COMING EVENTS
CUB SCOUT ASTRONOMY
OCT 17, 2014, 7:00 PM
3139 Wescoe Hall

EVERYONE LOVES SCIENCE
MON. OCT. 20, 7:30 PM
Lawrence Public Library

PARTIAL SOLAR ECLIPSE
THU. OCT. 23, 4:30 PM
Lied Center Parking

PUBLIC OBSERVING
SUN. OCT. 26, 8:00 PM
Prairie Park Nature Center

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INFORMATION
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Report from the Officers
Our semester got off to a great start with an informative presentation by Dr. Ed Wiley. Ed has been heavily involved with pro-am cooperative projects which made use of small and medium size telescopes at the national observatory outside Tucson to study visual binaries using CCD cameras. We wish Ed the best of luck and clear skies as he transitions to his new residence in Texas.

Speaking of clear skies, on Sunday, Sept. 28, we had our first public observing session at Prairie Park Nature Center south of Lawrence. The weather was exquisite—clear dark skies and comfortable temperatures. Our observing sessions should always be this great, though it seems unlikely given normal Kansas weather. Our next session, part of a very busy month of October, is Sunday Oct. 26, starting a little earlier due to the shortening daylight of Fall.

Our annual Cub Scout evening is tentatively scheduled for Friday, Oct. 17. As usual, this will take place in Wescoe Hall and requires a significant degree of help in supplying observing stations for the 200 or so scouts and parents who normally attend. If you can help, please let Rick know at rcjbm@sbcglobal.net.

The following Monday, Oct. 20, 7:30 p.m., at the Lawrence Public Library Auditorium, 707 Vermont St., there will be an evening entitled Everybody Loves Science. "Everyone Loves Science," encourages community members to have fun with science and not be intimidated by it. The event is designed for attendees to ask questions and participate. Physics professor Mats Selen will lead hands-on, educational physics activities designed to engage attendees and improve learning. Selen and his colleagues at the University of Illinois developed these programs as part of student outreach efforts, showcasing the fun of science through a Physics Van.

Of Local Interest
VIEWING
PARTIAL SOLAR ECLIPSE
THURSDAY, OCT. 23, 2014

Begins 4:34 PM - Altitude 19.8°
Maximum obscuration by the Moon: 41.3%
Ends 5:44 PM - Altitude 7.9°

As we did with the Venus transit, we will organize observing in the parking lot of the Lied Center at the west end to optimize the view of the sun as it approaches the horizon. If you plan to bring a scope, make sure it is appropriately equipped for solar viewing.

(Continued on page 2)
The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the second Friday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. Approximately the last Sunday of each month we have an open house at the Prairie Park Nature Center. Periodic star parties are scheduled as well. For more information, please contact the club officers: president, Rick Heschmeyer at r cjbm@sbcglobal.net; webmaster, Howard Edin, at howard@howardedin.com; AlCor William Winkler, at billwink10@yahoo.com; or faculty advisor, Prof. Bruce Twarog at btwarog@ku.edu. Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Fridays and Sundays when events are scheduled. The information about AAL can be found at http://www.physics.ku.edu/aal/

Copies of the Celestial Mechanic can also be found on the web at http://www.physics.ku.edu/aal/celestialmechanic

And, if your calendar isn’t full enough, on Thursday, Oct. 23, we have a partial solar eclipse visible from Lawrence from 4:30 to 5:45. We will set up in the west end parking lot of the Lied Center for public viewing. Any suggestions for improving the club or the newsletter are always welcome.

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A Review of the book

PHYSICS by Tom Jackson

Books least likely to be found in the digital world are “coffee table” display books, wide and heavily illustrated, that invite flip-through curiosity. Some of these are in the series, “An Illustrated History of the Foundations of Science,” by long-time British science writer Tom Jackson. Each discusses “100 Breakthroughs that Changed History.”

Physics is 143 pages based on Jackson’s concept of the weightiest problems that became discoveries and changed the way we understand the world. His introduction shows how the other sciences are based on physics, and describes the main fields of classical and of modern physics.

