Astronomy & Physics Weekly News

Dept. of Applied Physics & Astronomy - University of Sharjah
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Top News

VLA, ALMA team up to give first look at birthplaces of most current stars

CERN scientists get the first glance of the innards of anti-matter 2

Electron-photon small-talk could have big impact on quantum computing

Best of Last Year—The top Phys.org articles of 2016 3

PANIC Lander to Revolutionize Asteroid Research

Festive nebulae light up Milky Way Galaxy satellite 4

Avalanche statistics suggest Tabby's star is near a continuous phase transition

New antimatter breakthrough to help illuminate mysteries of the Big Bang 5

Still no violation of Lorentz symmetry, despite strongest test yet

Devices that convert heat into electricity one step closer to reality 6

The hidden inferno inside your laser pointer

Famous red star Betelgeuse is spinning faster than expected; may have swallowed a companion 100,000 years ago 7

SCASS ACTIVITIES:

Astronomy Camp Arabic - Dec. 25 - 28

This Week's Sky at a Glance, Dec. 24-30

IT Support Issam Jami
Designed by Mohamed Bakir

VLA, ALMA team up to give first look at birthplaces of most current stars

Radio/Optical combination images of distant galaxies as seen with NSF's Very Large Array and NASA's Hubble Space Telescope. Their distances from Earth are indicated in the top set of images. Below, the same images, without labels. Image courtesy K. Trisupatsilp, NRAO/AUI/NSF, NASA.

Astronomers have gotten their first look at exactly where most of today's stars were born. To do so, they used the National Science Foundation's Karl G. Jansky Very Large Array (VLA) and the Atacama Large Millimeter/submillimeter Array (ALMA) to look at distant galaxies seen as they were some 10 billion years ago.

At that time, the Universe was experiencing its peak rate of star formation. Most stars in the present Universe were born then.

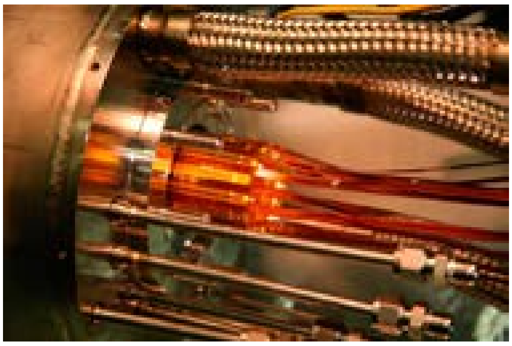
"We knew that galaxies in that era were forming stars prolifically, but we didn't know what those galaxies looked like, because they are shrouded in so much dust that almost no visible light escapes them," said Wiphu Rujopakam, of the Kavli Institute for the Physics and Mathematics of the Universe at the University of Tokyo and Chulalongkorn University in Bangkok, who was lead author on the research paper.

Radio waves, unlike visible light, can get through the dust. However, in order to reveal the details of such distant - and faint - galaxies, the astronomers had to make the most sensitive images ever made with the VLA.

The new observations, using the VLA and ALMA, have answered longstanding questions about just what mechanisms were responsible for the bulk of star formation in those galaxies. They found that intense star formation in the galaxies they studied most frequently occured throughout the galaxies, as opposed to much smaller regions in present-day galaxies with similar high star-formation rates.

The astronomers used the VLA and ALMA to study galaxies in the Hubble Ultra Deep Field, a small area of sky observed since 2003 with NASA's Hubble Space Telescope (HST). The HST made very long exposures ..Read More...

CERN scientists get the first glance of the innards of anti-matter



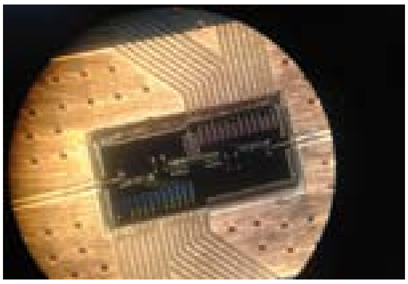
CERN

Antimatter is more than a science fiction concept that allows engineers to power the Enterprise. It's an actual – albeit small – constituent of our universe. While antimatter is rare, it can exist under the right conditions. Information about the way antimatter behaves provides a powerful tool for testing the Standard Model of particle physics we currently use to understand the forces that govern the way particles behave.

