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Astronomy & Physics Weekly News

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Top News

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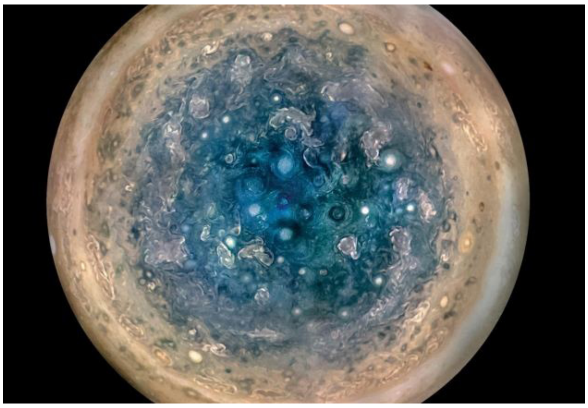
Juno Finds that Jupiter's Gravitational Field is "Askew"



A ring of cyclones swirls around Jupiter's south pole. Credit: NASA/JPL-Caltech/SwRI/MSSS/Betsy Asher Hall/Gervasio Robles

Since it established orbit around Jupiter in July of 2016, the Juno mission has been sending back vital information about the gas giant's atmosphere, magnetic field and weather patterns. With every passing orbit – known as perijoves, which take place every 53 days – the probe has revealed more interesting things about Jupiter, which scientists will rely on to learn more about its formation and evolution.

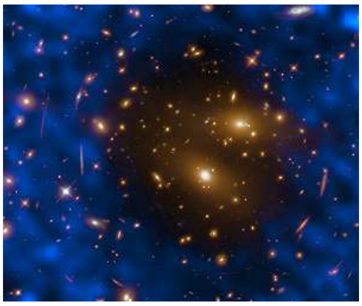
During its latest pass, the probe managed to provide the most detailed look to date of the planet's interior. In so doing, it learned that Jupiter's powerful magnetic field is askew, with different patterns in it's northern and southern hemispheres. These findings were shared on Wednesday. Oct. 18th, at the 48th Meeting of the American Astronomical Society's Division of Planetary Sciencejs in Provo, Utah.

Ever since astronomers began observing Jupiter with powerful telescopes, they have been aware of its swirling, banded appearance. These colorful stripes of orange, brown and white are the result of Jupiter's atmospheric composition, which is largely made up of hydrogen and helium but also contains ammonia crystals and compounds that change color when exposed to sunlight (aka. chromofores).

Until now, researchers have been unclear as to whether or not these bands are confined to a shallow layer of the atmosphere or reach deep into the interior of the planet. Answering this question is one of the main goals of the Juno mission, which has been studying Jupiter's magnetic field to see how it's interior atmosphere works. Based on the latest results, the Juno team has concluded that hydrogen-rich gas is flowing asymmetrically deep in the planet.

These findings were also presented in a study titled Comparing Jupiter interior structure models to Juno gravity measurements and the role of a dilute core, which appeared in the May 28th issue of Geophysical Research Letters. The study was led by Sean Wahl, a grad student from UC Berkeley, and included members ...Read More...

New evidence for dark matter makes it even more exotic



The galaxy clusters that the astronomers studied also act as strong gravitational lenses: they are so massive that they warp spacetime enough to distort light passing through them, like a lens. As a result, they can be used to make a map of dark matter, working out where the center is and then observing how the BCG wobbles around this center.

Galaxy clusters are the largest known structures in the Universe, containing thousands of galaxies and hot gas. But more importantly, they contain the mysterious dark matter, which accounts for 27 percent of all matter and energy. Current models of dark matter predict that galaxy clusters have very dense cores, and those cores contain a very massive galaxy that never moves from the cluster's center.

