physical Review Letters.

“We presented an experimental realization of cosmic random number generators (RNGs) and a realistic design of an event-ready Bell test experiment with these RNGs to address the freedom-of-choice loophole while closing the locality and efficiency loopholes simultaneously,” coauthor Jingyun Fan told Phys.org. “It will be of high interest to implement the proposed experiment in the near future.”

In their work, the researchers used an optical telescope located at the Astronomy Observatory in Xinglong, China, to collect light from a variety of very bright and distant cosmic radiation sources. Some of these objects are more than a trillion times brighter than our Sun and located hundreds of millions of light-years away.

Since the time interval between photon emission events is random, the photons are detected by the telescope at random time intervals. The device has a time resolution of 25 picoseconds (a picosecond is one trillionth).

Physicists use Einstein’s ‘spooky’ entanglement to invent super-sensitive gravitational wave detector

When black holes collide, gravitational waves are created in space itself (image is a computer simulation). Credit: The SXS (Simulating eXtreme Spacetimes) Project

The first direct detection of gravitational waves, a phenomenon predicted by Einstein’s 1915 general theory of relativity, was reported by scientists in 2016.

Armed with this “discovery of the century”, physicists around the world have been planning new and better detectors of gravitational waves.

Physicist Professor Chunnong Zhao and his recent PhD students Haixing Miao and Yiqiu Ma are members of an international team that has created a particularly exciting new design for gravitational wave detectors.

The new design is a real breakthrough because it can measure signals below a limit that was previously believed to be an insurmountable barrier. Physicists call this limit the standard quantum limit. It is set by the quantum uncertainty principle.

The new design, published in Nature magazine this week, shows that this may not be a barrier any longer.

Using this and other new approaches may allow scientists to monitor black hole collisions and “spacequakes” across the whole of the visible universe.

How gravitational wave detectors work

Gravitational waves are not vibrations travelling through space, but rather vibrations of space itself. They have already told us about an unexpectedly large population of black holes. We hope that further study of gravitational waves will help us to better understand our universe.

But the technologies of gravitational wave detectors are likely to have enormous significance beyond this aspect of science, because in themselves they are teaching us how to measure unbelievably tiny amounts.
**First Result from XENON1T Dark Matter Detector**

XENON1T installation in the underground hall of Laboratori Nazionali del Gran Sasso. The three story building on the right houses various auxiliary systems. The cryostat containing the LXeTPC is located inside the large water tank on the left, next to the building. (Photo by Roberto Corrieri and Patrick De Perio)

This is how scientists behind XENON1T, now the most sensitive dark matter experiment world-wide, hosted in the INFN Laboratori Nazionali del Gran Sasso, Italy (http://www.lngs.infn.it), commented on their first result from a short 30-day run presented to the scientific community.

Dark matter is one of the basic constituents of the universe, five times more abundant than ordinary matter. Several astronomical measurements have corroborated the existence of dark matter, leading to a world-wide effort to observe directly dark matter particle interactions with ordinary matter in extremely sensitive detectors, which would confirm its existence and shed light on its properties. However, these interactions are so feeble that they have escaped direct detection up to this point, forcing scientists to build detectors that are more and more sensitive.

The XENON Collaboration, that with XENON100 led the field for years in the past, is now back on the frontline with XENON1T. The result from a first short 30-day run shows that this detector has a new record low radioactivity level, many orders of magnitude below surrounding materials on Earth. With a total mass of about 3,200 kg, XENON1T is at the same time the largest detector of this type ever built. The combination of significantly increased size with much lower background implies an excellent discovery potential in the years to come.

The XENON Collaboration consists of 135 researchers from the US, Germany, Italy, Switzerland, Portugal, France, the Netherlands, Israel, Sweden and the United Arab Emirates. The latest detector of the XENON family has been in science operation at the LNGS underground laboratory since autumn 2016.

The only things you see when visiting the underground experimental site now are a gigantic cylindrical metal tank, filled with ultra-pure water to shield the detector at his center, and a three-story-tall ...Read More...

**ALMA eyes icy ring around young planetary system**

Debris disks are common features around young stars and represent a very dynamic and chaotic period in the history of a solar system. Astronomers believe they are formed by the ongoing collisions of comets and other planetesimals in the outer reaches of a recently formed planetary system. The leftover debris from these collisions absorbs light from its central star and reradiates that energy as a faint millimeter-wavelength glow that can be studied with ALMA.

An international team of astronomers using the Atacama Large Millimeter/submillimeter Array (ALMA) has made the first complete millimeter-wavelength image of the ring of dusty debris surrounding the young star Fomalhaut. This remarkably well-defined band of rubble and gas is likely the result of exocomets smashing together near the outer edges of a planetary system 25 light-years from Earth.