Antimatter was first predicted by British physicist Paul Dirac in 1928. He proposed that every particle of matter should have a corresponding antiparticle. These antiparticles are identical to their particle counterparts in every way except for charge. For example, the antimatter counterpart to the negatively-charged electron is the positively-charged antielectron, also called the positron. When matter and antimatter meet, they annihilate each other and leave only energy behind. The Big Bang should have created matter and antimatter in equal amounts, but today, our universe is dominated by matter, with very little antimatter present. Understanding why this asymmetry exists would be a significant step towards understanding the origin and evolution of our universe. However, naturally-occurring antimatter is often immediately destroyed when it encounters the universe's abundant matter. Today, particle physicists can routinely create antimatter for study at the CERN Antiproton Decelerator facility, which has led to several new breakthroughs in the characterization of antimatter.

In a recently-published Nature article, CERN's ALPHA collaboration has announced the very first measurement of a spectral line in an antihydrogen atom. This result, which was over 20 years in the making, was achieved using a laser to observe the 1S-2S transition in antihydrogen. To within experimental limits, the ALPHA collaboration's results show that this transition is identical in both hydrogen and antihydrogen atoms – a condition required by the Standard Model. If these transitions were different, it would essentially break our current understanding of physics. The 1S-2S transition is one of many that contribute to hydrogen's spectrum. A spectrum is created when electrons that have been excited by radiation "fall" from a higher energy level inside an atom to a lower one. This process releases energy at precise ...Read More...

Electron-photon small-talk could have big impact on quantum computing



A Princeton University-led team has built a device that advances silicon-based quantum computers, which when built will be able to solve problems beyond the capabilities of everyday computers. The device isolates an electron so that can pass its quantum information to a photon, which can then act as a messenger to carry the information to other electrons to form the circuits of the computer. Credit: Princeton University

In a step that brings silicon-based quantum computers closer to reality, researchers at Princeton University have built a device in which a single electron can pass its quantum information to a particle of light. The particle of light, or photon, can then act as a messenger to carry the information to other electrons, creating connections that form the circuits of a quantum computer.

The research, published in the journal Science and conducted at Princeton and HRL Laboratories in Malibu, California, represents a more than five-year effort to build a robust capability for an electron to talk to a photon, said Jason Petta, a Princeton professor of physics.

"Just like in human interactions, to have good communication a number of things need to work out—it helps to speak the same language and so forth," Petta said. "We are able to bring the energy of the electronic state into resonance with the light particle, so that the two can talk to each other."

The discovery will help the researchers use light to link individual electrons, which act as the bits, or smallest units of data, in a quantum computer. Quantum computers are advanced devices that, when realized, will be able to perform advanced calculations using tiny particles such as electrons, which follow quantum rules rather than the physical laws of the everyday world.

Each bit in an everyday computer can have a value of a 0 or a 1. Quantum bits—known as qubits—can be in a state of 0, 1, or both a 0 and a 1 simultaneously. This superposition, as it is known, enables quantum computers to tackle complex questions that today's computers cannot solve.

Simple quantum computers have already been made using trapped ions and superconductors, but technical challenges have slowed the development of silicon-based quantum devices. Silicon is a highly attractive material because it is inexpensive and is already widely used ...Read More...

Best of Last Year—The top Phys.org articles of 2016

"If confirmed by further experiments, this discovery of a possible fifth force would completely change our understanding of the universe," says UCI professor of physics & astronomy Jonathan Feng, including what holds together galaxies such as this spiral one, called NGC 6814. Credit: ESA/Hubble & NASA; Acknowledgement: Judy Schmidt

It has been another great year for physics as a team at the University of California, Irvine confirmed the possible discovery of a fifth force of nature—an unknown subatomic particle that, if proven to exist, could change how scientists view their understanding of the universe.

Also making headlines was work done by a team with members from Trinity College Dublin's School of Physics and the CRANN Institute, Trinity College—they discovered a new form of light which, if future tests confirm its existence, could change how physicists view the fundamental nature of light itself. And a team with members from the University of California, Santa Barbara and Microsoft Station Q found evidence that suggested time crystals might exist after all.