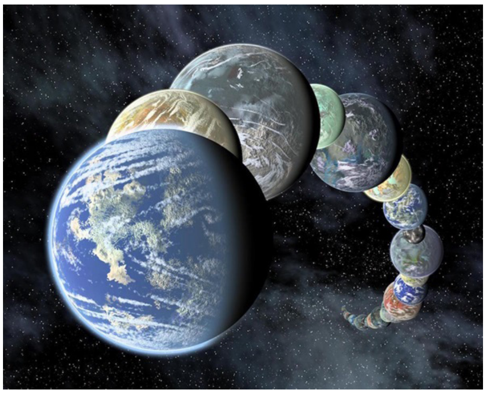
But after studying ten galaxy clusters, David Harvey at EPFL's Laboratory of Astrophysics and his colleagues in France and the UK have discovered that the density is much smaller than predicted, and that the galaxy at the center actually moves.

Every galaxy cluster contains a galaxy that is brighter than the others, aptly named "brightest cluster galaxy" or BCG. Recent evidence from simulations of exotic, non-standard dark matter shows that BCGs actually wobble long after the galaxy cluster has relaxed. This is residual wobbling caused by massive merging of galaxy clusters.

The researchers compared their observations to the predictions from the BAHAMAS suite of cosmological hydro-dynamical simulations finding that the two did not match. According to the Standard Model of dark matter (called "cold dark matter"), this wobbling doesn't exist because the enormous density of dark matter keeps it tightly bound at the center of the galaxy cluster. Therefore, this mismatch suggests the existence of yet-unknown physics that have not been accounted for.

The galaxy clusters that the astronomers studied also act as strong gravitational lenses: they are so massive that they warp spacetime enough to distort light passing through them, like a lens. As a result, they can be used to make a map of dark matter, working out where the center is and then observing how the BCG wobbles around this center. "We found that that the BCGs 'slosh' around at the bottom of the halos," says David Harvey. "This indicates that, instead of a dense region in the center of the galaxy cluster, there is a much shallower ..Read More...

Kronos: The eater of planets



Researchers found evidence that Kronos, a Sun-like star located about 350 light-years away, has gobbled up 15 Earth masses worth of rocky planets. This artist's concept illustrates the diverse range of rocky planets already found in our own galaxy. NASA/JPL-Caltech/R. Hurt (SSC-Caltech)

The Sun has been pretty good to us here on Earth over the last billion or so years. Sure we get the occasional solar storm and some deviations from ideal temperatures. But, by and large, we have a relatively supportive parent star. It's nothing like those poor planets that orbit the star Kronos (HD 240430), located some 350 light-years away.

On September 15, a team of Princeton astronomers posted a paper on the physics pre-print site arXiv.org that argues the star Kronos devoured over a dozen of its rocky inner planets during the course of its 4 billion year lifetime. However, its companion star, Krios (HD 240429), has managed to avoid feasting on its own solid worlds.

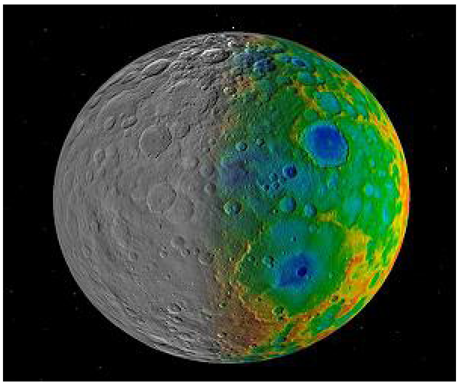
The lead author of the study, Semyeong Oh, explained in a press release that Kronos — named after the mythological Greek Titan who ate his own children — is the most obvious and dramatic example yet of a Sun-like star consuming its own planets. And, "because [Kronos] has a stellar companion to compare it to, it makes the case a little stronger," she said.

Initially, Oh and her team were not trying to find a planet-eating star and its thin twin. Instead, they were using new stellar data collected by the European Space Agency's Gaia spacecraft to simply identify co-moving stars that formed together from the same materials around the same time.

