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Astronomy & Physics Weekly News

Dept. of Applied Physics & Astronomy - University of Sharjah
Compiled by Dr. Ilias Fernini

Top News

IT Support Issam Jami

Designed by Mohamed Bakir

Two stars will merge in 2022 and explode into red fury

STSci

In 2022, there will be a spectacular sky show. Two stars will merge into one, pushing out excess gas into an explosion known as a red nova. At magnitude 2, it will be as bright as Polaris in the sky, and just behind Sirius and Vega in brightness. The collision in the constellation of Cygnus will be visible for up to six months.

That's pretty impressive. What's more impressive: we've never been able to predict a nova before. But Lawrence Molnar, a professor of astronomy and physics at Calvin College, was able to find a pair of oddly behaving stars giving an indication of what might happen.

The objects, termed KIC 9832227, are currently contact binaries. Contact binary refers to two objects that are so close they are currently touching. The object was discovered by Kepler. The expected outcome is a merger between the two stars that will put on quite a show. Because both are low mass stars, the expected temperature is low, with Molnar terming it a "red nova."

So how does Molnar know what will happen? After all, as he puts it, it's "a very specific prediction that can be tested, and a big explosion." He and his team have an example to look at: V1309 Scorpii. First observed in 2008, astronomers were able to watch the light curve as the event unfolded. First, there were a few "booms" in the sky. Then, a spectacular light show unfolded. Using precovery data, astronomers were able to trace back the evolution from 2001 on, giving a big picture of the decade of progression of the event.

How did they know it was a merging star?

"V1309 was (brightening) before the explosion," Molnar said in a press conference at the 229th meeting of the American Astronomical Society. "It isn't doing it today. That's the smoking gun of a merging star."

Using Kepler data, Molnar found that KIC 9832227 fit the lightcurve of V1309 almost perfectly. All radial velocity measurements seem to indicate a contact binary, and by aligning the light curve to the period in ...Read More...

When and How Did the Moon Form?

Artwork of a Mars-sized object colliding into the Earth early in solar system history. Many planetary scientists believe that an impact such as this threw off the debris which eventually formed the Moon. Lynette Cook / Getty Images

New studies offer contrasting scenarios for making the Moon. One argues for a one big splat early in solar-system history; a second envisions a score of lesser blows that built up the Moon over time; and a third suggests water was involved.

Given the trove of lunar samples in hand and the power of modern laboratory analyses, you'd think that by now geochemists should have completely nailed exactly how the Moon formed. But not so — in fact, there's still lots of debate on how Earth formed.

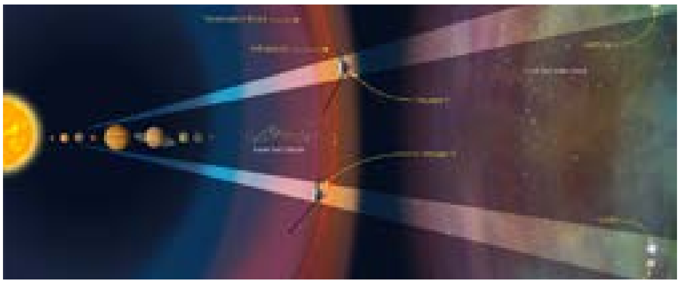
Here's the basic problem: about 30 years ago, dynamicists showed that a body roughly the mass of Mars could have struck Earth a glancing blow and ejected enough debris into orbit to collect into a Moon-size object. In virtually all of those simulations, most of what ends up in the Moon came from the impactor rather than from Earth.

But the Apollo (and Luna) lunar samples, not to mention lunar meteorites, show that the Moon and Earth have very similar compositions. Apart from their lack of iron and extreme lack of water, Moon rocks match Earth's isotopic ratios for the geochemically diagnostic elements titanium, calcium, silicon, and (especially) oxygen and tungsten. This really pins the dynamicists in a corner — only in rare cases, 1% or 2% of the time, do their simulations yield a Moon with an Earthlike composition. There's also a problem of fine-tuning the impact to yield the angular momentum of the current Earth-Moon system.

