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Astronomy & Physics Weekly News

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Top News

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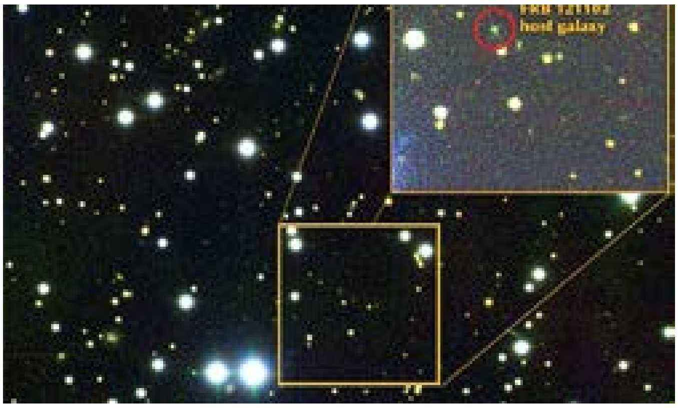
Home galaxy found for fast radio burst



Visible-light image of the host galaxy of the fast radio burst FRB 121102. Image via NRAO/ Gemini Observatory/AURA/NSF/ NRC.

Astronomers meeting this week in Grapevine, Texas for the 229th meeting of the American Astronomical Society are abuzz with the news that a sporadically repeating, milliseconds-long fast radio burst has now been identified with a precise location in the sky. They see a dwarf galaxy at this sky location and believe the burst is emanating from this little galaxy, which is some 3 billion light-years away. Their work is published January 4, 2017 in the peer-reviewed journal Nature. Astronomer Shami Chatterjee of Cornell University is the first author.

It's exciting, because it's the first time they've been able to identify a fast radio burst's home galaxy. And it's surprising, because the galaxy is a dwarf and not a bigger, more glamorous galaxy. Astronomers say the new information rules out several suggested explanations for the cause of fast radio bursts, which were first discovered in 2007, in archived data taken in 2001 by the Parkes radio telescope in Australia.

Sarah Burke-Spolaor, an astronomer at the National Radio Astronomy Observatory in Socorro, New Mexico, and West Virginia University in Morgantown was quoted in Nature as saying:

This detection has really broken open the gates of a new realm of science and discovery.

There are only 18 known fast radio bursts, and they are very mysterious. Known to astronomers as FRBs, these bursts pack an energetic punch, but are short-lived, only milliseconds in length. The National Radio Astronomy Observatory explained in a statement:

All were discovered using single-dish radio telescopes that are unable to narrow down the object's location with enough precision to allow other observatories to identify its host environment or to find it at other wavelengths. Unlike all the others, however, one [fast radio burst], discovered in November of 2012 at the Arecibo Observatory in Puerto Rico, has recurred numerous times. ..Read More...

Venerable Radio Telescope Sets Standard for Universal Constant

Illustration only.

About 150 hours of observing time on the 1,000-ft radio telescope at the Arecibo Observatory in Puerto Rico over the course of the last several years have been devoted to determining whether the most fundamental constant in physics really is constant.

The target is the so-called fine structure constant, usually known as alpha, which describes the electromagnetic interaction between elementary charged particles. Its value is crucial to understanding the nature of atomic spectra, which in turn allows astronomers to measure the radial velocity of galaxies from which these spectral lines are observed.

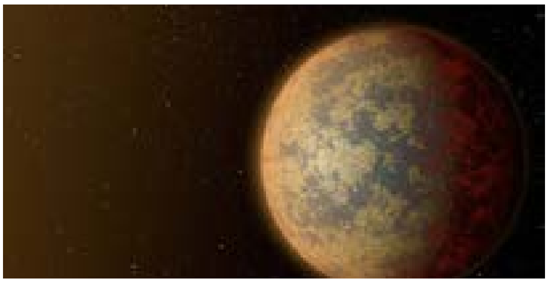
Such observations led to the discovery that galaxies appear to be receding from one another with velocities that increase with the distance between them. This is a manifestation of the expansion of the universe following the Big Bang.

