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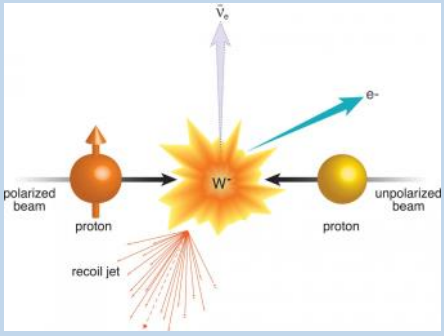
Inside this issue:

A view of the colorful microcosm within a proton

The proton sounds like a simple object, but it's not. Inside, there's a teeming microcosm of quarks and gluons with properties such as spin and "color" charge that contribute to the particle's seemingly simplistic role as a building block of visible matter. By analyzing the particle debris emitted from collisions of polarized protons at the Relativistic Heavy Ion Collider (RHIC), scientists say they've found a new way to glimpse that internal microcosm. They've measured a key effect of the so-called color interaction-the basis for the strong nuclear force that binds quarks within the proton. This new measurement tests, for the first time, theoretical concepts that are essential for mapping the proton's three-dimensional internal structure.

The research, described in a paper to be published as an Editor's Suggestion in Physical Review Letters, is only possible at RHIC, a 2.4-mile circular particle collider that operates as a U.S. Department of Energy (DOE) Office of Science User Facility for nuclear physics research at DOE's Brookhaven National Laboratory. RHIC is unique in that it uses specialized magnets to strategically align the spins of billions of tiny protons so they are mostly pointing in a particular direction as they circulate and collide. ...Read More...



RHIC physicists used collisions of protons with their spins aligned transverse (perpendicular) to their direction of motion (left) with an unpolarized proton beam (right) to search for the effects of the interaction between "like" color …

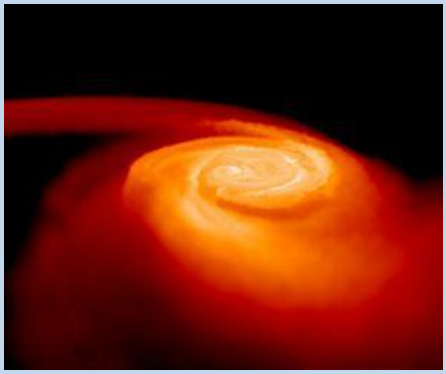
Seeking the origin of gold in the universe

So you think the gold in your ring or watch came from a mine in Africa or Australia? Well, think farther away. Much, much farther. Michigan State University researchers, working with colleagues from Technical University Darmstadt in Germany, are zeroing in on the answer to one of science's most puzzling questions: Where did heavy elements, such as gold, originate?

Currently there are two candidates, neither of which are located on Earth - a supernova, a massive star that, in its old age, collapsed and then catastrophically exploded under its own weight; or a neutron-star merger, in which two of these small yet incredibly massive stars come together and spew out huge amounts of stellar debris.

In a recently published paper in the journal Physical Review Letters, the researchers detail how they are using computer models to come closer to an answer.

"At this time, no one knows the answer," said Witold Nazarewicz, a professor ...Read More...



This illustration depicts two neutron stars colliding. As they merge, the stars eject material into space at 10 to 50 percent the speed of light. Mergers of these kinds of stars are thought to be the source of gold and other heavy metals found throughout the universe. Image courtesy Stephan Rosswog, Jacobs University Bremen.

Flat boron is a superconductor

Rice University scientists have determined that two-dimensional boron is a natural low-temperature superconductor. In fact, it may be the only 2-D material with such potential.

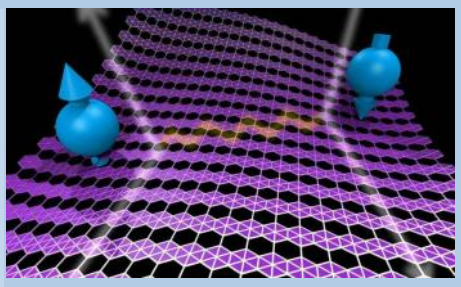
Rice theoretical physicist Boris Yakobson and his co-workers published their calculations that show atomically flat boron is metallic and will transmit electrons with no resistance. The work appears this month in the American Chemical Society journal Nano Letters.

The hitch, as with most superconducting materials, is that it loses its resistivity only when very cold, in this case between 10 and 20 kelvins (roughly, minus-430 degrees Fahrenheit). But for making very small superconducting circuits, it might be the only game in town.

The basic phenomenon of superconductivity has been known for more than 100 years, said Evgeni Penev, a research scientist in the Yakobson group, but had not been tested for its presence in atomically flat boron.