I've written about possible solutions to these conundrums (or is it "conundra"?) here and here, but no one idea checks all the boxes. One can imagine that the giant impactor and proto-Earth had nearly identical compositions — but statistically and intuitively that seems unlikely.

In January 9th's Nature Geoscience, Israeli researchers Raluca Rufu, Oded Aharonson, and Hagai Perets argue that the notion of a single, giant impact is wrong. Instead, they propose that Earth endured dozens of lesser (but still potent) impacts with object ranging from 1% to 10% of its mass, each of which ejected debris into an orbiting ...Read More...

What Will the Voyager Spacecraft Encounter Next? Hubble Helps Provide a Roadmap



In this illustration, NASA's Hubble Space Telescope is looking along the paths of NASA's Voyager 1 and 2 spacecraft as they journey through the solar system and into interstellar space. Hubble is gazing at two sight lines (the twin cone-shaped features) along each spacecraft's path. The telescope's goal is to help astronomers map interstellar structure along each spacecraft's star-bound route. Each sight line stretches several light-years to nearby stars. Credit: NASA, ESA, and Z. Levy (STScI).

The twin Voyager spacecraft are now making their way through the interstellar medium. Even though they are going where none have gone before, the path ahead it is not completely unknown.

Astronomers are using the Hubble Space Telescope to observe the 'road' ahead for these pioneering spacecraft, to ascertain what various materials may lay along the Voyagers' paths through space.

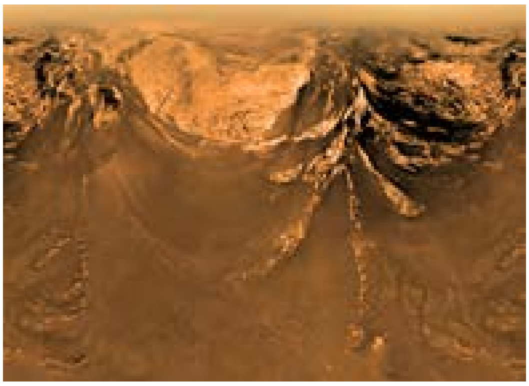
Combining Hubble data with the information the Voyagers are able to gather and send back to Earth, astronomers said a preliminary analysis reveals "a rich, complex interstellar ecology, containing multiple clouds of hydrogen laced with other elements."

"This is a great opportunity to compare data from in situ measurements of the space environment by the Voyager spacecraft and telescopic measurements by Hubble," said Seth Redfield of Wesleyan University, who led the study. "The Voyagers are sampling tiny regions as they plow through space at roughly 38,000 miles per hour. But we have no idea if these small areas are typical or rare. The Hubble observations give us a broader view because the telescope is looking along a longer and wider path. So Hubble gives context to what each Voyager is passing through."

The combined data is also providing new insights into how our Sun travels through interstellar space, and astronomers hope that these combined observations will help them characterize the physical properties of the local interstellar medium.

"Ideally, synthesizing these insights with in situ measurements from Voyager would provide an unprecedented overview of the local interstellar environment," said Hubble team member Julia Zachary of Wesleyan ...Read More...

Huygens: 'Ground Truth' From an Alien Moon



Images taken by Huygens were used to create this view, which shows the probe's perspective from an altitude of about 6 miles (10 kilometers). Image courtesy ESA/NASA/JPL/University of Arizona.

After a two-and-a-half-hour descent, the metallic, saucer-shaped spacecraft came to rest with a thud on a dark floodplain covered in cobbles of water ice, in temperatures hundreds of degrees below freezing. The alien probe worked frantically to collect and transmit images and data about its environs - in mere minutes its mothership would drop below the local horizon, cutting off its link to the home world and silencing its voice forever.

Although it may seem the stuff of science fiction, this scene played out 12 years ago on the surface of Saturn's largest moon, Titan. The "aliens" who built the probe were us. This was the triumphant landing of ESA's Huygens probe.

