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Top News

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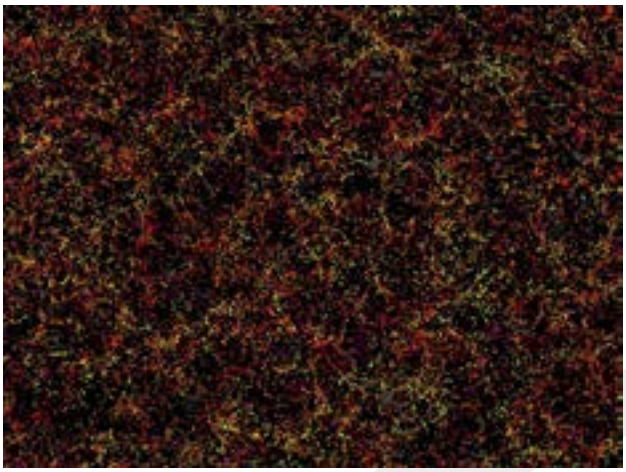
Biggest galactic map will throw light on 'dark energy'



A slice through the map of the large-scale structure of the Universe from the Sloan Digital Sky Survey and its Baryon Oscillation Spectroscopic Survey. Each dot in this picture indicates the position of a galaxy six billion years into the past. The image covers about 1/20th of the sky, a slice of the Universe 6 billion light-years wide, 4.5 billion light-years high, and 500 million light-years thick. Color indicates distance from Earth, ranging from yellow on the near side of the slice to purple on the far side. Credit: Daniel Eisenstein and SDSS-III.

An international team of astronomers has created the largest ever three-dimensional map of distant galaxies in a bid to help them understand one of the most mysterious forces in the universe.

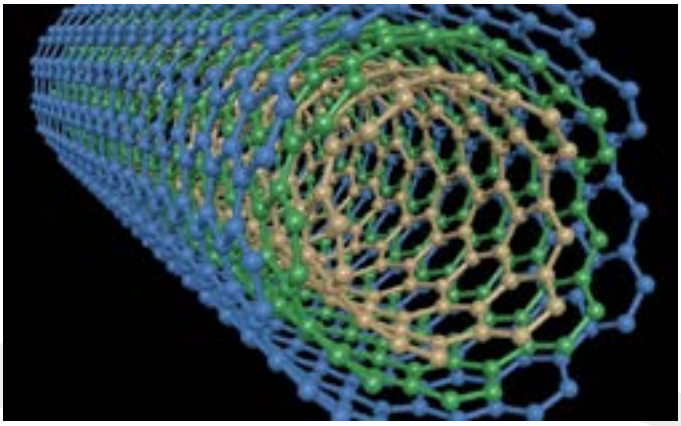
Scientists including a team led by Dr Florian Beutler at the University of Portsmouth's Institute of Cosmology and Gravitation have spent a decade collecting measurements of 1.2 million galaxies as part of the Sloan Digital Sky Survey III (SDSS-III).

This will allow them to make the most precise measurements to date of 'dark energy' – the force that is driving the accelerated expansion of the universe.

Dr Beutler said: "This extremely detailed three-dimensional map represents a colossal amount of work. The University of Portsmouth has worked with partner institutions for ten years, helping to gather measurements of galaxies making up a quarter of the sky. "Using this map we will now be able to make the most accurate possible measurements of dark energy, and the part it plays in the expansion of the universe."

The new measurements were carried out by the Baryon Oscillation Spectroscopic Survey (BOSS) program of SDSS-III. Shaped by a continuous tug-of-war between dark matter and dark energy, the map revealed by BOSS allows astronomers to measure the expansion rate of the universe and thus determine the amount of matter and dark energy that make up the present-day universe. ...Read More...

Lightweight Telescopes in Cubesats using Carbon Nanotube Mirrors



A team of NASA engineers has fashioned the world's first telescope mirrors made from carbon nanotubes. Credit: NASA

Ever since they were first produced, carbon nanotubes have managed to set off a flurry excitement in the scientific community. With applications ranging from water treatment and electronics, to biomedicine and construction, this should come as no surprise. But a team of NASA engineers from the Goddard Space Flight Center in Greenbelt, Maryland, has pioneered the use of carbon nanotubes for yet another purpose – space-based telescopes.