The author believes that great discoveries make great stories, and each of the one- or two-page descriptions is very much told and illustrated as a story. That approach enables Jackson to go surprisingly deep while holding one’s interest; his use of classical art and historic manuscript selections and photos, is excellent. There is cleverness, too. Mach goes supersonic. Hertz was a sparky young German. Tesla was an alternating character. The book uses few equations, such as Snell’s Law, but an eight-page appendix on physics basics explains 17 formulas. Yet some of the descriptions are titled as equations, such as Maxwell and Boltzmann.

The 100 breakthroughs are described chronologically from the first primitive attempts to explain nature, offers Thales of Miletus as the father of physics, and concludes with the hunt for the Higgs boson and the search for supersymmetry. A glance at the Contents will tell the amateur what parts of physics he should brush up on, now that astronomy is hyphenated with it in many departments. “Dawn of Science” concludes with the gas laws. “Scientific Revolution” runs from Newton’s Principles to Brownian motion. “From Classical to Modern” covers electric induction to X rays. “Subatomic Age” discusses radioactivity to nuclear fission. “Modern Physics” extends from quantum electrodynamics to supersymmetry?

This expansive book concludes with some author speculations called “Imponderables,” 37 biographical sketches of physicists, a bibliography, good 12-column index, and a back pocket with three foldouts (missing from my library copy). Examples of depth covered: the five Planck dimensions, a chart of the 17 known particles of the Standard Model, Hawking radiation, super fluidity, string theory. Suggested improvements: a comprehensive section on units of measurement and stronger emphasis on the remarkable understanding that, as far as is known, everything in the universe depends on only four forces, even life.

This is probably the best general physical science book I have read. It will serve as a physics topic checkup for amateur astronomers and the public. A middle school science teacher could use it as a 1-year guide to topics to be covered using other materials, that will prepare and motivate students for high school physics. Priced remarkably low in hardcover, it is a feast for gifted youngsters. Wow!

Gaia discovers its first supernova

While scanning the sky to measure the positions and movements of stars in our Galaxy, Gaia has discovered its first stellar explosion in another galaxy far, far away. This powerful event, now named Gaia14aaa, took place in a distant galaxy some 500 million light-years away, and was revealed via a sudden rise in the galaxy's brightness between two Gaia observations separated by one month. Gaia, which began its scientific work on 25 July, repeatedly scans the entire sky, so that each of the roughly one billion stars in the final catalogue will be examined an average of 70 times over the next five years.

"This kind of repeated survey comes in handy for studying the changeable nature of the sky," comments Simon Hodgkin from the Institute of Astronomy in Cambridge, UK.

Many astronomical sources are variable: some exhibit a regular pattern, with a periodically rising and declining brightness, while others may undergo sudden and dramatic changes.

"As Gaia goes back to each patch of the sky over and over, we have a chance to spot thousands of 'guest stars' on the celestial tapestry," notes Dr Hodgkin. "These transient sources can be signposts to some of the most powerful phenomena in the Universe, like this supernova."

Dr Hodgkin is part of Gaia's Science Alert Team, which includes astronomers from the Universities of Cambridge, UK, and Warsaw, Poland, who are combing through the scans in search of unexpected changes. It did not take long until they found the first 'anomaly' in the form of a sudden spike in the light coming from a distant galaxy, detected on 30 August. The same galaxy appeared much dimmer when Gaia first looked at it just a month before.

"We immediately thought it might be a supernova, but needed more clues to back up our claim," explains Łukasz Wyrzykowski from the Warsaw University Astronomical Observatory, Poland.

Other powerful cosmic events may resemble a supernova in a distant galaxy, such as outbursts caused by the mass-devouring supermassive black hole at the galaxy centre. However, in Gaia14aaa, the position of the bright spot of light was slightly offset from the galaxy's core, suggesting that it was unlikely to be related to a central black hole. So, the astronomers looked for more information in the light of this new source. Besides recording the position and brightness of stars and galaxies, Gaia also splits their light to create a spectrum. In fact, Gaia uses two prisms spanning red and blue wavelength regions to produce a low-resolution spectrum that allows astronomers to seek signatures of the various chemical elements present in the source of that light.