Earlier ALMA observations of Fomalhaut - taken in 2012 when the telescope was still under construction - revealed only about one half of the debris disk. Though this first image was merely a test of ALMA’s initial capabilities, it nonetheless provided tantalizing hints about the nature and possible origin of the disk.

The new ALMA observations offer a stunningly complete view of this glowing band of debris and also suggest that there are chemical similarities between its icy contents and comets in our own solar system.

"ALMA has given us this staggeringly clear image of a fully formed debris disk," said Meredith MacGregor, an astronomer at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and lead author on one of two papers accepted for publication in the Astrophysical Journal describing these observations. "We can finally see the well-defined shape of the disk, which may tell us a great deal about the underlying planetary system responsible for its highly distinctive appearance."

Fomalhaut is a relatively nearby star system and one of only about 20 in which planets have been imaged directly. The entire system is approximately 440 million years old, or about one-tenth the age of our solar system.

As revealed in the new ALMA image, a brilliant band of icy dust about 2 billion kilometers wide has formed approximately 20 billion kilometers from the star. ...Read More...
Two studies show possibility of some cosmic rays existing due to dark matter collisions

Engineers have invented tiny structures inspired by butterfly wings that open the door to new solar cell technologies and other applications requiring precise manipulation of light.

The inspiration comes from the blue Morpho Didius butterfly, which has wings with tiny cone-shaped nanostructures that scatter light to create a striking blue iridescence, and could lead to other innovations such as stealth and architectural applications.

Lead researcher Dr Niraj Lal from the ANU Research School of Engineering said the team made similar structures at the nanoscale and applied the same principles in the butterfly wing phenomenon to finely control the direction of light in experiments.

“There’s a whole bunch of potential new applications using our light-control technique, including next-generation solar cell, architectural and stealth technologies,” said Dr Lal from the ANU Research School of Engineering.

He said scientists can greatly improve the efficiency of solar cells with effective light management.

“Techniques to finely control the scattering, reflection and absorption of different colours of light are being used in the next generation of very high-efficiency solar panels,” he said.

“Being able to make light go exactly where you want it to go has proven to be tricky up until now.”

Dr Lal said the aim was to absorb all of the blue, green and ultraviolet colours of sunlight in the perovskite layer of a solar cell, and all of the red, orange and yellow light in the silicon layer - known as a tandem solar cell with double-decker layers. Researchers at the ANU surpassed silicon efficiency records with such a cell last month. Read More...

Butterfly wings inspire invention that opens door to new solar technologies

A blue Morpho butterfly on top of a solar cell. Credit: Stuart Hay, ANU.

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UV Spectropolarimetry Opens a New Window for Solar Physics Research

For the first time in the world, scientists have explored the magnetic field in the upper solar atmosphere by observing the polarization of ultraviolet light from the Sun. They accomplished this by analyzing data taken by the CLASP sounding rocket experiment during its 5-minute flight in space on September 3, 2015.

The data show that the structures of the solar chromosphere and transition region are more complicated than expected. Now that ultraviolet spectropolarimetry, the method used in the CLASP project, has been proven to work, it can be used in future investigations of the magnetic fields in the upper chromosphere and the transition region to better understand activity in the solar atmosphere.

By analyzing the characteristics of light from the Sun, astronomers can determine how it has been emitted and scattered in the solar atmosphere, and thus determine the conditions in the solar atmosphere. Because magnetic fields are thought to play an important role in various types of solar activity, many precise measurements have been made of the magnetic fields at the solar surface (“photosphere”), but not so many observations have measured the magnetic fields in the solar atmosphere above the surface.

While visible light is emitted from the photosphere, ultraviolet (UV) light is emitted and scattered in the parts of the solar atmosphere known as the chromosphere and the transition region. CLASP is a project to investigate the magnetic fields in the upper chromosphere and the transition region, using the hydrogen Lyman-alpha line in UV.

The international team used data from the CLASP spectropolarimeter, an instrument which provides detailed wavelength (color) and polarization (orientation of the light waves) information for light passing through a thin slit.

The researchers discovered that the hydrogen Lyman-alpha line from the Sun is actually polarized. Some of the polarization characteristics match those predicted by the theoretical scattering models. However, others are unexpected, indicating that the structures of... Read More...

Punching Above Its Weight, Brown Dwarf Launches Parsec-Scale Jet

The HH 1165 jet launched by a brown dwarf in the outer periphery of the Sigma Orionis cluster. Traced by emission from singly ionized sulfur, which appears green in the image, the jet extends 0.7 light-year (equivalent to 0.2 parsec) northwest of the brown dwarf.