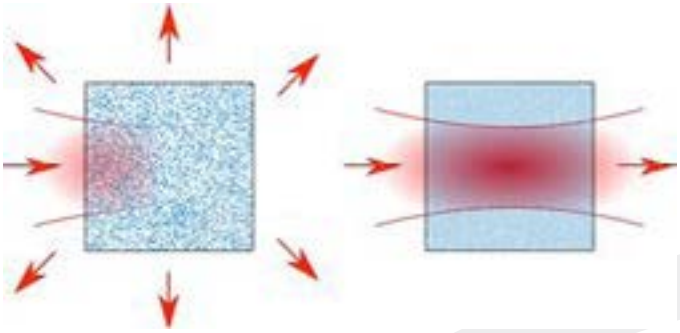
Using carbon nanotubes, the Goddard team – which is led by Dr. Theodor Kostiuk of NASA's Planetary Systems Laboratory and Solar System Exploration Division – have created a revolutionary new type of telescope mirror. These mirrors will be deployed as part of a CubeSat, one which may represent a new breed of low-cost, highly effective space-based telescopes.

This latest innovation also takes advantage of another field that has seen a lot of development of late. CubeSats, like other small satellites, have been playing an increasingly important role in recent years. Unlike the larger, bulkier satellites of yesteryear, miniature satellites are a low-cost platform for conducting space missions and scientific research.

Beyond federal space agencies like NASA, they also offer private business and research institutions the opportunity to conduct communications, research and observation from space. On top of that, they are also a low-cost way to engage students in all phases of satellite construction, deployment, and space-based research.

Granted, missions that rely on miniature satellites are not likely to generate the same amount of interest or scientific research as large-scale operations like the Juno mission or the New Horizons space probe. But they can provide vital information as part of larger missions, or work in groups to gather greater amounts of data. ...Read More...

Dense yet transparent materials offer new way to control light



Materials made of a large number of particles placed at random in a homogeneous medium will strongly scatter light, and thus no transmitted beam emerges (left). However, a hyperuniform material made of the same particles at the same density will appear transparent because scattering is suppressed, and the incident beam of light is transmitted (right). Credit: Rémi Carminati, Romain Pierrat, Institut Langevin, ESPCI Paris, CNRS

Researchers recently made the surprising discovery that a special class of materials called "hyperuniform materials" can be both dense and transparent. This work demonstrates a new way to control light and could lead to novel materials for many light-based applications including solar photovoltaics. These so-called "hyperuniform materials" can be made of plastic or glass that contains light-scattering particles spaced in a disordered, but not completely random, pattern.

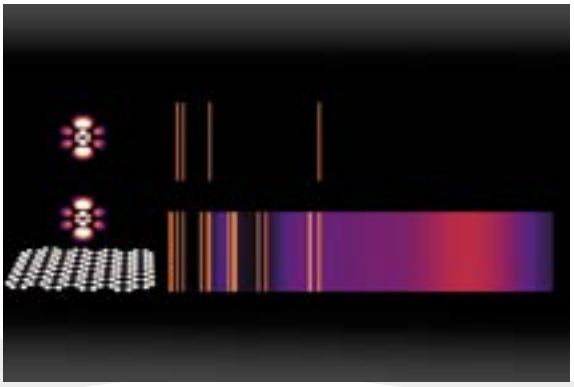
In The Optical Society's journal for high impact research, Optica, researchers led by Rémi Carminati, Institut Langevin, ESPCI Paris and CNRS, France, detail the transparency properties they discovered using computer simulations and outline a theory to explain the wavelengths of light for which hyperuniform materials appear transparent.

"We showed that hyperuniform materials can be transparent for certain wavelengths while at the same time being very dense," said Carminati. "Although our work is conceptual, we have found something very new."

Optical properties of hyperuniform materials

Although hyperuniform materials have been studied for the last decade, their optical properties are only recently being uncovered. Researchers previously showed that a hyperuniform material is transparent when it has a particle density that allows light going through the material to interact with each particle no more than once. "Typically if you make a material denser, it will scatter light more and thus appear opaque," said Carminati. ...Read More...