"It's well-known that the material is pretty light because the atomic mass is small," Penev said. "If it's metallic too, these are two major prerequisites for superconductivity. That means at low temperatures, electrons can pair up in a kind of dance in the crystal."

"Lower dimensionality is also helpful," Yakobson said. "It may be the only, or one of very few, two-dimensional metals. So there are three factors that gave the initial motivation for us to pursue the research. Then we just got more and more excited as we got into it." ...Read More...



Electrons with opposite momenta and spins pair up via lattice vibrations at low temperatures in two-dimensional boron and give it superconducting properties, according to new research by theoretical physicists at Rice University. Credit: Evgeni Penev/Rice University

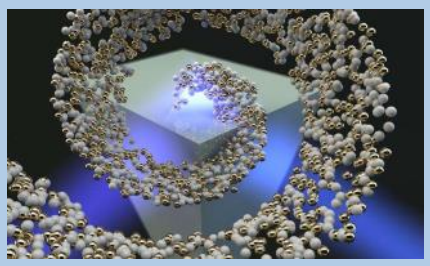
Spinning light waves might be 'locked' for photonics technologies

A newly described property related to the "spin" and momentum of light waves suggests potential practical applications in photonic communications and photonic circuits.

Scientists already knew that light waves have an electric field that can rotate as they propagate, which is known as the polarization property of light, and that light waves carry momentum in their direction of motion. In new findings, researchers have discovered a "spin-momentum locking," meaning, for example, light waves that spin in a counterclockwise direction can only move forward, and vice versa.

"Researchers had noticed intriguing effects related to directional propagation of light coupled to its polarization," said Zubin Jacob, an assistant professor of electrical and computer engineering at Purdue University. "What we have shown is that this is a unique effect related to the spin and momentum of light analogous in many ways to the case of spin-momentum locking which occurs for electrons. We showed there is a very simple rule that governs this spin and momentum locking. And it's a universal property for all optical materials and nanostructures, which makes it potentially very useful for photonic devices. This universality is unique to light and does not occur for electrons."

Findings were detailed in a research paper that appeared in February in the journal Optica, published by the The Optical Society. ...Read More...

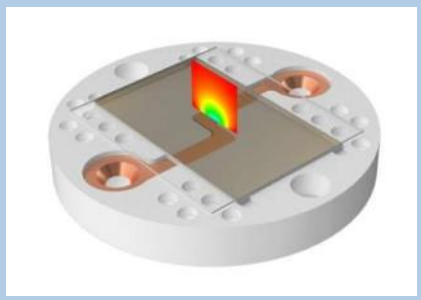


As shown in this artist's rendering, a light beam shining on a glass prism generates evanescent waves and spin-momentum locking, suggesting potential practical applications in photonic communications and photonic circuits. The effect could be probed using nanoparticles. Credit: Todd Van Mechelen, Zubin Jacob

Second quantum revolution a reality with chip-based atomic physics

A University of Oklahoma-led team of physicists believes chip-based atomic physics holds promise to make the second quantum revolution—the engineering of quantum matter with arbitrary precision—a reality. With recent technological advances in fabrication and trapping, hybrid quantum systems are emerging as ideal platforms for a diverse range of studies in quantum control, quantum simulation and computing.

ames P. Shaffer, professor in the Homer L. Dodge Department of Physics and Astronomy, OU College of Arts and Sciences; Jon Sedlacek, OU graduate student; and a team from the University of Nevada, Western Washington University, The United States Naval Academy, Sandia National Laboratories and Harvard-Smithsonian Center for Astrophysics, have published research important for integrating Rydberg atoms into hybrid quantum systems and the fundamental study of atom-surface interactions, as well as applications for electrons bound to a 2D surface. "A convenient surface for application in hybrid quantum systems is quartz because of its extensive use in the semiconductor and optics industries," Sedlacek said. "The surface has been the subject of recent interest as a result of it stability and low surface energy. Mitigating electric fields near 'trapping' surfaces is the holy grail for realizing hybrid quantum systems," added Hossein Sadeghpour, director of the Institute ...Read More..



The image shows a quartz surface above the electrodes used to trap atoms. The color map on the surface shows the electric field amplitude. Credit: University of Oklahoma

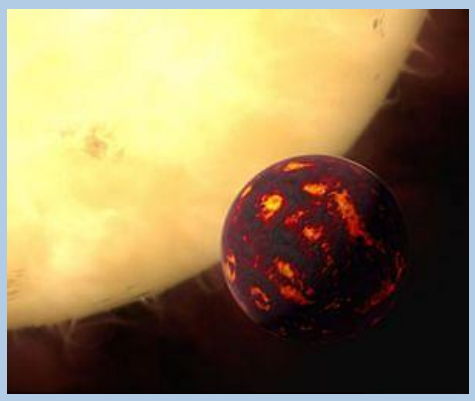
Map of rocky exoplanet reveals a lava world

An international team of astronomers, led by the University of Cambridge, has obtained the most detailed 'fingerprint' of a rocky planet outside our solar system to date, and found a planet of two halves: one that is almost completely molten, and the other which is almost completely solid.