When they went to present their research at a Flatiron Institute meeting, a postdoctoral researcher from Yale University named John Brewer proposed they pool their data with his. "John suggested that maybe we should cross-match my co-moving catalogue with his chemical-abundance catalogue, because its interesting to ask whether they have the same compositions," Oh said. That's when they noticed that Kronos and Krios have vastly different chemical makeups.

While Kronos and Krios have about the same amount of volatile elements — those that are typically found in gas form — Kronos has a strikingly high amount..Read More...

Dawn Finds Possible Ancient Ocean Remnants at Ceres



By modeling how Ceres' crust flows, Fu and colleagues found it is likely a mixture of ice, salts, rock and an additional component believed to be clathrate hydrate. A clathrate hydrate is a cage of water molecules surrounding a gas molecule. This structure is 100 to 1,000 times stronger than water ice, despite having nearly the same density.

Minerals containing water are widespread on Ceres, suggesting the dwarf planet may have had a global ocean in the past. What became of that ocean? Could Ceres still have liquid today? Two new studies from NASA's Dawn mission shed light on these questions.

The Dawn team found that Ceres' crust is a mixture of ice, salts and hydrated materials that were subjected to past and possibly recent geologic activity, and that this crust represents most of that ancient ocean. The second study builds off the first and suggests there is a softer, easily deformable layer beneath Ceres' rigid surface crust, which could be the signature of residual liquid left over from the ocean, too.

"More and more, we are learning that Ceres is a complex, dynamic world that may have hosted a lot of liquid water in the past, and may still have some underground," said Julie Castillo-Rogez, Dawn project scientist and co-author of the studies, based at NASA's Jet Propulsion Laboratory, Pasadena, California.

What's inside Ceres? Gravity will tell.

Landing on Ceres to investigate its interior would be technically challenging and would risk contaminating the dwarf planet. Instead, scientists use Dawn's observations in orbit to measure Ceres' gravity, in order to estimate its composition and interior structure.

The first of the two studies, led by Anton Ermakov, a postdoctoral researcher at JPL, used shape and gravity data measurements from the Dawn mission to determine the internal structure and composition of Ceres. The measurements came from observing the spacecraft's motions with NASA's Deep Space Network to track small changes in the spacecraft's orbit. This study is published in the Journal of Geophysical Research. Ermakov and his colleagues' research supports the possibility that Ceres is geologically active - if not now, then it may have ...Read More...

Bringing the atomic world into full color

This is an example of silicon atoms represented in color.

A French and Japanese research group has developed a new way of visualizing the atomic world by turning data scanned by an atomic force microscope into clear color images. The newly developed method, which enables observation of materials and substances like alloys, semiconductors, and chemical compounds in a relatively short time, holds promise of becoming widely used in the research and development of surfaces and devices.

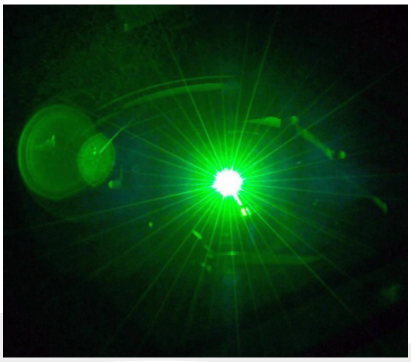
Individual molecules and atoms are much smaller than the wavelengths of light that we can see. Visualizing such tiny structures requires special instruments that often provide black-and-white representations of the positions of atoms. Atomic force microscopes (AFMs) are among the most powerful tools available for probing surfaces at the atomic scale level. A nanoscale tip moving over a surface can not only give all kinds of information about the physical positions of atoms but also give data on their chemical properties and behavior. However, much of this information is lost when the AFM signals are processed.

Now, researchers centered at the University of Tokyo's Institute of Industrial Science (IIS), led by Professor Hideki Kawakatsu, have created a new way of operating AFMs and visualizing the data to extract structural and chemical information into clear, full-color images. These findings were recently published in Applied Physics Letters.