Study opens new realms of light-matter interaction



Emission spectra are a widely used method for identifying chemical compounds; the bright lines reveal the different frequencies of light that can be emitted by an atom. Here, a normal emission spectrum for an atom in a high-energy state (top) is compared to the emission from the same atom placed just a few nanometers (billionths of a meter) away from graphene that has been doped with charge carriers (bottom). For each energy-level transition, an orange line (or purple cloud) appears if that transition is estimated to be faster than one per microsecond — making it frequent enough to be observed. Credit: Massachusetts Institute of Technology

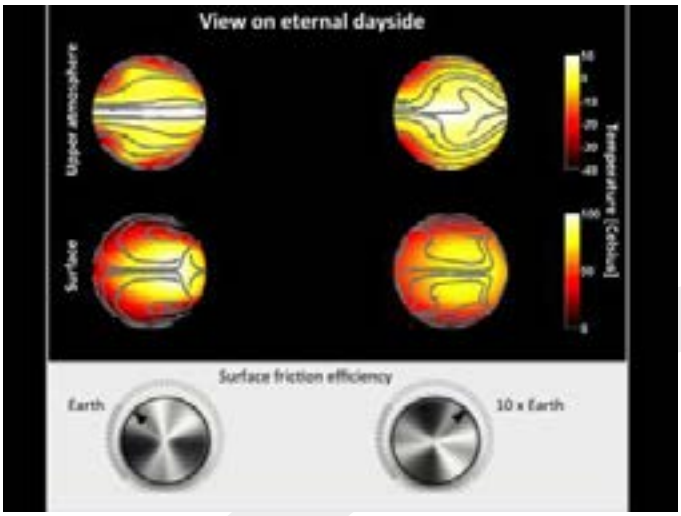
A new MIT study could open up new areas of technology based on types of light emission that had been thought to be "forbidden," or at least so unlikely as to be practically unattainable. The new approach, the researchers say, could cause certain kinds of interactions between light and matter, which would normally take billions of years to happen, to take place instead within billionths of a second, under certain special conditions.

The findings, based on a theoretical analysis, are reported today in the journal Science in a paper by MIT doctoral student Nicholas Rivera, Department of Physics Professor Marin Soljacic, Francis Wright Davis Professor of Physics John Joannopoulos, and postdocs Ido Kaminer and Bo Zhen.

Interactions between light and matter, described by the laws of quantum electrodynamics, are the basis of a wide range of technologies, including lasers, LEDs, and atomic clocks. But from a theoretical standpoint, "Most light-matter interaction processes are 'forbidden' by electronic selection rules, which limits the number of transitions between energy levels we have access to," Soljacic explains.

For example, spectrograms, which are used to analyze the elemental composition of materials, show a few bright lines against a mostly dark background. The bright lines represent the specific "allowed" energy level transitions in the atoms of that element that can be accompanied by the release of a photon (a particle of light). In the dark regions, which make up most of the spectrum, emission at those energy levels is "forbidden." ...Read More...

Surface composition determines temperature, habitability of a planet



The figures show the wind, temperature, and surface-atmosphere friction on a planet 1.45 times the size of the Earth in a 1-day orbit around an M dwarf. The two topmost figures show the wind and the temperature in the upper layers of the atmosphere. The two figures in the middle show the wind and the temperature on the surface of the planet. On the left-hand figures, the surface-atmosphere friction equals that on Earth. On the right-hand figures, there is ten times as much friction between surface and atmosphere than is the case on Earth. Both scenarios have a different impact on the climate of a planet: the climate represented in the right-hand figures is more habitable. Credit: (c) KU Leuven - Ludmila Carone and Leen Decin.

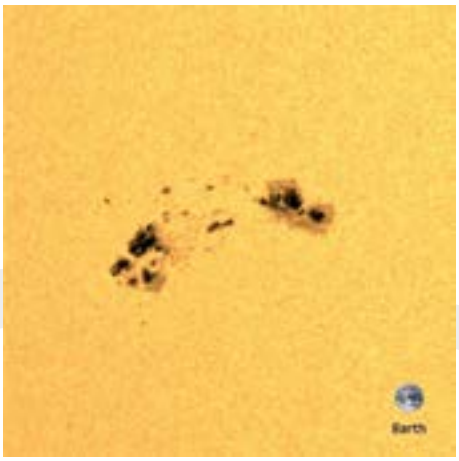
KU Leuven astronomers have shown that the interaction between the surface and the atmosphere of an exoplanet has major consequences for the temperature on the planet. This temperature, in turn, is a crucial element in the quest for habitable planets outside the solar system.

In the quest for exoplanets, astronomers are currently focusing on rocky planets that don't look like Earth. These planets orbit so-called M dwarfs—stars that are smaller than the sun. There are many more M dwarfs than there are sun-like stars, making it more likely that astronomers will discover the first habitable exoplanet around an M dwarf. Most planets orbiting these M dwarfs always face their stars with the same side. As a result, they have permanent day and night sides. The day side is too hot to make life possible, while the night side is too cold.