According to the researchers, conditions on the hot side of the planet are so extreme that it may have caused the atmosphere to evaporate, with the result that conditions on the two sides of the planet vary widely: temperatures on the hot side can reach 2500 degrees Celsius, while temperatures on the cool side are around 1100 degrees. The results are reported in the journal Nature.

Using data from NASA's Spitzer Space Telescope, the researchers examined a planet known as 55 Cancri e, which orbits a sun-like star located 40 light years away in the Cancer constellation, and have mapped how conditions on the planet change throughout a complete orbit, the first time this has been accomplished for such a small planet.

55 Cancri e is a 'super Earth': a rocky exoplanet about twice the size and eight times the mass of Earth, and orbits its parent star so closely that a year lasts just 18 hours. The planet is also tidally locked, meaning that it always shows the same face to its parent star, similar to the Moon, so there is a permanent 'day' side and a 'night' side. Since it is among the nearest super Earths whose composition can be studied, 55 Cancri e is among the best candidates for detailed observations of surface ...Read More...

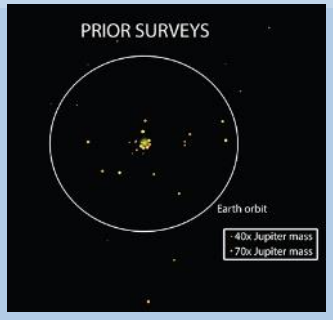


This is an illustration of 55 Cancri e. Image courtesy NASA/JPL-Caltech. Watch a video on the research here.

An oasis in the brown dwarf desert—astronomers surprised, relieved

A new paper published this month in The Astronomical Journal by astronomers from the Sloan Digital Sky Survey (SDSS) reports a wellspring of new brown dwarf stellar companions, throwing cold water on the entire idea of the "brown dwarf desert," the previously mystifying lack of these sub-stellar objects around stars.

Most stars in our Galaxy have a traveling companion. Often, these companions are stars of similar mass, as is the case for our nearest stellar neighbors, the triple star system Alpha Centauri. Our Sun, of course, has companions of its own – the planets of our Solar System. Planetary companions are vastly different from stellar companions: they are much smaller, and they do not shine with their own light created through nuclear fusion. Even the largest planet in our Solar System, Jupiter, would need to be 80 times more massive to even begin to shine this way. Stuck in the middle are "brown dwarfs," much bigger than Jupiter but still too small to be shining stars. These brown dwarfs give off merely a dim glow as they slowly cool. The Universe is full of stars, and now we know that it is full of planets too. Astronomers expected that the Universe would also be teeming ...Read More...



The "before" and "after" comparison of the number of known brown dwarfs orbiting other stars. For each of the 41 close-in brown dwarf companions detected previously, the left panel shows the distance to its host star.

The extremely hot heart of quasar 3C273

Scientists combined telescopes on Earth and in space to learn that this famous quasar has a core temperature hotter than 10 trillion degrees! That's much hotter than formerly thought possible.

By combining signals recorded from radio antennas on Earth and in space – effectively creating a telescope of almost 8-Earth-diameters in size – scientists have, for the first time, gotten a look at fine structure in the radio-emitting regions of quasar 3C273, which was the first quasar known and is still one of the brightest quasars known. The result has been startling, violating a theoretical upper temperature limit. Yuri Kovalev of the Lebedev Physical Institute in Moscow, Russia, commented:

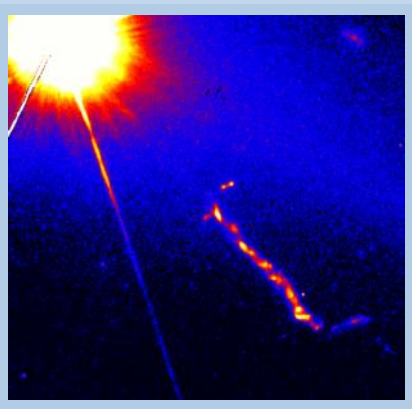
We measure the effective temperature of the quasar core to be hotter than 10 trillion degrees!

This result is very challenging to explain with our current understanding of how relativistic jets of quasars radiate.

These results were published on March 16, 2016 in the the Astrophysical Journal.