"In the spectrum of this source, we could already see the presence of iron and other elements that are known to be found in supernovas," says Nadejda Blagorodnova, a PhD student at the Institute of Astronomy in Cambridge.

In addition, the blue part of the spectrum appears significantly brighter than the red part, as expected in a supernova. And not just any supernova: the astronomers already suspected it might be a 'Type Ia' supernova – the explosion of a white dwarf locked in a binary system with a companion star. While other types of supernovas are the explosive demises of massive stars, several times more massive than the Sun, Type Ia supernovas are the end product of their less massive counterparts.

Low-mass stars, with masses similar to the Sun's, end their lives gently, puffing up their outer layers and leaving behind a compact white dwarf. Their high density means that white dwarfs can exert an intense gravitational pull on a nearby companion star, accreting mass from it until the white dwarf reaches a critical mass that then sparks a violent explosion. To confirm the nature of this supernova, the astronomers complemented the Gaia data with more observations from the ground, using the Isaac Newton Telescope (INT) and the robotic Liverpool Telescope on La Palma, in the Canary Islands, Spain. A high-resolution spectrum, obtained on 3 September with the INT, confirmed not only that the explosion corresponds to a Type Ia supernova, but also provided an estimate of its distance. This proved that the supernova happened in the galaxy where it was observed.

Supernovas are rare events: only a couple of these explosions happen every century in a typical galaxy. But they are not so rare over the whole sky, if we take into account the hundreds of billions of galaxies that populate the Universe. Astronomers in the Science Alert Team are currently getting acquainted with the data, testing and optimising their detection software. In a few months, they expect Gaia to discover about three new supernovas every day. In addition to supernovas, Gaia will discover thousands of transient sources of other kinds – stellar explosions on smaller scale than supernovas, flares from young stars coming to life, outbursts caused by black holes that disrupt and devour a nearby star, and possibly some entirely new phenomena never seen before.

"The sky is ablaze with peculiar sources of light, and we are looking forward to probing plenty of those with Gaia in the coming years."
Twinkle, twinkle, variable star

By Dr. Ethan Siegel

As bright and steady as they appear, the stars in our sky won't shine forever. The steady brilliance of these sources of light is powered by a tumultuous interior, where nuclear processes fuse light elements and isotopes into heavier ones. Because the heavier nuclei up to iron (Fe), have a greater binding energies-per-nucleon, each reaction results in a slight reduction of the star's mass, converting it into energy via Einstein's famous equation relating changes in mass and energy output, $E = mc^2$. Over timescales of tens of thousands of years, that energy migrates to the star's photosphere, where it's emitted out into the universe as starlight.

There's only a finite amount of fuel in there, and when stars run out, the interior contracts and heats up, often enabling heavier elements to burn at even higher temperatures, and causing sun-like stars to grow into red giants. Even though the cores of both hydrogen-burning and helium-burning stars have consistent, steady energy outputs, our sun's overall brightness varies by just ~0.1%, while red giants can have their brightness's vary by factors of thousands or more over the course of a single year! In fact, the first periodic or pulsating variable star ever discovered—Mira (omicron Ceti)—behaves exactly in this way.

There are many types of variable stars, including Cepheids, RR Lyrae, cataclysmic variables and more, but it's the Mira-type variables that give us a glimpse into our Sun's likely future. In general, the cores of stars burn through their fuel in a very consistent fashion, but in the case of pulsating variable stars the outer layers of stellar atmospheres vary. Initially heating up and expanding, they overshoot equilibrium, reach a maximum size, cool, then often forming neutral molecules that behave as light-blocking dust, with the dust then falling back to the star, ionizing and starting the whole process over again. This temporarily neutral dust absorbs the visible light from the star and re-emits it, but as infrared radiation, which is invisible to our eyes. In the case of Mira (and many red giants), it's Titanium Monoxide (TiO) that causes it to dim so severely, from a maximum magnitude of +2 or +3 (clearly visible to the naked eye) to a minimum of +9 or +10, requiring a telescope (and an experienced observer) to find!