Last year, KU Leuven researchers Ludmila Carone, Professor Rony Keppens, and Professor Leen Decin showed that planets with permanent day sides may still be habitable depending on their temperature circulation systems. Two out of three possible systems on these exoplanets use the cold air of the night side to cool down the day side. And with the right atmosphere and temperature, planets with permanent day and night sides are potentially habitable.

Whether the 'air conditioning' system is actually effective depends on the interaction between the surface ... Read More...

Scientists find that sunspots rise to the surface much more slowly than predicted



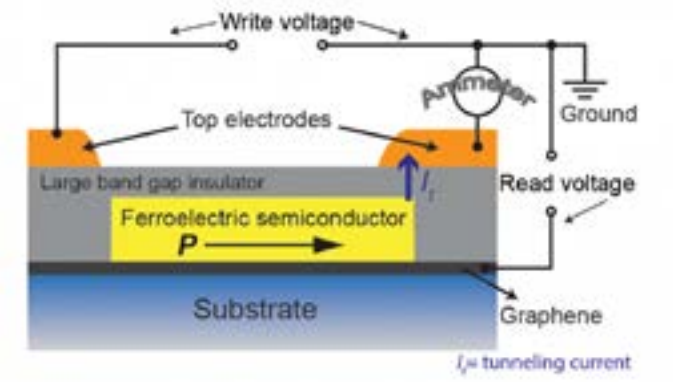
Solar active region as seen by the Helioseismic and Magnetic Imager on board the NASA Solar Dynamics Observatory. The dark circular regions are sunspots; these regions of strong magnetic field are dark as they are cool. The image of Earth is shown for scale. Credit: MPS. The HMI data were used courtesy of NASA/SDO and the HMI science team and processed at the German Data Center for SDO (GDC-SDO), funded by the German Aerospace Center (DLR)

Solar active regions consist of strongly magnetic sunspots and surrounding regions of more diffuse magnetic field. These regions are the origin of solar activity which controls space weather and causes beautiful phenomena such as aurora but in some cases also damage to satellites or power grids. Solar active regions are thought to be the result of magnetic flux concentrations - bundles of magnetic field lines - rising from deep in the solar interior and penetrating the surface. A team consisting of researchers from the Max Planck Institute for Solar System Research (MPS), The University of Göttingen, NorthWest Research Associates, and the High Altitude Observatory of the National Center for Atmospheric Research has now shown that these magnetic flux concentrations move upward through the solar interior at speeds of not more than about 150 m/s. This is much slower than predicted by the prevailing current model. For their study, which is published today in the journal Science Advances, they compared satellite observations and computer simulations.

A clear sign of a magnetic flux concentration penetrating the surface of the Sun are regions with magnetic fields of opposite polarity. These polarities are clearly visible on magnetic maps provided by the Helioseismic and Magnetic Imager (HMI) instrument onboard NASA's Solar Dynamics Observatory (SDO). The researchers used these images to identify active regions and to determine the moment of their emergence.

Since its launch in 2010, SDO has provided an almost uninterrupted stream of data. "For our research we needed observations of a statistically significant number of active regions," explains lead-author Aaron Birch from the MPS. "HMI is ideal for our purpose as it provides high-resolution images of the complete solar disc with essentially continuous coverage in time," he adds. Because of the Sun's activity minimum in 2010, during which active regions occur much less often than usual ..Read More...

Researchers demonstrate room-temperature ferroelectric states in ultra-thin films of tin and tellurium



Researchers at MIT and Tsinghua University have demonstrated room temperature ferroelectric states in ultra-thin films of tin and tellurium and have filed a provisional patent for a new kind of random access memory that they call ferroelectric tunneling random access memory. Experiments showed that memory could be written through a top gate voltage, which "flips" the in-plane polarization of the ferroelectric film, and read by a voltage tunneling through an edge without erasing the memory state. Credit: Junwei Liu

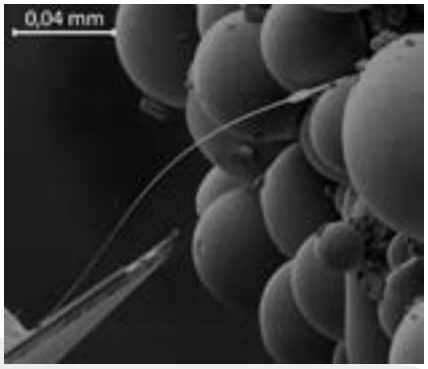
Just as magnetic materials have opposing North and South poles, ferroelectric materials have opposing positive charges and negative charges that exhibit measurable differences in electric potential. Researchers at MIT and colleagues in China recently demonstrated this ferroelectric behavior along the edges of atomically thin tin-tellurium film at room temperature.