Also, Verlinde's new theory of gravity passed the first test in experiments conducted by Leiden University astronomer Margot Brouwer through measuring the distribution of gravity around more than 33,000 galaxies. And Erik Verlinde with the University of Amsterdam and the Delta Institute for Theoretical Physics published a new theory of gravity that might explain dark matter and its curious impact on the motion of stars. Also, a pair of physicists—Julian Gonzalez-Ayala and F. Angulo-Brown—asked why is space three-dimensional? They report evidence that the second law of thermodynamics may help explain it. And a team of researchers at Leiden Institute of Physics confirmed a second layer of information in DNA—its mechanics, they believe, are also involved in determining who we are.

It was big year for space news as well, as a team working with the European Space Agency's Rosetta orbiter project confirmed that water ice was found on the surface of comet 67P—solving a longstanding mystery. Meanwhile, another team working with NASA's New Horizons project published imagery that revealed a ...Read More...

PANIC Lander to Revolutionize Asteroid Research

The PANIC lander's design as a proof-of-concept CAD-model. Image courtesy Schindler et al., 2011.

A US-German team of researchers has proposed to develop a micro-scale low-cost surface lander for the in situ characterization of an asteroid. The tiny spacecraft, called the Pico Autonomous Near-Earth Asteroid In Situ Characterizer (PANIC), could be a breakthrough for the scientific community, offering simple and cheap solutions for asteroid research.

The concept of the PANIC mission envisions a tetrahedron-shaped lander with an edge length of just 13.78 inch (35 centimeters) and a total mass of some 26.5 lbs. (12 kilograms). The spacecraft's size and structure will allow it to host four scientific instruments. The lander itself will be delivered to an asteroid aboard an interplanetary probe and once on the surface of a space rock it will utilize hopping as a locomotion mechanism in microgravity.

According to the authors of the paper describing the PANIC mission concept, one of the biggest advantages of the project would be its simplicity and cost-effectiveness.

"We aimed at a simple and low-cost concept, mitigating potential risks. I believe it is possible to build a PANIC lander within a cost budget of $5 to 10 million, also given that the lander would be powered solely by non-rechargeable primary cells providing a life time of 24 to 36 hours," Karsten Schindler of the Technische Universitat Dresden (TUD) in Germany and lead author of the paper, told Astrowatch.net.

The authors of the study believe that PANIC would be a great alternative to complex and expensive traditional landers. It could be a real milestone in the history of asteroid research as so far no landing attempt of a dedicated lander has been successful on an asteroid. NASA's NEAR Shoemaker probe's landing at the end of its mission in 2001 on the near-Earth asteroid (NEA) Eros and the two touchdowns of Japan's Hayabusa on the NEA Itokawa in 2005 provided only very limited information.

"Both probes touched the surface, but they did not have instruments on-board for an in situ analysis. A dedicated lander would be an important addition to any future asteroid exploration mission as it allows us to measure the 'ground truth' that is required to calibrate remote sensing data; a problem that each spacecraft mission faces, no matter which celestial body it explores, either remotely from orbit or during a fly-by," Schindler said.

The researchers argue that it is feasible to acquire this "ground truth" data with very modest expenses in spacecraft weight, cost and operations in the ...Read More...

Festive nebulae light up Milky Way Galaxy satellite

This glowing nebula, named NGC 248, is located within the Small Magellanic Cloud, a satellite galaxy of the Milky Way and about 200 000 light-years from Earth. The nebula was observed with Hubble's Advanced Camera for Surveys in Sept. 2015, as part of a survey called the Small Magellanic cloud Investigation of Dust and Gas Evolution (SMIDGE). Image courtesy NASA, ESA, STScI, K. Sandstrom (University of California, San Diego), and the SMIDGE team.

The sheer observing power of the NASA/ESA Hubble Space Telescope is rarely better illustrated than in an image such as this. This glowing pink nebula, named NGC 248, is located in the Small Magellanic Cloud, just under 200 000 light-years away and yet can still be seen in great detail.