Our current model for the expansion and acceleration of the universe depends on the assumption that neither alpha nor mu, the proton-to-electron mass ratio, have changed with time. This assumption is key to our current understanding of the age of the universe. But what if alpha does change with time? Then our knowledge of the distance between galaxies or the age of the universe would have to be revised.

The Arecibo telescope has recently been used to set a new limit on how constant things are. While the latest data suggest that there may be a small change in alpha, it is still too early to be sure. With an uncertainty on the measurement of about one part in a million, it is not yet time to celebrate, nor to heave a sigh of relief.

The Arecibo observations have been carried out by Nissim Kanekar and Jayaram Chengalur of the National Center for Radio Astrophysics in India, and Tapasi Ghosh, a Universities Space Research Association (USRA) astronomer at the Arecibo Observatory. Their experiment makes use of a marvelous concordance of cosmic circumstances involving quasar PKS 1413+135, which is located about 3 billion light-years away. In front of that quasar, and probably surrounding its radio-bright nucleus, is a cloud of OH molecules ...Read More...

Could Garnet Planets be Habitable?



A new study based on data from Sloan Digital Sky Survey (SDSS) shows how certain exoplanets are dominated by minerals like olivine and garnet. Credit: NASA

The hunt for exoplanet has revealed some very interesting things about our Universe. In addition to the many gas giants and "Super-Jupiters" discovered by mission like Kepler, there have also been the many exoplanet candidate that comparable in size and structure to Earth. But while these bodies may be terrestrial (i.e. composed of minerals and rocky material) this does not mean that they are "Earth-like".

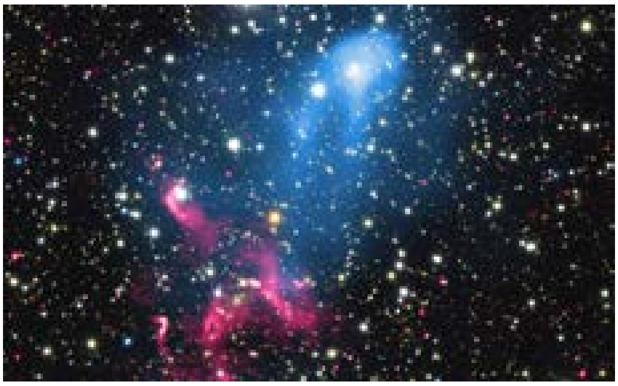
For example, what kind of minerals go into a rocky planet? And what could these particular compositions mean for the planet's geological activity, which is intrinsic to planetary evolution? According to new study produced by a team of astronomers and geophysicists, the composition of an exoplanet depends on the chemical composition of its star – which can have serious implications for its habitability.

The findings of this study were presented at the 229th Meeting of the American Astronomical Society (AAS), which will be taking place from Jan. 3rd to Jan. 7th. During an afternoon presentation – titled "Between a Rock and a Hard Place: Can Garnet Planets Be Habitable?" – Johanna Teske (an astronomer from the Carnegie Institute of Science) showed how different types of stars can produce vastly different types of planets.

Using the Apache Point Observatory Galactic Evolution Experiment (APOGEE), which is part of the Sloan Digital Sky Survey (SDSS) Telescope at Apache Point Observatory, they examined spectrographic information obtained from 90 star systems – which were also observed by the Kepler Mission. These systems are of particular interest to exoplanet hunters because they have been shown to contain rocky planets.

As Teske explained during the course of the presentation, this information could help scientists to place further constraints on what it takes for a planet to be habitable. "[O]ur study combines new observations of stars with new models of planetary interiors," she said. "We want to better understand the diversity of small, rocky exoplanet composition and structure — how likely are they to have plate tectonics or magnetic fields?" ...Read More...