Measurements showed the energy gap, or bandgap, of this ultra-thin (2-D) film to be about eight times higher than the bandgap in bulk (3-D) tin-tellurium, with an on/off ratio as high as 3,000, they report July 15 in the journal Science. Their findings hold promise for making random access memory (RAM) devices from this special semiconductor material, which is known as a topological crystalline insulator.

"This discovery is very exciting because usually when you decrease the thickness from the 3-D to 2-D, the phase transition temperature always decreases and therefore could destroy the ferroelectricity. But in this case, the [ferroelectric] phase transition temperature increased. It's quite unusual," explains MIT postdoc Junwei Liu, a first author of the paper. "As far as we know, this might be the first time to observe this very unusual property." MIT assistant professor of physics Liang Fu is one of the paper's senior authors.

These results follow three years of work based on a prediction by Fu, former student Timothy Hsieh...Read More...

MRI machine at the nanoscale breaks world records



NMR microscope, consisting of a thin wire and a small magnetic ball (fake colour purple). The purple ball induces a uniform magnetic field, so that the surrounding atomic nuclei all line up with their axis pointing in the same direction. The researchers send radio waves through their sample, causing some nuclei to flip the other way, and measure how long it takes before they flip back again. Credit: Leiden Institute of Physics

A new nuclear magnetic resonance (NMR) microscope gives researchers an improved instrument to study fundamental physical processes. It also offers new possibilities for medical science—for example, to better study proteins in Alzheimer's patients' brains. The development has been reported in Physical Review Applied.

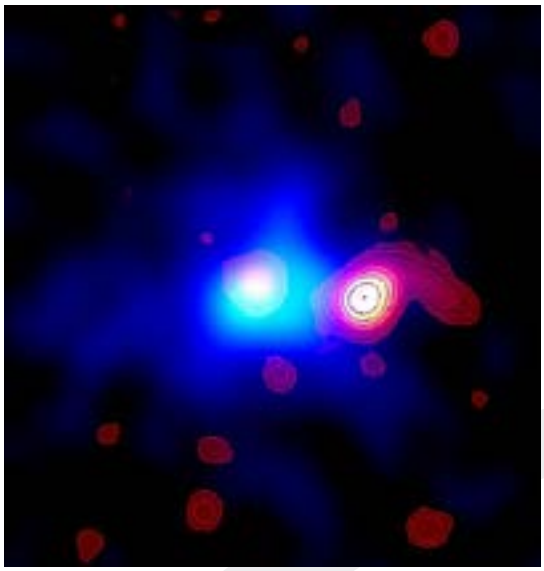
If you get a knee injury, physicians use an MRI machine to look into the joint and determine the problem. The body's atomic nuclei are electrically charged and spin around their axis. Just like small electromagnets, they induce their own magnetic field. By placing the knee in a uniform magnetic field, the nuclei line up with their axis, pointing in the same direction. The MRI machine then sends specific radio waves through the knee, causing some axes to flip. After terminating this signal, those nuclei flip back under excitation of a small radio wave. Those waves reveal the atoms' location, and provide physicians with an accurate image of the knee.

MRI is the medical application of NMR, which is based on the same principle and was invented by physicists to conduct fundamental research on materials. One of the things they study with NMR is the so-called relaxation time. This is the time scale at which the nuclei flip back and it gives a lot of information about a material's properties.

Microscope

To study materials on the smallest of scales, physicists have developed NMR microscopes, with which they study the mechanics behind physical processes at the level of a group of atoms. Now, Leiden Ph.D. students Jelmer Wagenaar and Arthur de Haan have built an NMR microscope, together with principal investigator Tjerk Oosterkamp, that operates at a record temperature of 42 milliKelvin—close to absolute zero. In their research reported ...Read More...