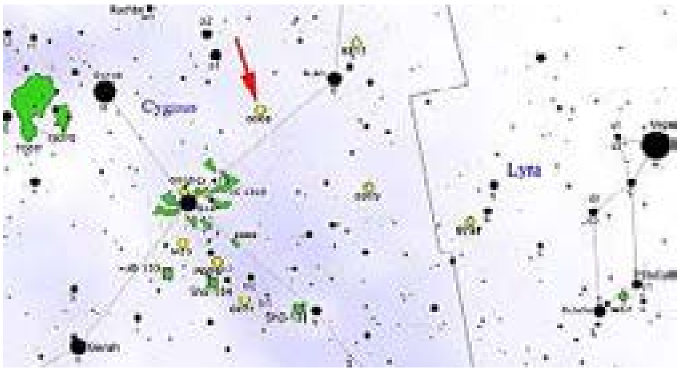
Our home galaxy, the Milky Way, is part of a collection of galaxies known as the Local Group. Along with the Andromeda Galaxy , the Milky Way is one of the Group's most massive members, around which many smaller satellite galaxies orbit. The Magellanic Clouds are famous examples, which can easily be seen with the naked eye from the southern hemisphere.

Within the smaller of these satellite galaxies, the Small Magellanic Cloud, the NASA/ESA Hubble Space Telescope captured two festive-looking emission nebulae, conjoined so they appear as one. Intense radiation from the brilliant central stars is causing hydrogen in the nebulae to glow pink.

Together the nebulae are called NGC 248. They were discovered in 1834 by the astronomer Sir John Herschel. NGC 248 is about 60 light-years long and 20 light-years wide. It is among a number of glowing hydrogen nebulae in the Small Magellanic Cloud, which lies in the southern constellation of Tucana(The Toucan), about 200 000 light-years away.

The nebula was observed as part of a Hubble survey, the Small Magellanic cloud Investigation of Dust and Gas Evolution (SMIDGE). In this survey astronomers are using Hubble to probe the Small Magellanic Cloud to understand how its dust - an important component of many galaxies and related to star formation - is different from the dust in the Milky Way. ...Read More...

Avalanche statistics suggest Tabby's star is near a continuous phase transition



The location of Tabby's Star.

In its search for extrasolar planets, the Kepler space telescope looks for stars whose light flux periodically dims, signaling the passing of an orbiting planet in front of the star. But the timing and duration of diminished light flux episodes Kepler detected coming from KIC 846852, known as Tabby's star, are a mystery. These dimming events vary in magnitude and don't occur at regular intervals, making an orbiting planet an unlikely explanation. The source of these unusual dimming events is the subject of intense speculation.

Suggestions from astronomers, astrophysicists, and amateur stargazers have ranged from asteroid belts to alien activity.

Now a team of scientists at the University of Illinois at Urbana-Champaign - physics graduate student Mohammed Sheikh, working with Professors Karin Dahmen and Richard Weaver - proffer an entirely novel solution to the Tabby's star puzzle. They suggest the luminosity variations may be intrinsic to the star itself.

Tabby's star is in most regards a standard F-class star, located in the constellation Cygnus, approximately 1,276 light years from Earth. Its unusual light curve - the graph of its light intensity as a function of time - shows intense dimming events of up to 20 percent, punctuated with smaller irregular dimming events.

Weaver comments, "There are a few telltale signs of occultation, or dimming by an independent body blocking the view. The most important is periodicity. In Tabby's star, the small and big events are not periodic - they don't occur at regular intervals - and this is one of the central mysteries of the light curve. "

The Illinois team applied a statistical analysis to the light curve's smaller irregular variations. What they found is a mathematical pattern consistent with a well-established avalanche model: the smaller dimming events are the "crackling noise" or small avalanches that are observed during the time intervals between the ...Read More...

New antimatter breakthrough to help illuminate mysteries of the Big Bang

Antimatter study at CERN is illustrated. Image courtesy Professor Niels Madsen.

Swansea University scientists working at CERN have made a landmark finding, taking them one step closer to answering the question of why matter exists and illuminating the mysteries of the Big Bang and the birth of the Universe.

In their paper published in Nature the physicists from the University's College of Science, working with an international collaborative team at CERN, describe the first precision study of antihydrogen, the antimatter equivalent of hydrogen.

Professor Mike Charlton said: "The existence of antimatter is well established in physics, and it is buried deep in the heart of some of the most successful theories ever developed. But we have yet to answer a central question of why didn't matter and antimatter, which it is believed were created in equal amounts when the Big Bang started the Universe, mutually self-annihilate?

"We also have yet to address why there is any matter left in the Universe at all. This conundrum is one of the central open questions in fundamental science, and one way to search for the answer is to bring the power of precision atomic physics to bear upon antimatter."