Chandra Spots Two Cosmic Heavy-Hitters at Once



Composite view of the collision between galaxy clusters Abell 3411 and Abell 3412 . Credit: X-ray: NASA/CXC/SAO/R. van Weeren et al./NAOJ/Subaru

This week, the 229th Meeting of the American Astronomical Society (AAS) kicked off in Grapevine, Texas. Between Monday and Friday (January 3rd to January 7th), attendees will be hearing presentations by researchers and scientists from several different fields as they share the latest discoveries in astronomy and Earth science.

One of the highlights so far this week was a presentation from NASA's Chandra X-ray Observatory, which took place on the morning of Wednesday, January 5th. In the course of the presentation, an international research team showed some stunning images of two of the most powerful cosmic forces seen together for the first time – a supermassive black hole and two massive galaxy clusters colliding.

The galaxy clusters are known as Abell 3411 and Abell 3412, which are located about two billion light years from Earth. Both of these clusters are quite massive, each possessing the equivalent of about a quadrillion times the mass of our Sun. Needless to say, the collision of these objects produced quite the shockwave, which included the release of hot gas and energetic particles.

This was made all the more impressive thanks to the presence of a supermassive black hole (SMBH) at the center of one of the galaxy clusters. As the team described in their paper – titled "The Case for Electron Re-Acceleration at Galaxy Cluster Shocks" – the galactic collision produced a nebulous outburst of x-rays (shown above), which were produced when hot clouds of gas from one cluster plowed through the hot gas clouds of the other.

Meanwhile, the inflowing gas was accelerated outward into a jet-like stream, thanks to the powerful electromagnetic fields of the SMBH. These particles were accelerated even further when they got swept up by the shock waves produced by the collision of the galactic clusters and their massive gas clouds. These streams were detected thanks to the burst of radio waves they released as a result.

By seeing these two major events happening at the same time in the same place, the research team ...Read More...

Cryogenic test probes Einstein's equivalence principle, general relativity, and spacetime 'foam'

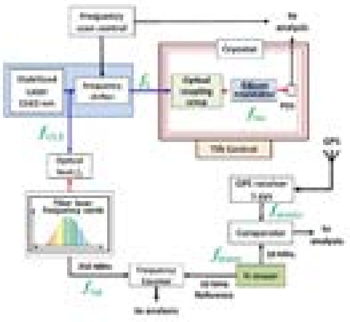


Illustration of the experimental set-up, in which scientists attempted to detect any change in the length of a cryogenic silicon resonator. They detected no change, in support of the equivalence principle. Credit: Wiens et al. ©2016 American Physical Society

Physicists have performed a test designed to investigate the effects of the expansion of the universe—hoping to answer questions such as "does the expansion of the universe affect laboratory experiments?", "might this expansion change the lengths of solid objects and the time measured by atomic clocks differently, in violation of Einstein's equivalence principle?", and "does spacetime have a foam-like structure that slightly changes the speed of photons over time?", an idea that could shed light on the connection between general relativity and quantum gravity.

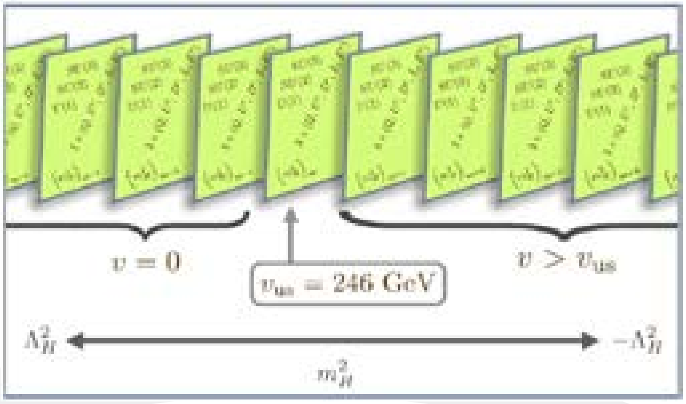
In their study published in Physical Review Letters, E. Wiens, A.Yu. Nevsky, and S. Schiller at Heinrich Heine Universität Düsseldorf in Germany have used a cryogenic resonator to make some of the most precise measurements yet on the length stability of a solid object. Overall, the results provide further confirmation of Einstein's equivalence principle, which is the foundation on which the theory of general relativity is based on. And in agreement with previous experiments, the researchers found no evidence of spacetime foam.