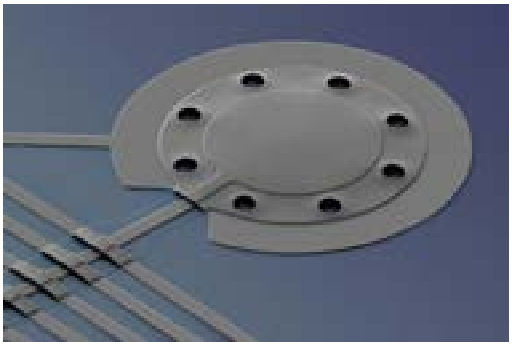
Huygens, a project of the European Space Agency, traveled to Titan as the companion to NASA's Cassini spacecraft, and then separated from its mothership on Dec. 24, 2004, for a 20-day coast toward its destiny at Titan.

The probe sampled Titan's dense, hazy atmosphere as it slowly rotated beneath its parachutes, analyzing the complex organic chemistry and measuring winds. It also took hundreds of images during the descent, revealing bright, rugged highlands that were crosscut by dark drainage channels and steep ravines. The area where the probe touched down was a dark, granular surface, which resembled a dry lakebed.

Thoughts on Huygens

Today the Huygens probe sits silently on the frigid surface of Titan, its mission concluded mere hours after touchdown, while the Cassini spacecraft continues the exploration of Titan from above as part of its mission to learn more about Saturn and its moons. Now in its dramatic final year, the spacecraft's own journey will conclude on September 15 with a fateful plunge into Saturn's atmosphere. ...Read More...

Physicists 'squeeze' light to cool microscopic drum below quantum limit



NIST researchers applied a special form of microwave light to cool a microscopic aluminum drum to an energy level below the generally accepted limit, to just one fifth of a single quantum of energy. The drum, which is 20 micrometers in diameter and 100 nanometers thick, beat10 million times per second while its range of motion fell to nearly zero. Credit: Teufel/NIST

Physicists at the National Institute of Standards and Technology (NIST) have cooled a mechanical object to a temperature lower than previously thought possible, below the so-called "quantum limit."

The new NIST theory and experiments, described in the Jan. 12, 2017, issue of Nature, showed that a microscopic mechanical drum—a vibrating aluminum membrane—could be cooled to less than one-fifth of a single quantum, or packet of energy, lower than ordinarily predicted by quantum physics. The new technique theoretically could be used to cool objects to absolute zero, the temperature at which matter is devoid of nearly all energy and motion, NIST scientists said.

"The colder you can get the drum, the better it is for any application," said NIST physicist John Teufel, who led the experiment. "Sensors would become more sensitive. You can store information longer. If you were using it in a quantum computer, then you would compute without distortion, and you would actually get the answer you want."

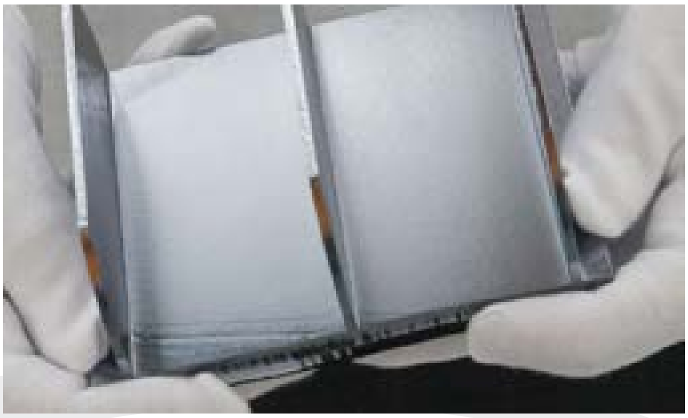
"The results were a complete surprise to experts in the field," Teufel's group leader and co-author José Aumentado said. "It's a very elegant experiment that will certainly have a lot of impact."

The drum, 20 micrometers in diameter and 100 nanometers thick, is embedded in a superconducting circuit designed so that the drum motion influences the microwaves bouncing inside a hollow enclosure known as an electromagnetic cavity. Microwaves are a form of electromagnetic radiation, so they are in effect a form of invisible light, with a longer wavelength and lower frequency than visible light.

The microwave light inside the cavity changes its frequency as needed to match the frequency at which the cavity naturally resonates, or vibrates. This is the cavity's natural "tone," analogous to the musical pitch that a water-filled glass will sound when its rim is rubbed with a finger or its side is struck with a spoon.