"AFM is an extremely versatile technique and our approach of linking the AFM tip height to the bottom of the frequency curve enabled us to perform measurements at the same time but without the risk of losing information from the surface," study lead author Pierre Etienne Allain, a LIMMS/CNRS-IIS postdoctoral researcher, says.

People often perform AFM measurements by keeping the AFM tip at a fixed height while measuring changes in its vibrations as it interacts with the surface. Alternatively, it is possible to move the AFM tip up and down so that the frequency of the vibrations stays the same. Both these approaches have their advantages, but they also carry disadvantages in that one can be very time consuming, and the other can result in loss of information. ...Read More...

Laser beams for superconductivity: Research sheds light on unexpected physical phenomena



Credit: ORNL

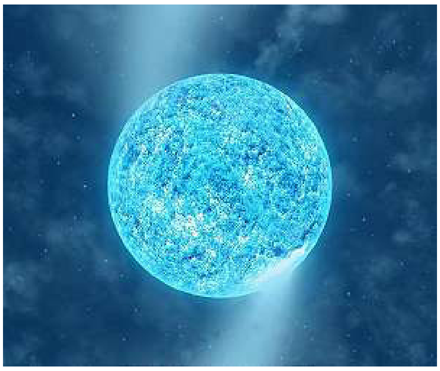
A laser pulse, a special material, an extraordinary property which appears inexplicably. These are the main elements that emerge from a research conducted by an international team, coordinated by Michele Fabrizio and comprising Andrea Nava and Erio Tosatti from SISSA, Claudio Giannetti from the Università Cattolica di Brescia and Antoine Georges from the Collège de France. The results of their study have recently been published in the journal Nature Physics. The key element of the study is a compound of the most symmetrical molecule that exists in Nature, namely C60 bucky-ball, a spherical fullerene.

It is well known that this compound, with the chemical formula K3C60, can behave as a superconductor - that is, conduct without dissipating energy - below a critical temperature of 20 degrees Kelvin, i.e. around -253 degrees Celsius.

It has recently been discovered that K3C60 is capable of transforming into a high-temperature superconductor when struck by an extremely brief laser pulse. This material takes on superconductive properties - albeit extremely briefly - up to a temperature of -73 degrees Centigrade, almost 100 degrees above the critical equilibrium temperature. The research just published by the scientists explains the reason for this mysterious behaviour.

K3C60 is a compound in which purely molecular features coexist alongside metallic properties, a characteristic shared by so-called "strongly correlated" materials. According to the theory developed by the researchers in this study, the laser beam creates a high-energy molecular excitation, yet in order to do so it must absorb heat from the low-energy metallic component, which thus cools. As it is specifically the metallic component involved in conduction, its cooling may lead to a superconductivity phase despite the external temperature is higher than the critical temperature. As the researchers explain: "It is an example of laser cooling, yet with a new operating mechanism which had never been proposed until now. The fact that the laser pulse can transiently change the characteristics of a material is a significant observation. ...Read More...

Spots on supergiant star drive spirals in stellar wind



Artist's impression of the hot massive supergiant Zeta Puppis. The rotation period of the star indicated by the new BRITE observations is 1.78 d, and its spin axis is inclined by (24 +/- 9) degrees with respect to the line of sight.

A Canadian-led international team of astronomers recently discovered that spots on the surface of a supergiant star are driving huge spiral structures in its stellar wind. Their results are published in a recent edition of Monthly Notices of the Royal Astronomical Society.

Massive stars are responsible for producing the heavy elements that make up all life on Earth. At the end of their lives they scatter the material into interstellar space in catastrophic explosions called supernovae - without these dramatic events, our solar system would never have formed.