"It is not easy to imagine ways of testing for consequences of the expansion of the universe that occur in the laboratory (as opposed to studying distant galaxies)," Schiller told Phys.org. "Our approach is one way to perform such a test. That we have not observed any effect is consistent with the prediction of general relativity."

Over the course of five months, the researchers made daily measurements of the resonator's length by measuring the frequency of an electromagnetic wave trapped within it. In order to suppress all thermal motion, the researchers operated the resonator at cryogenic temperature (1.5 degrees above absolute zero). In addition, external disturbances, such as tilt, irradiation by laser light, and some other effects that might destabilize the device were kept as small as possible.

To measure the resonator's frequency, the researchers used an atomic clock. Any change in frequency would indicate that the change in length of the resonator differs from the change in time measured by the atomic clock. The experiment detected virtually no change in frequency, or "zero drift"—more precisely, the mean ...Read More...

Multiple copies of the Standard Model could solve the hierarchy problem



In the proposed model, the universe contains multiple sectors, each of which is governed by its own version of the Standard Model with its own Higgs vacuum expectation value. The sector with the smallest non-zero vacuum expectation value contains our copy of the Standard Model. Credit: Arkani-Hamed et al. ©2016 American Physical Society

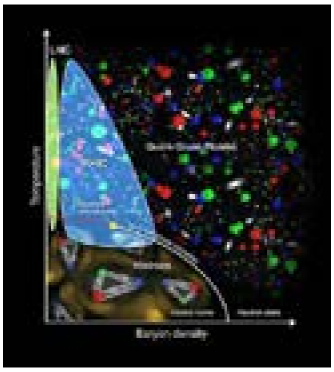
One of the unanswered questions in particle physics is the hierarchy problem, which has implications for understanding why some of the fundamental forces are so much stronger than others. The strengths of the forces are determined by the masses of their corresponding force-carrying particles (bosons), and these masses in turn are determined by the Higgs field, as measured by the Higgs vacuum expectation value.

So the hierarchy problem is often stated as a problem with the Higgs field: specifically, why is the Higgs vacuum expectation value so much smaller than the largest energy scales in the universe, in particular the scale at which gravity (by far the weakest of the forces) becomes strong? Reconciling this apparent discrepancy would impact physicists' understanding of particle physics at the most fundamental level.

"The hierarchy problem is one of the deepest questions in particle physics, and almost every one of its known solutions corresponds to a different vision of the universe," Raffaele Tito D'Agnolo, a physicist at Princeton, told Phys.org. "Identifying the correct answer will not just solve a conceptual puzzle, but will change the way we think about particle physics."

In a new paper published in Physical Review Letters, D'Agnolo and his coauthors have proposed a solution to the hierarchy problem that involves multiple (up to 1016) copies of the Standard Model, each with a different Higgs vacuum expectation value. In this model, the universe consists of many sectors, each of which is governed by its own version of the Standard Model with its own Higgs vacuum expectation value. Our sector is the one with the smallest nonzero value. If, in the very early universe, all sectors had comparable temperatures and seemingly ...Read More...

Theory provides roadmap in quest for quark soup 'critical point'



The STAR collaboration's exploration of the "nuclear phase diagram" shows signs of a sharp border—a first-order phase transition—between the hadrons that make up ordinary atomic nuclei and the quark-gluon plasma (QGP) of the early universe when the QGP is produced at relatively low energies/temperatures. The data may also suggest a possible critical point, where the type of transition changes from the abrupt, first-order kind to a continuous crossover at higher energies. Credit: Brookhaven National Laboratory

Thanks to a new development in nuclear physics theory, scientists exploring expanding fireballs that mimic the early universe have new signs to look for as they map out the transition from primordial plasma to matter as we know it. The theory work, described in a paper recently published as an Editor's Suggestion in Physical Review Letters (PRL), identifies key patterns that would be proof of the existence of a so-called "critical point" in the transition among different phases of nuclear matter. Like the freezing and boiling points that delineate various phases of water—liquid, solid ice, and steam—the points nuclear physicists seek to identify will help them understand fundamental properties of the fabric of our universe.