NIST scientists previously cooled the quantum drum to its lowest-energy "ground state," or one-third of one quantum. They used a technique called sideband ...Read More...

New method allows for quick, precise measurement of quantum states



Triple Laue (LLL) neutron interferometer. Credit: Vienna University of Technology

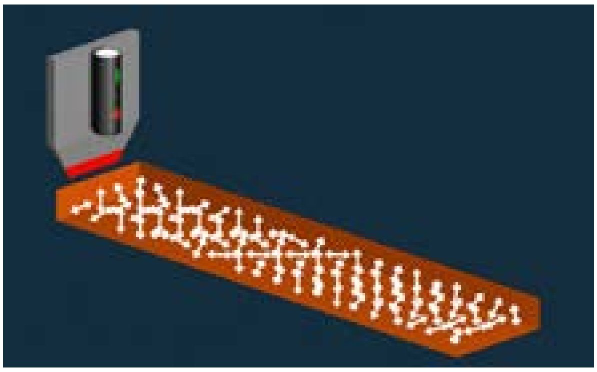
Nuclear spin tomography is an application in medicine. The patient absorbs and re-emits electromagnetic radiation in all directions, which is detected and reconstructed as 3-D images or 2-D slice images. In a fundamental science laboratory, quantum state tomography is the process of completely characterizing the quantum state of an object as it is emitted by its source, before a possible measurement or interaction with the environment takes place.

This technique has become an essential tool in the emerging field of quantum technologies. The theoretical framework of quantum state tomography dates back to the 1970s. Its experimental implementations are nowadays routinely carried out in a wide variety of quantum systems. The basic principle of quantum state tomography is to repeatedly perform measurements from different spatial directions on quantum systems in order to uniquely identify the system's quantum state. This requires a lot of computational post-processing of the measured data to deduce the initial quantum state from the observed measurement results.

Consequently, in 2011, a novel, more direct tomographical method was established to determine the quantum state without the need for post-processing. However, that novel method had a major drawback: It uses minimally disturbing measurements, so-called weak measurements, to determine the system's quantum state. The basic idea behind weak measurements is to gain very little information about the observed system by keeping the disturbance of the measurement process negligible. Usually, making a measurement has a huge impact on a quantum system, causing quantum phenomena like entanglement or interference to vanish irretrievably.

Since the amount of information gained via this procedure is very small, the measurements have to be repeated multiple times—a huge disadvantage of this measurement procedure in practical applications. A research team at the Institute of Atomic and Subatomic ...Read More...

Study uses an electric field to create magnetic properties in nonmagnetic material



In the experiment, the scientists moved the electric tip along the surface and applied a positive voltage. The electric field aligns the spins of the electrons in the nonmagnetic material, and the ordering creates magnetic properties. If the voltage is reversed, the spins once again become disordered and magnetism is lost. The researchers were able to see the changes using X-ray microscopy at the Stanford Synchrotron Radiation Lightsource. Credit: SLAC National Accelerator Laboratory

In a proof-of-concept study published in Nature Physics, researchers drew magnetic squares in a nonmagnetic material with an electrified pen and then "read" this magnetic doodle with X-rays.

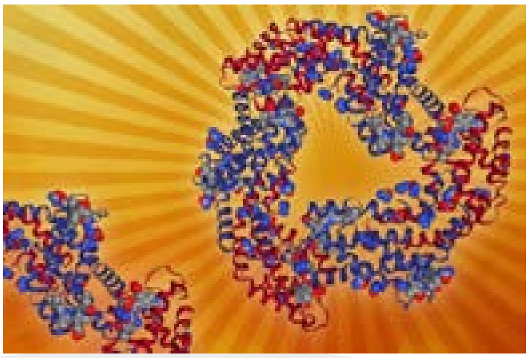
The experiment demonstrated that magnetic properties can be created and annihilated in a nonmagnetic material with precise application of an electric field – something long sought by scientists looking for a better way to store and retrieve information on hard drives and other magnetic memory devices. The research took place at the Department of Energy's SLAC National Accelerator Laboratory and the Korea Advanced Institute of Science and Technology.