Astronomers using the SOAR telescope at the Cerro Tololo Inter-American Observatory report the discovery of a spectacular extended jet from a young brown dwarf. With masses too low to sustain hydrogen fusion in their interiors, brown dwarfs occupy the mass range between stars and giant planets. While young stars are commonly found to launch jets that extend over a light-year or more, this is the first jet with a similar extent detected from a brown dwarf. The result lends new insight into how substellar objects form.

Intrinsically faint, brown dwarfs have been more elusive and difficult to study than stars. Although they are often portrayed as exotic creatures as a result, brown dwarfs are actually far more numerous in our galaxy than stars like the Sun.

The discovery, accepted for publication in the Astrophysical Journal, supports the emerging picture that brown dwarfs form similarly to stars.

The image shows the jet, HH 1165, launched by the brown dwarf Mayrit 1701117 in the outer periphery of the 3 million year old Sigma Orionis cluster. Traced by emission from singly ionized sulfur, which appears green in the image, the jet extends 0.7 light-year (equivalent to 0.2 parsec) northwest of the brown dwarf. The emission knots along the jet reveal that the mass loss is time variable, probably a result of episodic accretion onto the brown dwarf. The red nebulosity southeast of the brown dwarf is a reflection nebula that traces the outflow cavity in the direction of the counterjet.

While outflows have been detected previously from young brown dwarfs, the earlier detections were of “microjets” 10 times smaller in extent. “Our result shows that brown dwarfs can launch parsec-scale jets similar to those from young stars,” explains... Read More...
Special Read:

SFL signs contract with Dubai to build environmental monitoring satellite

The Space Flight Laboratory (SFL) of Toronto reports it has signed a new contract to provide Dubai-based Mohammed Bin Rashid Space Centre (MBRSC) with a microsatellite for aerosol and greenhouse gas monitoring. SFL’s Next-generation Earth Monitoring and Observation (NEMO) platform technology, which incorporates high-performance ground target tracking capability, is a key enabler for the mission.

The DMSat-1 (also known as “AirWatch”) satellite will leverage past developments at SFL for a rapidly developed mission that will incorporate two payloads. The primary payload is a multislolar polatimer used to monitor aerosols - fine particles of liquid and solids in the upper atmosphere normally caused by man-made sources, but also correlating to natural phenomena such as dust storms.

The secondary instrument is a pair of spectrometers that will enable MBRSC to detect greenhouse gases like carbon dioxide and methane over the United Arab Emirates. The study of aerosols and greenhouse gases will be conducted by researchers local to the UAE. “We are pleased that the Mohammed Bin Rashid Space Centre has selected SFL as their spacecraft provider for this important mission,” remarked Dr. Robert Zee, Director, SFL. “We look forward to fruitful collaboration with MBRSC and this exciting mission that will benefit the UAE for years to come.”

In previous missions, the SFL NEMO bus has demonstrated precise attitude control and target tracking capabilities - rare among satellite platforms of this size - that will play a key role in the accurate pointing of the DMSat-1 sensors.

SFL, based at the University of Toronto Institute for Aerospace Studies (UTIAS), will highlight its nearly 20-year history of developing successful small satellite missions at the 2017 CANSEC Conference being held May 31 - June 1 in Ottawa. Visit SFL in booth 1036 at the EY Centre. ...Read More...

Indian Student Builds World’s Smallest Satellite For NASA

Rifath Shaarook, an 18-year-old student from the south Indian state of Tamil Nadu, has built a satellite which weighs only 64 grams and will be launched by NASA next month. Shaarook won the competition Cubes in Space, sponsored by NASA and the I Doodle Learning organization.

Shaarook expressed his excitement over the news that his satellite will be launched by NASA. “I belong to Pallapatti, a small place in Tamil Nadu. I lost my father at a very early age but my mother motivated me to excel in space science, as my father was also interested in astronomy,” he told Sputnik.

The world smallest satellite, KalamSat, designed by Shaarook has been named after the former Indian President Dr. APJ Abdul Kalam. “I am deeply impressed by late former President APJ Abdul Kalam, therefore the name of the satellite KalamSat is a tribute to him,” Shaarook told Sputnik. KalamSat is made from 3-D printed carbon fiber. The satellite will be launched by NASA on June 21 from the Wallops Island, Virginia in a sounding rocket. The mission will last for 240 minutes. The world’s smallest and lightest satellite will be operational in micro-gravity environment of space for about 12 minutes. KalamSat will be used to exhibit how 3D-printed carbon fiber performs in these conditions.
This Week’s Sky at a Glance:
May 20-26, 2017

May 24  Mercury 1.6° N of Moon 05:20
May 25  New Moon 23:44
May 26  Moon at Perigee 05:23 (357210 km)

Memories of College of Sciences End of Year 2017 Celebration at SCASS (May 14, 2017)