Nuclear physicists create the fireballs by colliding ordinary nuclei—made of protons and neutrons—in an "atom smasher" called the Relativistic Heavy Ion Collider (RHIC), a U.S. Department of Energy Office of Science User Facility at Brookhaven National Laboratory. The subatomic smash-ups generate temperatures measuring trillions of degrees, hot enough to "melt" the protons and neutrons and release their inner building blocks—quarks and gluons. The collider essentially turns back the clock to recreate the "quark-gluon plasma" (QGP) that existed just after the Big Bang. By tracking the particles that emerge from the fireballs, scientists can learn about nuclear phase transitions—both the melting and how the quarks and gluons "freeze out" as they did at the dawn of time to form the visible matter of today's world.

"We want to understand the properties of QGP," said nuclear theorist Raju Venugopalan, one of the authors on the new paper. "We don't know how those properties might be used, but 100 years ago, we didn't know how we'd use the collective properties of electrons, which ...Read More...

Devices that convert heat into electricity

This is a scanning transmission electron microscope image of a nickel-platinum composite material created at The Ohio State University. At left, the image is overlaid with false-color maps of elements in the material, including platinum (red), nickel (green) and oxygen (blue). Image courtesy Isabel Boona, OSU Center for Electron Microscopy and Analysis; Left image prepared by Renee Ripley. Courtesy of The Ohio State University.

The same researchers who pioneered the use of a quantum mechanical effect to convert heat into electricity have figured out how to make their technique work in a form more suitable to industry.

In Nature Communications, engineers from The Ohio State University describe how they used magnetism on a composite of nickel and platinum to amplify the voltage output 10 times or more - not in a thin film, as they had done previously, but in a thicker piece of material that more closely resembles components for future electronic devices.

Many electrical and mechanical devices, such as car engines, produce heat as a byproduct of their normal operation. It's called "waste heat," and its existence is required by the fundamental laws of thermodynamics, explained study co-author Stephen Boona.

But a growing area of research called solid-state thermoelectrics aims to capture that waste heat inside specially designed materials to generate power and increase overall energy efficiency.

"Over half of the energy we use is wasted and enters the atmosphere as heat," said Boona, a postdoctoral researcher at Ohio State. "Solid-state thermoelectrics can help us recover some of that energy. These devices have no moving parts, don't wear out, are robust and require no maintenance. Unfortunately, to date, they are also too expensive and not quite efficient enough to warrant widespread use. We're working to change that."

In 2012, the same Ohio State research group, led by Joseph Heremans, demonstrated that magnetic fields could boost a quantum mechanical effect called the spin Seebeck effect, and in turn boost the voltage output of thin films made from exotic nano-structured materials from a few microvolts to a few millivolts. ...Read More...

NASA Announces Missions to Explore Early Solar System

An artist's conception of the Lucy spacecraft (left) flying by the Trojan Eurybates, and Psyche (Right) Psyche, the first mission to the metal world 16 Psyche. Credits: SwRI and SSL/Peter Rubin

It's a New Year, with new challenges and new opportunities! And NASA, looking to kick things off, has announced the two new missions that will be launching in the coming decade. These robotic missions, named Lucy and Psyche, are intended to help us understand the history of the early Solar System, and will deploy starting in 2021 and 2023, respectively.