It has long been established that any excited atom will reach its lowest state by emitting photons, and the spectrum of light emitted from them represents a kind of atomic fingerprint and it is a unique identifier. The most familiar everyday example is the orange of the sodium streetlights.

Hydrogen has its own spectrum and, as the simplest and most abundant atom in the Universe, it holds a special place in physics. The properties of the hydrogen atom are known with high accuracy, and one in particular, the so-called 1S-2S transition has been determined with a precision close to one part in a hundred trillion - equivalent to knowing the distance between Swansea and London to about a billionth of a metre! ..Read More...

Still no violation of Lorentz symmetry, despite strongest test yet

This retroreflector was left on the Moon by astronauts on the Apollo 11 mission in 1969. Astronomers all over the world have reflected laser light off the reflector to precisely measure the Earth-Moon distance. Credit: NASA - NASA Apollo Archive, Public Domain

Physicists have found the strongest evidence yet for no violation of Lorentz symmetry, one of the fundamental symmetries of relativity. Lorentz symmetry states that the outcome of an experiment does not depend on certain aspects of its surroundings, namely the velocity and the direction of its moving reference frame—properties that become relevant when studying astronomical objects and launching satellites, for instance, as well as for unifying quantum mechanics and general relativity.

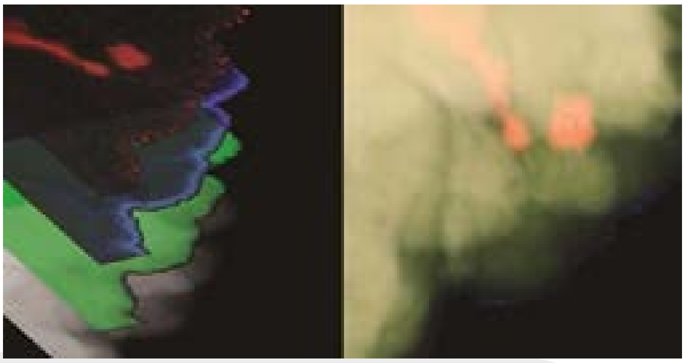
"We know that general relativity and the Standard Model of particle physics are not the ultimate theories," coauthor Marie-Christine Angonin at the Paris Observatory told Phys.org. "Furthermore, so far, it has been impossible to conciliate in one common theory these two aspects of physics. To succeed in this quest, almost all unification theories predict a breaking of Lorentz symmetry."

To perform the improved test of Lorentz symmetry, the team of physicists from the Paris Observatory and the University of California, Los Angeles, analyzed 44 years of data from lunar laser ranging (LLR) observations.

LLR involves sending laser pulses between a station on the Earth to a reflector on the Moon and back, and measuring the time it takes for the light to complete the round trip, which is roughly 2.5 seconds. Modern LLR experiments can determine the distance between the Earth and Moon to within less than a centimeter.

In the new study, the researchers analyzed data from more than 20,000 reflected laser beams sent between 1969 and 2013 by five LLR stations located at different places on the Earth. The round-trip travel time of the light is influenced by numerous factors, from the location of the Moon in the sky, to the weather and the ...Read More...

Devices that convert heat into electricity one step closer to reality



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). Credit: Imaging by 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.

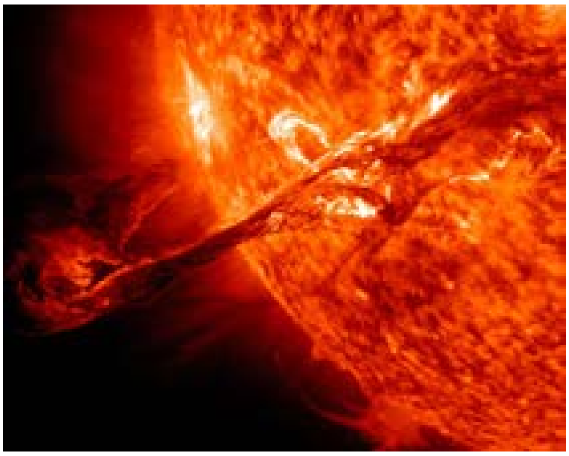
Many electrical and mechanical devices, such as car engines, produce heat as a byproduct of their normal operation. It's called "waste heat," and its existence is required by the fundamental laws of thermodynamics, explained study co-author Stephen Boona.