"The important thing is that it's reversible. Changing the voltage of the applied electric field demagnetizes the material again," said Hendrik Ohldag, a co-author on the paper and scientist at the lab's Stanford Synchrotron Radiation Lightsource (SSRL), a DOE Office of Science User Facility.

"That means this technique could be used to design new types of memory storage devices with additional layers of information that can be turned on and off with an electric field, rather than the magnetic fields used today," Ohldag said. "This would allow more targeted control, and would be less likely to cause unwanted effects in surrounding magnetic areas."

"This experimental finding is important for overcoming the current difficulties in storage applications," said Jun-Sik Lee, a SLAC staff scientist and one of the leaders of the experiment. "We can now make a definitive statement: This approach can be implemented to design future storage devices." ..Read More...

New model could help scientists design materials for artificial photosynthesis



This photosynthetic antenna consists of several pigments, which collect light energy, and their associated proteins. Credit: MIT News

Plants and other photosynthetic organisms use a wide variety of pigments to absorb different wavelengths of light. MIT researchers have now developed a theoretical model to predict the spectrum of light absorbed by aggregates of these pigments, based on their structure.

The new model could help guide scientists in designing new types of solar cells made of organic materials that efficiently capture light and funnel the light-induced excitation, according to the researchers.

"Understanding the sensitive interplay between the self-assembled pigment superstructure and its electronic, optical, and transport properties is highly desirable for the synthesis of new materials and the design and operation of organic-based devices," says Aurelia Chenu, an MIT postdoc and the lead author of the study, which appeared in Physical Review Letters on Jan. 3.

Photosynthesis, performed by all plants and algae, as well as some types of bacteria, allows organisms to harness energy from sunlight to build sugars and starches. Key to this process is the capture of single photons of light by photosynthetic pigments, and the subsequent transfer of the excitation to the reaction centers, the starting point of chemical conversion. Chlorophyll, which absorbs blue and red light, is the best-known example, but there are many more, such as carotenoids, which absorb blue and green light, as well as others specialized to capture the scarce light available deep in the ocean.

These pigments serve as building blocks that can be arranged in different ways to create structures known as light-harvesting complexes, or antennae, which absorb different wavelengths of light depending on the composition of the pigments and how they are assembled.

"Nature has mastered this art, evolving from a very limited number of building blocks an impressive diversity of photosynthetic light-harvesting complexes, which are highly versatile and efficient," says Chenu, who is ...Read More...

Looking for life in all the right places with the right tool

The researchers created methods based on capillary electrophoresis to process soil or ice samples and detect 17 different amino acids simultaneously. This particular set of amino acids can be found in large quantities in biological and non-living samples, but in certain patterns, could serve as an indicator of life.

Researchers have invented a range of instruments from giant telescopes to rovers to search for life in outer space, but so far, these efforts have yielded no definitive evidence that it exists beyond Earth. Now scientists have developed a new tool that can look for signs of life with 10,000 times more sensitivity than instruments carried on previous spaceflight missions. Their report appears in the ACS journal Analytical Chemistry.

One path to finding life on other planets - or moons - involves looking for signature patterns of amino acids, which are organic molecules that are critical to life on Earth. But looking for these molecules on Mars or other planetary surfaces has been a major challenge.

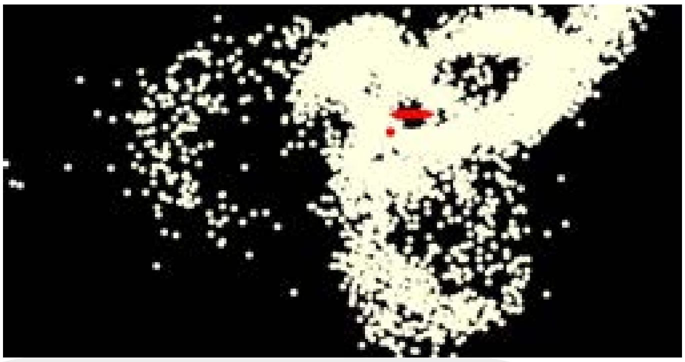
The Curiosity rover exploring Mars attempted to accomplish this, but the rover's experiments to identify organic chemicals in Martian samples were complicated by reactions with other materials in the samples. So Peter A. Willis, Jessica Creamer and Maria F. Mora set out to address this limitation.