Visible in the constellation of Cetus during the fall-and-winter from the Northern Hemisphere, Mira is presently at magnitude +7 and headed towards its minimum, but will reach its maximum brightness again in May of next year and every 332 days thereafter. Shockingly, Mira contains a huge, 13 light-year-long tail -- visible only in the UV -- that it leaves as it rockets through the interstellar medium at 130 km/sec! Look for it in your skies all winter long, and contribute your results to the AAVSO (American Association of Variable Star Observers) International Database to help study its long-term behavior!

Check out some cool images and simulated animations of Mira here: http://www.nasa.gov/mission_pages/galex/20070815/v.html

Kids can learn all about Mira at NASA’s Space Place: http://spaceplace.nasa.gov/mira/en/
CUB SCOUT ASTRONOMY NIGHT

Rick Heschmeyer - President, AAL

FRIDAY OCT. 17, 2014
7:00 PM
3139 Wescoe Hall
University of Kansas
NASA Telescopes Find Clear Skies and Water Vapor on Exoplanet

Astronomers using data from three of NASA's space telescopes -- Hubble, Spitzer and Kepler -- have discovered clear skies and steamy water vapor on a gaseous planet outside our solar system. The planet is about the size of Neptune, making it the smallest planet from which molecules of any kind have been detected.

"This discovery is a significant milepost on the road to eventually analyzing the atmospheric composition of smaller, rocky planets more like Earth," said John Grunsfeld, assistant administrator of NASA's Science Mission Directorate. "Such achievements are only possible today with the combined capabilities of these unique and powerful observatories."

Clouds in a planet's atmosphere can block the view to underlying molecules that reveal information about the planet's composition and history. Finding clear skies on a Neptune-size planet is a good sign that smaller planets might have similarly good visibility.

"When astronomers go observing at night with telescopes, they say 'clear skies' to mean good luck," said Jonathan Fraine of the University of Maryland, College Park, lead author of a new study appearing in Nature. "In this case, we found clear skies on a distant planet. That's lucky for us because it means clouds didn't block our view of water molecules."

The planet, HAT-P-11b, is categorized as an exo-Neptune -- a Neptune-sized planet that orbits the star HAT-P-11. It is located 120 light-years away in the constellation Cygnus. This planet orbits closer to its star than does our Neptune to our sun, making one lap roughly every five days. It is a warm world thought to have a rocky core and gaseous atmosphere. Not much else was known about the composition of the planet, or other exo-Neptunes like it, until now.

Part of the challenge in analyzing the atmospheres of planets like this is their size. Larger Jupiter-like planets are easier to see because of their impressive girth and relatively inflated atmospheres. In fact, researchers already have detected water vapor in the atmospheres of those planets. The handful of smaller planets observed previously had proved more difficult to probe, partly because they all appeared to be cloudy.

In the new study, astronomers set out to look at the atmosphere of HAT-P-11b, not knowing if its weather would call for clouds. They used Hubble's Wide Field Camera 3 and a technique called transmission spectroscopy, in which a planet is observed as it crosses in front of its parent star. Starlight filters through the rim of the planet's atmosphere. If molecules like water vapor are present, they absorb some of the starlight, leaving distinct signatures in the light that reaches our telescopes.

(Continued on page 10)
NASA's Chandra X-ray Observatory Finds Planet That Makes Star Act Deceptively Old

A planet may be causing the star it orbits to act much older than it actually is, according to new data from NASA's Chandra X-ray Observatory. This discovery shows how a massive planet can affect the behavior of its parent star.