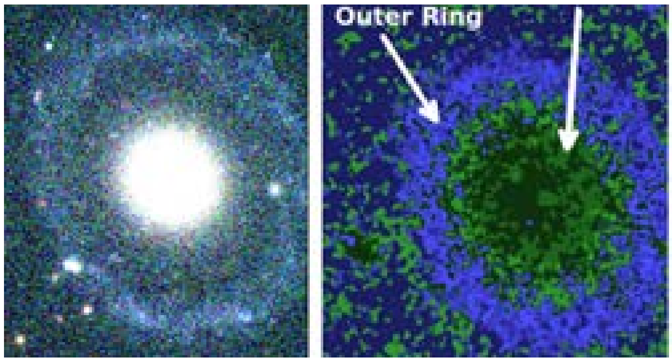
While Lucy's mission is to explore one of Jupiter's Trojan asteroids, Psyche will explore a metal asteroid known as 16 Psyche. And between the two of them, it is hoped that they will answer some enduring questions about planetary formation and how the Solar System came to be. More than that, these mission represent historic firsts for NASA and human space exploration.

NASA's Discovery Program, of which Lucy and Psyche are part, was created in 1992 to compliment their larger "flagship" programs. By bringing scientists and engineers together to design missions, the Discovery Program's focus has been to maximize scientific research by creating many smaller missions that have shorter development periods and require less in the way of operational resources.

The Lucy mission is scheduled to launch in October of 2021, and is expected to arrive at its first destination (a Main Belt asteroid) in 2025. It will then set course for Jupiter's Trojans, a group of asteroids that are trapped by Jupiter's gravity and share its orbit. These asteroids are thought to be relics of the early Solar System; and between 2027 and 2033, Lucy will study six of them.

In addition to being the first mission to explore Jupiter's Trojan population, Lucy is also of historic importance because of the number of asteroids it will visit. Throughout the course of its mission, it is will investigate six Trojans, which is the total number of Main Belt asteroids that have been studied to date. The nature of these six asteroids is also expected to tell us much about the early history of the Solar System. ...Read More...

Researchers get first look at new, extremely rare galaxy



The left panel shows a false-color image of PGC 1000714. The right panel shows a B-I color index map that reveals both the outer ring (blue) and diffuse inner ring (light green). Credit: Ryan Beauchemin

Approximately 359 million light-years away from Earth, there is a galaxy with an innocuous name (PGC 1000714) that doesn't look quite like anything astronomers have observed before. New research provides a first description of a well-defined elliptical-like core surrounded by two circular rings—a galaxy that appears to belong to a class of rarely observed, Hoag-type galaxies. This work was done by scientists at the University of Minnesota Duluth and the North Carolina Museum of Natural Sciences.

"Less than 0.1% of all observed galaxies are Hoag-type galaxies," says Burcin Mutlu-Pakdil, lead author of a paper on this work and a graduate student at the Minnesota Institute for Astrophysics, University of Minnesota Twin Cities and University of Minnesota Duluth. Hoag-type galaxies are round cores surrounded by a circular ring, with nothing visibly connecting them. The majority of observed galaxies are disc-shaped like our own Milky Way. Galaxies with unusual appearances give astronomers unique insights into how galaxies are formed and change.

The researchers collected multi-waveband images of the galaxy, which is only easily observable in the Southern Hemisphere, using a large diameter telescope in the Chilean mountains. These images were used to determine the ages of the two main features of the galaxy, the outer ring and the central body.

While the researchers found a blue and young (0.13 billion years) outer ring, surrounding a red and older (5.5 billion years) central core, they were surprised to uncover evidence for second inner ring around the central body. To document this second ring, researchers took their images and subtracted out a model of the core. This allowed them to observe and measure the obscured, second inner ring structure.

"We've observed galaxies with a blue ring around a central red body before, the most well-known of these is Hoag's object. However, the unique feature of this galaxy is what appears to be an older diffuse red inner ring," ...Read More...