The researchers created methods based on capillary electrophoresis to process soil or ice samples and detect 17 different amino acids simultaneously. This particular set of amino acids can be found in large quantities in biological and non-living samples, but in certain patterns, could serve as an indicator of life.

The researchers validated their approach by analyzing samples from California's Mono Lake, an extremely salty body of water acting as a stand-in for briny water on Mars and on some moons. The methods detected the amino acids with 10,000 times the sensitivity of past approaches and identified three different biosignatures that were present.

Willis, a member of the Europa Lander Science Definition Team, says that this type of technology is ...Read More...

Farthest stars in Milky Way might be ripped from another galaxy



In this computer-generated image, a red oval marks the disk of our Milky Way galaxy and a red dot shows the location of the Sagittarius dwarf galaxy. The yellow circles represent stars that have been ripped from the Sagittarius dwarf and flung far across space. Five of the 11 farthest known stars in our galaxy were probably stolen this way. Image courtesy Marion Dierickx / CfA.

The 11 farthest known stars in our galaxy are located about 300,000 light-years from Earth, well outside the Milky Way's spiral disk. New research by Harvard astronomers shows that half of those stars might have been ripped from another galaxy: the Sagittarius dwarf. Moreover, they are members of a lengthy stream of stars extending one million light-years across space, or 10 times the width of our galaxy.

"The star streams that have been mapped so far are like creeks compared to the giant river of stars we predict will be observed eventually," says lead author Marion Dierickx of the Harvard-Smithsonian Center for Astrophysics (CfA).

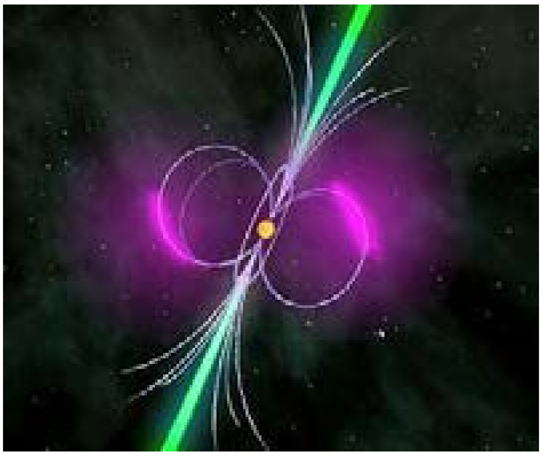
The Sagittarius dwarf is one of dozens of mini-galaxies that surround the Milky Way. Over the age of the universe it made several loops around our galaxy. On each passage, the Milky Way's gravitational tides tugged on the smaller galaxy, pulling it apart like taffy.

Dierickx and her PhD advisor, Harvard theorist Avi Loeb, used computer models to simulate the movements of the Sagittarius dwarf over the past 8 billion years. They varied its initial velocity and angle of approach to the Milky Way to determine what best matched current observations.

"The starting speed and approach angle have a big effect on the orbit, just like the speed and angle of a missile launch affects its trajectory," explains Loeb.

At the beginning of the simulation, the Sagittarius dwarf weighed about 10 billion times the mass of our Sun, or about one percent of the Milky Way's mass. Dierickx's calculations showed that over time, the hapless dwarf lost about a third of its stars and a full nine-tenths of its dark matter. This resulted in three distinct streams of stars that reach as far as one million light-years from the Milky Way's center. They stretch all the way out to ...Read More...

A dozen and one neutron stars



A gamma-ray pulsar is a compact neutron star that accelerates charged particles to relativistic speeds in its extremely strong magnetic field. This process produces gamma radiation (violet) far above the surface of the compact remains of the star, for example, while radio waves (green) are emitted over the magnetic poles in the form of a cone. The rotation moves the emission regions across the terrestrial line of sight, making the pulsar light up periodically in the sky. Image courtesy NASA/Fermi/Cruz de Wilde.