Zeta Puppis is an evolved massive star known as a 'supergiant'. It is about sixty times more massive than our sun, and seven times hotter at the surface. Massive stars are rare, and usually found in pairs called 'binary systems' or small groups known as 'multiple systems'. Zeta Puppis is special however, because it is a single massive star, moving through space alone, at a velocity of about 60 kilometers per second.

"Imagine an object about sixty times the mass of the Sun, travelling about sixty times faster than a speeding bullet!" the investigators say. Dany Vanbeveren, professor at Vrije Universiteit Brussel, gives a possible explanation as to why the star is travelling so fast; "One theory is that Zeta Puppis has interacted with a binary or a multiple system in the past, and been thrown out into space at an incredible velocity".

Using a network of 'nanosatellites' from the "BRIght Target Explorer" (BRITE) space mission, astronomers monitored the brightness of the surface of Zeta Puppis over a six-month period, and simultaneously monitored the behavior of its stellar wind from several ground-based professional and amateur observatories.

Tahina Ramiaramanantsoa (PhD student at the Universite de Montreal and member of the Centre de Recherche en Astrophysique du Quebec; CRAQ) explains the authors' results: "The observations revealed a repeated.Read More...

Scientists detect comets outside our solar system

An artist's conception of a view from within the Exocomet system KIC 3542116. Image: Danielle Futselaar

Scientists from MIT and other institutions, working closely with amateur astronomers, have spotted the dusty tails of six exocomets - comets outside our solar system - orbiting a faint star 800 light years from Earth.

These cosmic balls of ice and dust, which were about the size of Halley's Comet and traveled about 100,000 miles per hour before they ultimately vaporized, are some of the smallest objects yet found outside our own solar system.

The discovery marks the first time that an object as small as a comet has been detected using transit photometry, a technique by which astronomers observe a star's light for telltale dips in intensity. Such dips signal potential transits, or crossings of planets or other objects in front of a star, which momentarily block a small fraction of its light.

In the case of this new detection, the researchers were able to pick out the comet's tail, or trail of gas and dust, which blocked about one-tenth of 1 percent of the star's light as the comet streaked by.

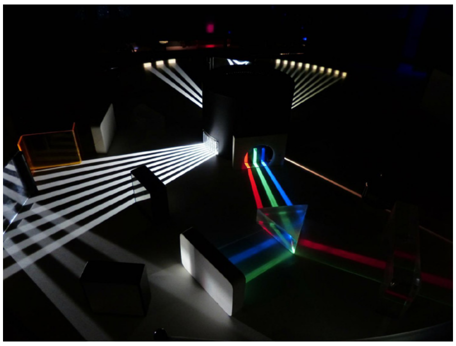
"It's amazing that something several orders of magnitude smaller than the Earth can be detected just by the fact that it's emitting a lot of debris," says Saul Rappaport, professor emeritus of physics in MIT's Kavli Institute for Astrophysics and Space Research. "It's pretty impressive to be able to see something so small, so far away."

Rappaport and his team have published their results this week in the Monthly Notices of the Royal Astronomical Society. The paper's co-authors are Andrew Vanderburg of the Harvard-Smithsonian Center for Astrophysics; several amateur astronomers including Thomas Jacobs of Bellevue, Washington; and researchers from the University of Texas at Austin, NASA's Ames Research Center, and Northeastern University.

"Where few have traveled"

The detection was made using data from NASA's Kepler Space Telescope, a stellar observatory that was launched into space in 2009. For four years, the spacecraft monitored about 200,000 stars for dips in ...Read More....