Observations cast new light on cosmic microwave background

The suspended support platform of radio receivers at Arecibo Observatory in Puerto Rico. Credit: USRA

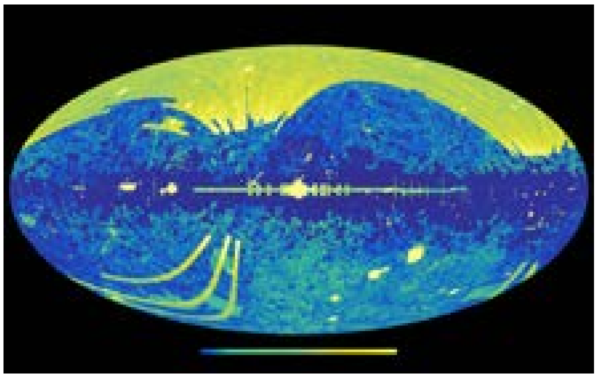
Arecibo Observatory observations of galactic neutral hydrogen structure confirm the discovery of an unexpected contribution to the measurements of the cosmic microwave background observed by the WMAP and Planck spacecraft. An accurate understanding of the foreground (galactic) sources of radiation observed by these two spacecraft is essential for extracting information about the small-scale structure in the cosmic microwave background believed to be indicative of events in the early universe.

The new source of radiation in the 22 to 100 GHz range observed by WMAP and Planck appears to be emission from cold electrons (known as free-free emission). While cosmologists have corrected for this type of radiation from hot electrons associated with galactic nebulae where the source temperatures are thousands of degrees, the new model requires electron temperatures more like a few 100 K.

The spectrum of the small-scale features observed by WMAP and Planck in this frequency range is very nearly flat—a finding consistent with the sources being associated with the Big Bang. At first glance it appears that the spectrum expected from the emission by cold galactic electrons, which exist throughout interstellar space, would be far too steep to fit the data. However, if the sources of emission have a small angular size compared with the beam width used in the WMAP and Planck spacecraft, the signals they record would be diluted. The beam widths increase with lower frequency, and the net result of this "beam dilution" is to produce an apparently flat spectrum in the 22 to 100 GHz range.

"It was the beam dilution that was the key insight," noted Dr. Gerrit Verschuur, astronomer emeritus at the Arecibo Observatory and lead author on the paper. "Emission from an unresolved source could mimic the flat spectrum observed by WMAP and Planck." The model invoking the emission from cold electrons not only gives ...Read More...

How far away is that galaxy? Vast catalog has answers



This graphic shows all the cosmic light sources in the sky that are included in the NASA/IPAC Extragalactic Database (NED), an online repository containing information on over 100 million galaxies. Credit: NASA/JPL-Caltech

A team of researchers has compiled a special catalog to help astronomers figure out the true distances to tens of thousands of galaxies beyond our own Milky Way.

The catalog, called NED-D, is a critical resource, not only for studying these galaxies, but also for determining the distances to billions of other galaxies strewn throughout the universe. As the catalog continues to grow, astronomers can increasingly rely on it for ever-greater precision in calculating both how big the universe is and how fast it is expanding. NED-D is part of the NASA/IPAC Extragalactic Database (NED), an online repository containing information on more than 100 million galaxies.

"We're thrilled to present this catalog of distances to galaxies as a valuable resource to the astronomical community," said Ian Steer, NED team member, curator of NED-D, and lead author of a new report about the database appearing in The Astronomical Journal. "Learning a cosmic object's distance is key to understanding its properties."

Steer and colleagues presented the paper this week at the 229th meeting of the American Astronomical Society in Grapevine, Texas.