With the help of tens of thousands of volunteers the distributed computing project Einstein@Home discovers 13 new gamma-ray pulsars

An analysis that would have taken more than a thousand years on a single computer has found within one year more than a dozen new rapidly rotating neutron stars in data from the Fermi gamma-ray space telescope. With computing power donated by volunteers from all over the world an international team led by researchers at the Max Planck Institute for Gravitational Physics in Hannover, Germany, searched for tell-tale periodicities in 118 Fermi sources of unknown nature.

In 13 they discovered a rotating neutron star at the heart of the source. While these all are - astronomically speaking - young with ages between tens and hundreds of thousands of years, two are spinning surprisingly slow - slower than any other known gamma-ray pulsar. Another discovery experienced a “glitch”, a sudden change of unknown origin in its otherwise regular rotation.

“We discovered so many new pulsars for three main reasons: the huge computing power provided by Einstein@Home; our invention of novel and more efficient search methods; and the use of newly-improved Fermi-LAT data. These together provided unprecedented sensitivity for our large survey of more than 100 Fermi catalog sources,” says Dr. Colin Clark, lead author of the paper now published in The Astrophysical Journal.

Neutron stars are compact remnants from supernova explosions and consists of exotic, extremely dense matter. They measure about 20 kilometers across and weigh as much as half a million Earths. Because of their strong magnetic fields and fast rotation they emit beamed radio waves and energetic gamma rays similar to a ...Read More...

Simulations suggest Planet Nine may have been a rogue

An artist’s conception of Planet Nine. Credit: Caltech/R. Hurt (IPAC)

Space researchers James Vesper and Paul Mason with New Mexico State University have given a presentation at this year’s American Astronomical Science meeting outlining the results of simulations they have been running to learn more about Planet Nine—a planet that many in the space science community believe exists far beyond Pluto. They presented evidence suggesting that if Planet Nine is out there, it is likely a rogue.

Planet Nine was first predicted to exist just two years ago, when a team of investigators noticed what appeared to be an unknown gravitational influence in the outer solar system. Since then, other researchers have also noticed gravitational influences consistent with a planet on the order of 10 times the size of Earth. Prior research has also suggested that if the planet does exist, it likely orbits the sun at approximately 1000 AU (the Earth resides at 1 AU). In this new effort, the researchers ran 156 computer simulations designed to show what sort of impact such a planet would have on our solar system if it came from somewhere else—a rogue planet that wandered close enough to our sun to be captured by its gravitational pull.

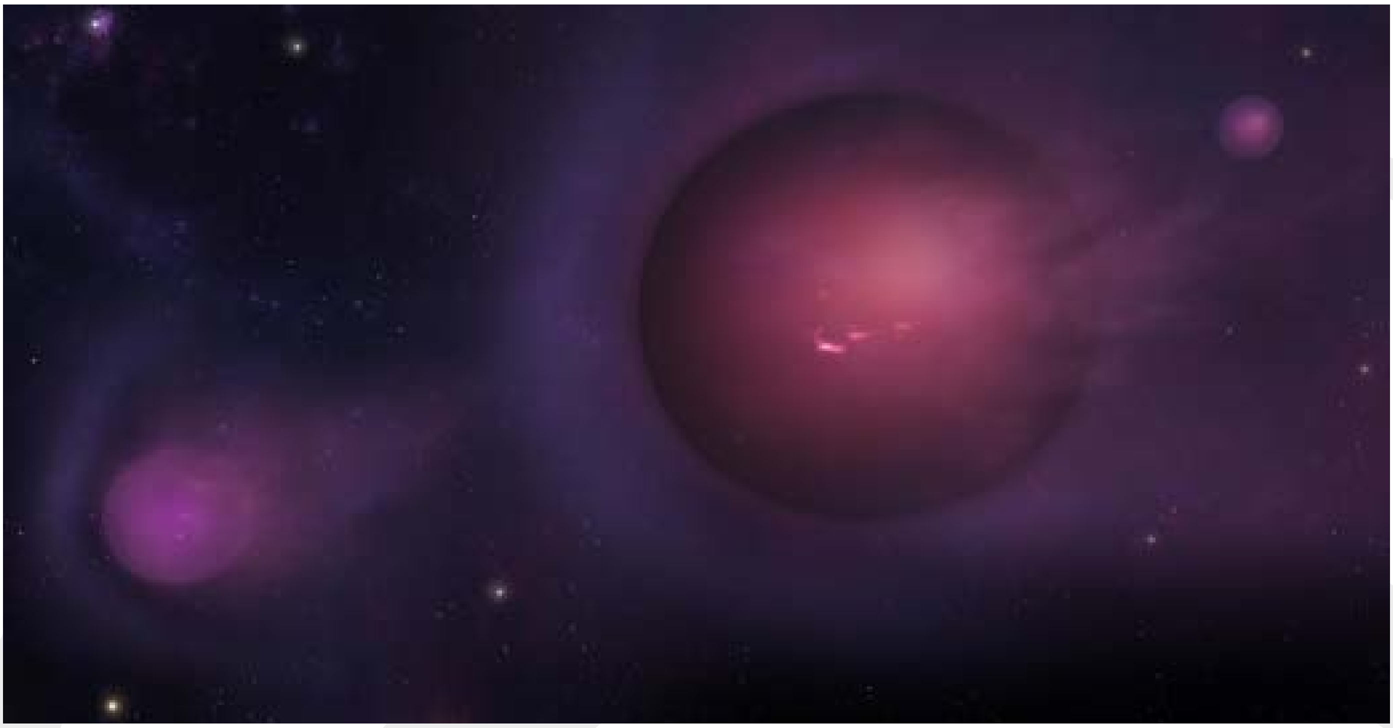
Rogue planets are those that either developed outside of the solar system, or developed in another star system and then somehow escaped. In either event, they travel alone through space.