Reflecting light off satellite backs up Wheeler's quantum theory thought experiment



Credit: CC0 Public Domain

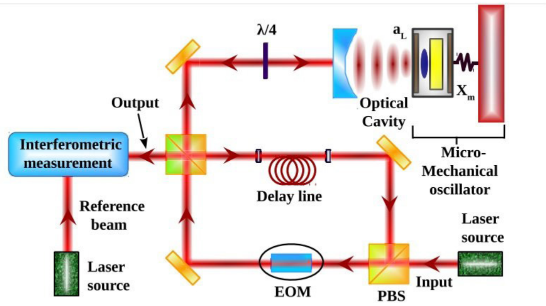
A team of researchers with Università degli Studi di Padova and the Matera Laser Ranging Observatory in Italy has conducted experiments that add credence to John Wheeler's quantum theory thought experiment. In their paper published on the open access site Science Advances, the group describes their experiment and what they believe it showed.

The nature of light has proven to be one of the more difficult problems facing physicists. Nearly a century ago, experiments showed that light behaved like both a particle and a wave, but subsequent experiments seemed to show that light behaved differently depending on how it was tested, and weirdly, seemed to know how the researchers were testing it, changing its behavior as a result.

Back in the late 1970s, physicist Johan Wheeler tossed around a thought experiment in which he asked what would happen if tests allowed researchers to change parameters after a photon was fired, but before it had reached a sensor for testing—would it somehow alter its behavior mid-course? He also considered the possibilities as light from a distant quasar made its way through space, being lensed by gravity. Was it possible that the light could somehow choose to behave as a wave or a particle depending on what scientists here on Earth did in trying to measure it? In this new effort, the team in Italy set out to demonstrate the ideas that Wheeler had proposed—but instead of measuring light from a quasar, they measured light bounced from a satellite back to Earth.

The experiment consisted of shooting a laser beam at a beam splitter, which aimed the beam at a satellite traveling in low Earth orbit, which reflected it back to Earth. But as the light traveled back to Earth, the researchers had time to make a choice whether or not to activate a second beam splitter as the light was en route. Thus, they could test whether the light was able to sense what they were doing and respond accordingly. The team reports that the light behaved just as Wheeler had predicted—demonstrating either particle-like or wave-like behavior, depending on the behavior of those studying it. ...Read More...

Physicists propose test of quantum gravity using current technology



Proposed experimental setup to probe the effects of noncommutative structure. Credit: S. Dey et al. ©2017 Nuclear Physics B

Physicists have proposed a way to test quantum gravity that, in principle, could be performed by a laser-based, table-top experiment using currently available technology. Although a theory of quantum gravity would overcome one of the biggest challenges in modern physics by unifying general relativity and quantum mechanics, currently physicists have no way of testing any proposed theories of quantum gravity.

Now a team of seven physicists from various countries, S. Dey, A. Bhat, D. Momeni, M. Faizal, A. F. Ali, T. K. Dey, and A. Rehman, have come up with a novel way to experimentally test quantum gravity using a laser-based experiment. They have published a paper on their proposed test in a recent issue of Nuclear Physics B.

One reason why testing quantum gravity is so challenging is that its effects appear only at very high-energy scales and their corresponding tiny length scales. These extreme scales, which are very near the Planck scale, are roughly 15 orders of magnitude beyond those accessible by the Large Hadron Collider (LHC), by far the world's highest-energy experiment.

In order to address these challenges, the physicists took a completely different approach to reaching Planck-scale energies and lengths, which is by measuring the effects of a property called noncommutativity.

Many proposed theories of quantum gravity, including loop quantum gravity and string theory, are noncommutative theories, in which spacetime geometry is noncommutative. In this framework, certain parameters have noncommutative relations, a concept that is closely related to the idea of complementary variables in Heisenberg's uncertainty principle. One of the consequences of a noncommutative spacetime is that there are no singularities, which has implications for other areas of cosmology, such as the big bang and black holes.

With their proposed test, the physicists' goal is to find experimental evidence supporting the idea that spacetime does indeed have a noncommutative ...Read More....

Unconfirmed exomoon could be unlike any of those in our solar system

Credit: CC0 Public Domain

René Heller, a space scientist with the Maxx Planck Institute for Solar System Research has uploaded a paper to the arXiv preprint server offering possible attributes for the still-unconfirmed exomoon Kepler 1625 b-i. He suggests that if the exomoon does truly exist, it is probably unlike any of the moons in our solar system, which suggests that theories about the origins of moons might have to be expanded.