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 ...Read More...

The hidden inferno inside your laser pointer



What would happen if you threw an iceberg into the sun? Surprising as it may seem, physicists still aren't sure. Credit: NASA/SDO/AIA, NASA/STEREO, SOHO (ESA & NASA)

If you thought that a kid's room, a Norwegian Nobel Laureate and a laser pointer had nothing in common, two UA physicists are about to enlighten you.

It's hard to believe, but after having unraveled many of the laws that make the universe tick, physicists still haven't reached an agreement on whether something as seemingly simple as "hot" or "cold" can be measured in a system under certain circumstances.

"Imagine you threw an iceberg into the sun and right before it's melted and gone, you wanted to know, 'How hot is that iceberg at that moment?' Would that be a meaningful question to ask?" says Charles Stafford, a professor in the Department of Physics in the UA's College of Science. "According to traditional physics, it wouldn't be."

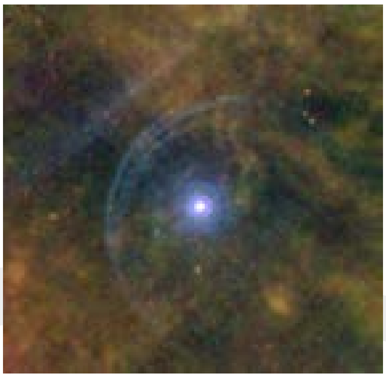
Put simply, traditional knowledge holds that properties such as temperature or voltage can only be measured as long as a system is in equilibrium. (Hint: an iceberg plunging into the sun is not.)

"Temperature and voltage are two basic variables developed in the 19th century," Stafford says, "so it may come as a shock that such basic notions have until now lacked a mathematically rigorous definition except for the case of equilibrium, an idealized case that does not actually occur in nature, except perhaps for the 'heat death' predicted to mark the end of the universe."

Together with doctoral student Abhay Shastry, the first author of the study, Stafford used mathematical modeling to explore this conundrum. They published their results recently in the journal Physical Review B. Their manuscript shows that these two quantities are so closely linked that it is impossible to know one without knowing the other.

"We have shown that actually any state of a system whatsoever, even far from equilibrium, can be characterized by a temperature," Stafford says. ...Read More...

Famous red star Betelgeuse is spinning faster than expected; may have swallowed a companion 100,000 years ago



This 2012 infrared image of Betelgeuse by the orbiting Herschel telescope shows two shells of interacting matter on one side of the star. Credit: L. Decin/University of Leuven/ESA

Astronomer J. Craig Wheeler of The University of Texas at Austin thinks that Betelgeuse, the bright red star marking the shoulder of Orion, the hunter, may have had a past that is more interesting than meets the eye. Working with an international group of undergraduate students, Wheeler has found evidence that the red supergiant star may have been born with a companion star, and later swallowed that star. The research is published today in the journal Monthly Notices of the Royal Astronomical Society.

For such a well-known star, Betelgeuse is mysterious. Astronomers know that it's a red supergiant, a massive star that is nearing the end of its life and so has bloated up to many times its original size. Someday it will explode as a supernova, but no one knows when.

"It might be ten thousand years from now, or it might be tomorrow night," Wheeler, a supernova expert, said.

A new clue to the future of Betelgeuse involves its rotation. When a star inflates to become a supergiant, its rotation should slow down. "It's like the classic spinning ice skater—not bringing her arms in, but opening her arms up," Wheeler said. As the skater opens her arms, she slows down. So, too, should Betelgeuse's rotation have slowed as the star expanded. But that is not what Wheeler's team found.

"We cannot account for the rotation of Betelgeuse," Wheeler said. "It's spinning 150 times faster than any plausible single star just rotating and doing its thing."

He directed a team of undergraduates including Sarafina Nance, Manuel Diaz, and James Sullivan of The University of Texas at Austin, as well as visiting students from China and Greece, to study Betelgeuse with a computer modeling program called MESA. ..Read More...

This Week's Sky at a Glance - Dec. 24-30

Dec. 25	Moon at Apogee: 405870 km (09:55)
Dec. 25	Mercury at Perihelion (19:00)
Dec. 28	Mercury at Inferior Conjunction (23:00)
Dec. 29	New Moon (10:53)

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