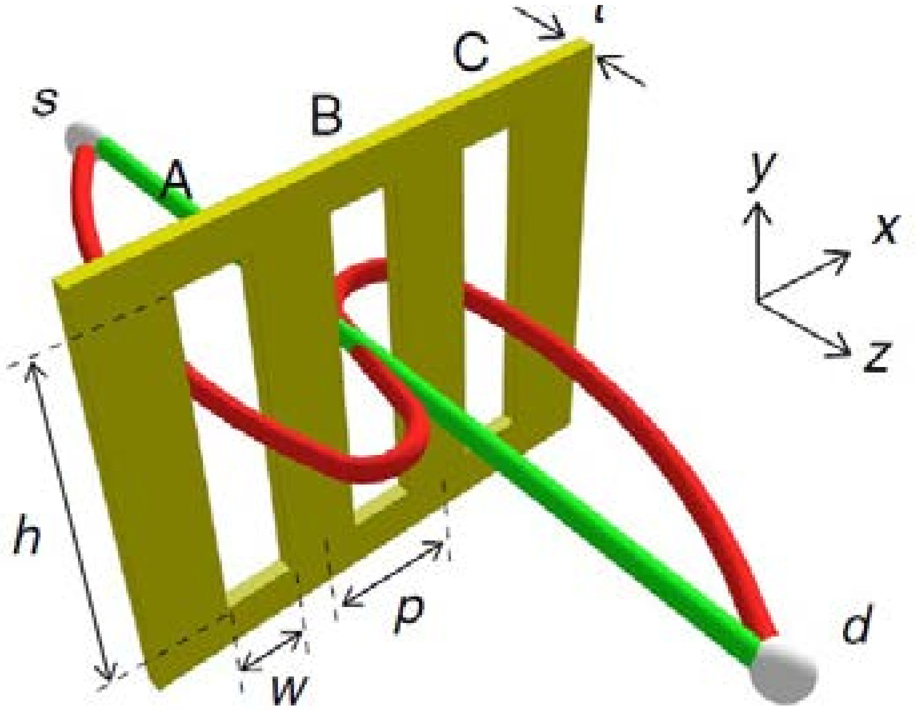
Since other galaxies are extremely far away, there's no tape measure long enough to measure their distances from us. Instead, astronomers rely on extremely bright objects, such as Type La supernovae and pulsating stars called Cepheids variables, as indicators of distance. To calculate how far away a distant galaxy is, scientists use known mathematical relationships between distance and other properties of objects, such as their total emitted energy. More objects useful for these calculations have emerged in recent years. NED-D has revealed that there are now more than six dozen different indicators used to estimate such distances.

NED-D began as a small database pulled together in 2005 by Steer. He began serving at NED the following year to build out the database, poring over ...Read More...

This Week's Sky at a Glance - Jan. 07 - 13

Jan. 09 Aldebaran 0.4° S of Moon (18:07)
Jan. 10 Moon at perigee 10:07 (363242 km)
Jan. 12 Venus at greatest eastern elongation 47.1° E
Jan. 12 Full Moon (15:33)

Physicists detect exotic looped trajectories of light in three-slit experiment



The red path shows an exotic looped trajectory of light through a three-slit structure, which was observed for the first time in the new study. Credit: Magaña-Loaiza et al. Nature Communications

Physicists have performed a variation of the famous 200-year-old double-slit experiment that, for the first time, involves "exotic looped trajectories" of photons. These photons travel forward through one slit, then loop around and travel back through another slit, and then sometimes loop around again and travel forward through a third slit. Interestingly, the contribution of these looped trajectories to the overall interference pattern leads to an apparent deviation from the usual form of the superposition principle. This apparent deviation can be understood as an incorrect application of the superposition principle—once the additional interference between looped and straight trajectories is accounted for, the superposition can be correctly applied.

The team of physicists, led by Omar S. Magaña-Loaiza and Israel De Leon, has published a paper on the new experiment in a recent issue of Nature Communications.

Loops of light

"Our work is the first experimental observation of looped trajectories," De Leon told Phys.org. "Looped trajectories are extremely difficult to detect because of their low probability of occurrence. Previously, researchers had suggested that these exotic trajectories could exist but failed to observe them." To increase the probability of the occurrence of looped trajectories, the researchers designed a three-slit structure that supports surface plasmons, which the scientists describe as "strongly confined electromagnetic fields that can exist at the surface of metals." ...Read More...