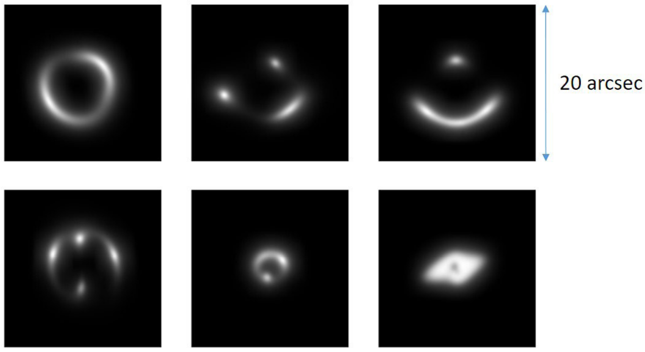
Back in July, a team of researchers led by Alex Teachey and David Kipping of Columbia University announced that they had found possible evidence of a moon circling a planet outside of our solar system. If the exomoon turns out to be real, it would mark the first time that one has ever been discovered. News of a possible exomoon sighting has set off speculation regarding what it might be like.

In his paper, Heller describes the research he has conducted studying the Kepler data that suggests the possible exomoon. He notes the data is not strong enough to pin down a size for the moon, suggesting it could be anywhere from approximately the size of the Earth to the size of Saturn. He does not suggest the data proves the existence of an exomoon, but does offer a wild guess on the size of the exomoon if it is there—approximately the size of Neptune.

A moon that size does not exist in our own solar system, of course, which suggests that if one that large does exist elsewhere, it likely formed in ways that are not described by one of the three main moon creation theories—something impacting a planet, assimilation of material orbiting a planet, or a passing object captured by a planet's gravity. This means that if the exomoon is confirmed and its size and makeup can be determined, it is likely that there will be a race between space groups around the world to find a theory explaining its existence.

Teachey and Kipping have been vocal about their view that researchers should wait to see if the exomoon exists before conducting research or creating theories, lest it all be in vain. They have their sights set firmly on this weekend, when the Hubble Space Telescope will be aimed at the system, possibly confirming or ruling out its existence. ...Read More...

Artificial intelligence finds 56 new gravitational lens candidates



This picture shows a sample of the handmade photos of gravitational lenses that the astronomers used to train their neural network. Credit: Enrico Petrillo, University of Groningen

A group of astronomers from the universities of Groningen, Naples and Bonn has developed a method that finds gravitational lenses in enormous piles of observations. The method is based on the same artificial intelligence algorithm that Google, Facebook and Tesla have been using in the last years. The researchers published their method and 56 new gravitational lens candidates in the November issue of Monthly Notices of the Royal Astronomical Society.

When a galaxy is hidden behind another galaxy, we can sometimes see the hidden one around the front system. This phenomenon is called a gravitational lens, because it emerges from Einstein's general relativity theory which says that mass can bend light. Astronomers search for gravitational lenses because they help in the research of dark matter.