Super-massive and supersonic black hole studied with the Sardinia Radio Telescope



Credit: INAF

Using the brand-new Sardinia Radio Telescope (SRT), a giant parabolic dish of 64 meters diameter, a team of astronomers from the Italian National Institute for Astrophysics (INAF) and the University of Cagliari have produced a detailed image of a super-massive black hole proceeding at high speed towards the core of the distant cluster of galaxies designed as 3C 129. The results are going to be published in the scientific journal Monthly Notices of the Royal Astronomical Society.

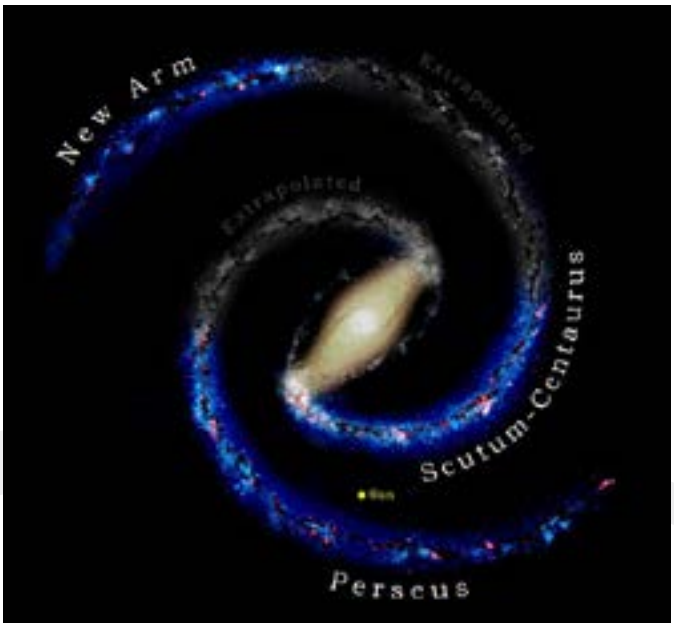
The black hole sits at the center of an elliptical galaxy some at 300 million light years from Earth.

The black hole and its galaxy are in collision course with a nearby galaxy cluster, pulled by the gravitational force generated by the huge concentration of dark matter, galaxies, and hot gas. The radio images reveal that the black hole is actively accreting matter. Part of this material is not falling into the black hole but expelled into two streams of plasma that merge to form a spectacular tail much longer than the size of the galaxy itself.

"The phenomenon is quite likely a jet contrail," says Matteo Murgia researcher at the INAF - Astronomical Observatory of Cagliari, lead author of the study. "In the case of the black hole jets, the 'unburned fuel' consists of a plasma composed by mixture of high-energy electrons and magnetic fields that cools down by emitting radio waves. By comparing the new SRT observations with those performed with other radio telescopes, we were able to obtain for the first time a map of the age of this radio source and to conclude that the black hole is cruising at supersonic speed."

In the Earth's atmosphere the sound speed is about 1,200 km/h, but in the 'atmosphere' of the cluster ...Read More...

Where is Earth in the Milky Way?



The Milky Way's basic structure is believed to involve two main spiral arms emanating from opposite ends of an elongated central bar. Credit: T. Dame

For thousand of years, astronomers and astrologers believed that the Earth was at the center of our Universe. This perception was due in part to the fact that Earth-based observations were complicated by the fact that the Earth is embedded in the Solar System. It was only after many centuries of continued observation and calculations that we discovered that the Earth (and all other bodies in the Solar System) actually orbits the Sun.

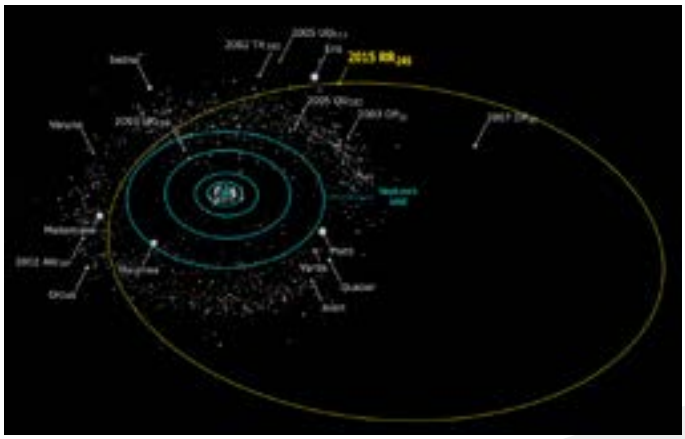
Much the same is true about our Solar System's position within the Milky Way. In truth, we've only been aware of the fact that we are part of a much larger disk of stars that orbits a common center for about a century. And given that we are embedded within it, it has been historically difficult to ascertain our exact position. But thanks to ongoing efforts, astronomers now know where our Sun resides in the galaxy.