The researchers report that their simulations showed that 60 percent of the times a rogue planet encountered our solar system, it came in and then left, sometimes taking another smaller planet with it. In 40 percent of cases, however, the rogue was captured and remained in orbit. The simulations also suggested that if such a rogue was captured, it could orbit the sun at the speculated distance and that it was unlikely that a planet any bigger than Neptune has ever entered our solar system—the orderliness of our system suggests it has not been disturbed since the period when the solar system was created. Space scientists have expressed a strong belief in recent months that Planet Nine will be confirmed soon, perhaps as early as next year as more ...Read More...

This Week's Sky at a Glance, Jan. 14 - 20

Jan. 15	Moon at ascending node (14:44)
Jan. 19	Mercury at greatest western elongation 24.1° W
Jan. 20	Third Quarter Moon (02:13)

The Milky Way's black hole is spewing out planet-size 'spitballs'



This artist's conception portrays a collection of planet-mass objects that have been flung out of the galactic center at speeds of 20 million miles per hour (10,000 km/s). These cosmic "spitballs" formed from fragments of a star that was shredded by the galaxy's supermassive black hole. Credit: Mark A. Garlick/CfA

Every few thousand years, an unlucky star wanders too close to the black hole at the center of the Milky Way. The black hole's powerful gravity rips the star apart, sending a long streamer of gas whipping outward. That would seem to be the end of the story, but it's not. New research shows that not only can the gas gather itself into planet-size objects, but those objects then are flung throughout the galaxy in a game of cosmic "spitball."

"A single shredded star can form hundreds of these planet-mass objects. We wondered: Where do they end up? How close do they come to us? We developed a computer code to answer those questions," says lead author Eden Girma, an undergraduate student at Harvard University and a member of the Banneker/Aztlan Institute.

Girma is presenting her findings at a Wednesday poster session and Friday press conference at a meeting of the American Astronomical Society.

Girma's calculations show that the closest of these planet-mass objects might be within a few hundred light-years of Earth. It would have a weight somewhere between Neptune and several Jupiters. It would also glow from the heat of its formation, although not brightly enough to have been detected by previous surveys. Future instruments like the Large Synoptic Survey Telescope and James Webb Space Telescope might spot these far-flung oddities.

She also finds that the vast majority of the planet-mass objects - 95 percent - will leave the galaxy entirely due to their speeds of about 20 million miles per hour (10,000 km/s). Since most other galaxies also have giant black holes at their cores, it's likely that the same process is at work in them. ...Read More...