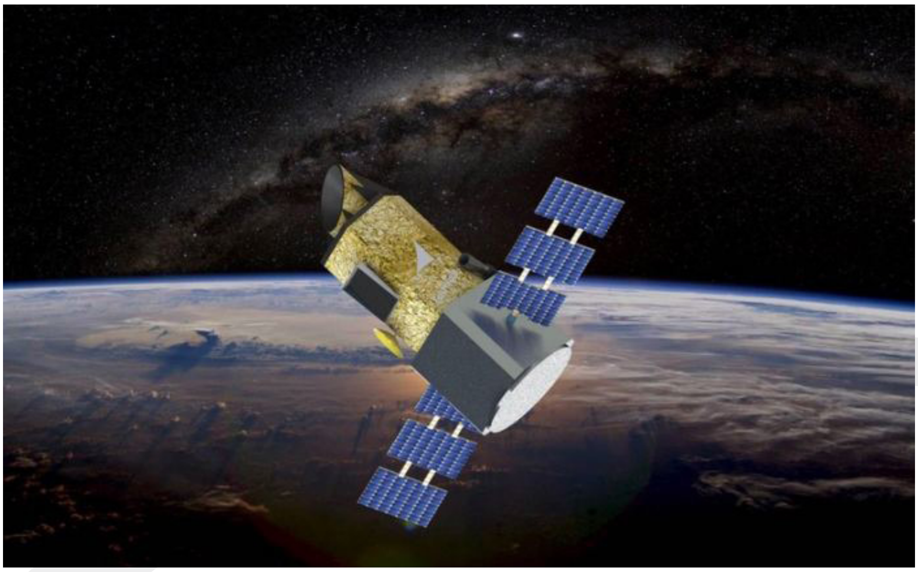
The hunt for gravitational lenses is painstaking. Astronomers have to sort thousands of images. They are assisted by enthusiastic volunteers around the world. So far, the search was more or less in line with the availability of new images. But thanks to new observations with special telescopes that reflect large sections of the sky, millions of images are added. Humans cannot keep up with that pace.

To tackle the growing amount of images, the astronomers have used so-called 'convolutional neural networks'. Google employed such neural networks to win a match of Go against the world champion. Facebook uses them to recognize what is in the images of your timeline. And Tesla has been developing self-driving cars thanks to neural networks.

The astronomers trained the neural network using millions of homemade images of gravitational lenses. Then they confronted the network with millions of images from a small patch of the sky. That patch had a surface area of 255 square degrees. That's just over half a percent of the sky. ...Read More...

Special Read:

Project Blue: Building a Space Telescope that Could Directly Observe Planets Around Alpha Centauri



Artist's concept of the Project Blue space telescope, which the organization hopes to use to spot exoplanets in Alpha Centauri beginning in 2020. Credit: projectblue.org

In the past few decades, thousands of exoplanets have been discovered in neighboring star systems. In fact, as of October 1st, 2017, some 3,671 exoplanets have been confirmed in 2,751 systems, with 616 systems having more than one planet. Unfortunately, the vast majority of these have been detected using indirect means, ranging from Gravitational Microlensing to Transit Photometry and the Radial Velocity Method.

What's more, we have been unable to study these planets up close because the necessary instruments do not yet exist. Project Blue, a consortium of scientists, universities and institutions, is looking to change that. Recently, they launched a crowdfunding campaign through Indiegogo to finance the development of a space telescope that will start looking for exoplanets in the Alpha Centauri system by 2021.

In addition to its commercial and academic partners, Project Blue is a collaborative effort between the BoldlyGo Institute, Mission Centaur, the SETI Institute, and the University of Massachusetts Lowell. It is steered by a Science & Technology Advisory Committee (STAC) composed of science and technology experts who are dedicated to space exploration and the search for life in our Universe.

To accomplish their goal of directly studying exoplanets, Project Blue is seeking to leverage recent changes in space exploration, which include improved instruments and methodology, the rate at which exoplanet have been discovered in recent years, and increased collaboration between the private and public sector. As SETI Institute President and CEO Bill Diamond explained in a recent SETI press statement:

"Project Blue builds on recent research in seeking to show that Earth is not alone in the cosmos as a planet capable of supporting life, and wouldn't it be amazing to see such a planet in our nearest neighboring star system? This is the fundamental reason we search." ...Read More...

This Week's Sky at a Glance: Oct. 28 - Nov. 03, 2017

Oct 28	First Quarter Moon 02:22
Oct 29	Moon at descending node 10:41
Nov 02	Venus 3.3⁰ N of Spica (06:10)