Size of the Milky Way:

For starters, the Milky Way is really, really big! Not only does it measure some 100,000-120,000 light-years in diameter and about 1,000 light-years thick, but up to 400 billion stars are located within it (though some estimates think there are even more). Since one light year is about 9.5 x 1012 km (9.5 trillion km) long, the diameter of the Milky Way galaxy is about 9.5 x 1017 to 11.4 x 1017 km, or 9,500 to 11,400 quadrillion km.

It became its current size and shape by eating up other galaxies, and is still doing so today. In fact, the Canis Major Dwarf Galaxy is the closest galaxy to the Milky Way because its stars are currently being ...Read More...

Kuiper Belt's Big, New, Far-Out Object



Observers calculate that Kuiper Belt object 2015 RR245 has an elliptical path that takes 733 years to go around the Sun and carries it from near Neptune's orbit out to 129 astronomical units. Alex Parker / OSSOS team

First spied last year, an object designated 2015 RR245 turns out to be one of the largest and most distant objects yet found orbiting the Sun.

Planetary astronomers have been busy of late. The IAU's Minor Planet Center has tallied 1,491 objects in orbits more distant than Neptune ("transneptunians") and another 501 in the outer solar system that occupy odd, usually quite elliptical orbits ("Centaurs" and "scattered-disk objects"). On average, one more gets added to the list about every 5 days.

But a distant discovery announced two days ago has created heightened interest among Kuiper Belt cognoscenti. Designated 2015 RR245, it's some 64 astronomical units (9½ billion km) from the Sun, more than twice Neptune's distance. And despite appearing just 22nd magnitude, it could be as large as 700 km (450 miles) across.

Observer JJ Kavelaars (National Research Council of Canada) first spotted it last September 9th using the Canada-France-Hawaii Telescope atop Mauna Kea. His observations were part of a larger search effort called the Outer Solar System Origins Survey (OSSOS), which since 2013 has paired CFHT's 3.6-m optics with a sensitive camera called MegaPrime that captures fields 1° square.

But it wasn't until Michele Bannister (University of Victoria) and others took follow-up images in February and again in June that the orbit could calculated with any certainty. It turns out that the mean solar distance (81.3 a.u.) and large orbital large eccentricity (0.59) of 2015 RR245 carries it from Neptune's vicinity out to 128 a.u. (19.2 billion km). One trip around the Sun takes about 730 years. Dynamicists already suspect that the new find might be in an orbital resonance with Neptune. ...Read More...

Mathematical models explain east-west asymmetry of jet lag recovery

File Image

Travelers frequently report experiencing a significantly slower jet lag recovery after an eastward vs. westward flight. While some are quick to dismiss this complaint as being "all in their head," new research suggests it may be caused by the oscillation of a certain type of brain cells.

Circadian rhythms, which govern jet lag recovery, are controlled by the synchronization of many neuronal oscillators within the brain. Brain cells within the hypothalamus—the region of the brain that governs circadian rhythms—undergo daily cycles of activity.

But after a rapid time zone shift, the brain's oscillatory circadian pacemaker cells are incapable of instantly adjusting to a rhythm appropriate to the new time zone.

So a team of University of Maryland researchers decided to explore whether the east-west asymmetry of jet lag could be understood via mathematical models of these oscillations of cells within the brain, and made some interesting discoveries about the dynamics involved, which they report in the journal Chaos, from AIP Publishing.

Akin to cars racing around a circular track, some of the brain's "circadian pacemaker cells" could complete the circuit faster on their own than others. But due to their mutual interactions sharing the track, these cells tend to form a traffic clump and travel around the track as a group.

"In the absence of a controlling influence, say 'a man with a yellow flag,' the clump of cells completes the circuit within a period of time that may not correspond exactly to one day," explained Michelle Girvan, an associate professor of physics at the University of Maryland's Institute for Physical Science and Technology.

Studies have shown that without daily variations of sunlight acting as that "man with the yellow flag," or traffic controller, the brain's circadian pacemaker cells complete their cycle in a time slightly longer than a day.

"Our mathematical model is based on this type of picture," Girvan said. "We start by explicitly modeling the dynamics of a large number of cells, and then use a novel method for simplifying this very large ...Read More...

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