A March 29 statement from the Max Planck Institute explained:

Supermassive black holes, containing millions to billions times the mass of our sun, reside at the centers of all massive galaxies. These black holes can drive powerful jets that emit prodigiously, often outshining all the stars in their host galaxies. But there is a limit to how bright these jets can be – when electrons get hotter than about 100 billion degrees, they interact with their own emission to produce X-rays and Gamma-rays and quickly cool down. ...Read More...



Chandra X-Ray Observatory image of quasar 3C273. Its extremely powerful jet probably originates from gas that is falling toward a supermassive black hole. Image via Chandra.

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Global Astronomy Month begins April 1

Click on the picture

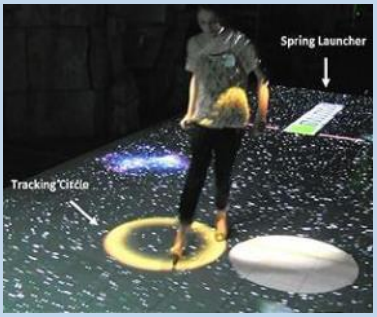
Students learn astrophysics through mixed-reality computer simulation

Had the "learn'd astronomer's" charts and theorems inspired the 19th century writer Walt Whitman as much as strolling under the nighttime sky, Whitman might have become an astrophysicist instead of a star-gazing poet.

Researchers at the University of Illinois hope to inspire greater numbers of young people to become astronomers - or at least to embrace learning science - with a new computer simulation that engages children's bodies as well as their minds in learning about how objects move in space.

MEteor is a mixed-reality computer simulation that teaches middle school students concepts of physics such as planetary motion and gravitational acceleration by having students physically act the part of an asteroid traveling through space.

Mixed-reality simulations such as MEteor merge virtual reality with the physical world so that participants interact physically with digital objects, said curriculum and instruction professor Robb ...Read More...



After launching the asteroid, a participant walks across the simulation field to predict the asteroid's path to the target. The tracking circle shows the participant's position; however, a planet's gravitational field has caused the asteroid to accelerate and curve around the planet. Image courtesy Robb Lindgren.

Graphene layer could allow solar cells to generate power when it rains

Solar energy is on the rise. Many technical advances have made solar cells quite efficient and affordable in recent years. A big disadvantage remains in the fact that solar cells produce no power when it's raining. This may change, however: In the journal Angewandte Chemie, Chinese researchers have now introduced a new approach for making an all-weather solar cell that is triggered by both sunlight and raindrops.

For the conversion of solar energy to electricity, the team from the Ocean University of China (Qingdao) and Yunnan Normal University (Kunming, China) developed a highly efficient dye-sensitized solar cell. In order to allow rain to produce electricity as well, they coated this cell with a whisper-thin film of graphene.

Graphene is a two-dimensional form of carbon in which the atoms are bonded into a honeycomb arrangement. It can readily be prepared by the oxidation, exfoliation, and subsequent reduction of graphite. Graphene is characterized by its unusual electronic properties: It conducts electricity and is rich in electrons that can move freely across the entire layer (delocalized). In aqueous solution, graphene can bind positively charged ions with its electrons (Lewis acid-base interaction). This property is used in graphene-based processes to remove lead ions and organic dyes from solutions.

This phenomenon inspired researchers working with Qunwei Tang to use graphene electrodes to obtain power from the impact of raindrops. Raindrops are not pure water. They contain salts that dissociate into positive and negative ions. The positively charged ions, including sodium, calcium, and ammonium ions, can ...Read More...

Is Planet X to blame for Earth's mass extinctions?

Earlier this year, scientists at Caltech offered the most convincing evidence yet of a ninth planet, Planet X. Now, a retired astrophysicist suggests the hidden planet is responsible for Earth's periodic mass extinctions -- like the disappearance of the dinosaurs.

In a new study published in the journal Monthly Notices of the Royal Astronomical Society, Daniel Whitmire argues that an undiscovered ninth planet triggers disruptive comet showers every 27 million years. It's not the first time Whitmire -- now a math teacher at the University of Arkansas -- has made such a claim in a major scientific journal. In 1985, he offered a similar explanation for mass extinctions in the journal Nature -- then an astrophysicist at the University of Louisiana at Lafayette.

Whitmire and his research partner John Matese pointed to evidence of periodic comet showers in the fossil record dating back some 500 million years.

In 1985, there were two alternative theories for what might trigger major comet showers -- a sister star to the sun, vertical oscillations of the sun as it orbits around the center of the Milky Way. Those theories have since been discredited, while the Planet X theory has acquired legitimacy. The Caltech study estimated Planet X to be approximately 10 times the mass of Earth ...Read More...

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