The star, WASP-18, and its planet, WASP-18b, are located about 330 light-years from Earth. WASP-18b has a mass about 10 times that of Jupiter and completes one orbit around its star in less than 23 hours, placing WASP-18b in the "hot Jupiter" category of exoplanets, or planets outside our solar system.

WASP-18b is the first known example of an orbiting planet that has apparently caused its star, which is roughly the mass of our sun, to display traits of an older star.

"WASP-18b is an extreme exoplanet," said Ignazio Pillitteri of the Istituto Nazionale di Astrofisica (INAF)-Osservatorio Astronomico di Palermo in Italy, who led the study. "It is one of the most massive hot Jupiters known and one of the closest to its host star, and these characteristics lead to unexpected behavior. This planet is causing its host star to act old before its time."

Pillitteri’s team determined WASP-18 is between 500 million and 2 billion years old, based on theoretical models and other data. While this may sound old, it is considered young by astronomical standards. By comparison, our sun is about 5 billion years old and thought to be about halfway through its lifetime.

Younger stars tend to be more active, exhibiting stronger magnetic fields, larger flares, and more intense X-ray emission than their older counterparts. Magnetic activity, flaring, and X-ray emission are linked to the star's rotation, which generally declines with age. However, when astronomers took a long look with Chandra at WASP-18 they didn’t detect any X-rays. Using established relations between the magnetic activity and X-ray emission of stars, as well as its actual age, researchers determined WASP-18 is about 100 times less active than it should be.

"We think the planet is aging the star by wreaking havoc on its innards," said co-author Scott Wolk of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

The researchers argue that tidal forces created by the gravitational pull of the massive planet – similar to those the moon has on Earth's tides, but on a much larger scale – may have disrupted the magnetic field of the star. The strength of the magnetic field depends on the amount of convection in the star, or how intensely hot gas stirs the interior of the star.

"The planet's gravity may cause motions of gas in the interior of the star that weaken the convection," said co-author Salvatore Sciortino also of INAF-Osservatorio Astronomico di Palermo in Italy. "This has a domino effect that results in the magnetic field becoming weaker and the star to age prematurely."

WASP-18 is particularly susceptible to this effect because its convection zone is narrower than most stars. This makes it more vulnerable to the impact of tidal forces that tug at it.

The effect of tidal forces from the planet may also explain an unusually high amount of lithium found in earlier optical studies of WASP-18. Lithium is usually abundant in younger stars, but over time convection carries lithium to the hot inner regions of a star, where it is destroyed by nuclear reactions. If there is less convection, the lithium does not circulate into the interior of the star as much, allowing more lithium to survive.
Hubble Helps Find Smallest Known Galaxy with a Supermassive Black Hole

Astronomers have found an unlikely object in an improbable place: a monster black hole lurking inside one of the tiniest galaxies known. Though the black hole is five times the mass of the black hole at the center of our Milky Way, it is inside a galaxy that crams 140 million stars within a diameter of about 300 light-years, only 1/500th of our galaxy's diameter.

The dwarf galaxy containing the black hole, called M60-UCD1, is the densest galaxy ever seen. If you lived inside of it, the night sky would dazzle with at least 1 million stars visible to the naked eye (as opposed to 4,000 stars in our nighttime sky, as seen from Earth's surface).

The finding implies that there are many other very compact galaxies in the universe that contain supermassive black holes. The observation also suggests that dwarf galaxies may actually be the stripped remnants of larger galaxies that were torn apart during collisions with yet other galaxies — rather than small islands of stars born in isolation.

"We don't know of any other way you could make a black hole so big in an object this small," said University of Utah astronomer Anil Seth, lead author of an international study of the dwarf galaxy published in Thursday's issue of the journal Nature.

His team of astronomers used the Hubble Space Telescope and the Gemini North 8-meter optical and infrared telescope on Hawaii's Mauna Kea to observe M60-UCD1 and measure the black hole's mass. The sharp Hubble images provide information about the galaxy's diameter and stellar density. Spectroscopy with Gemini measures the stellar motions as affected by the black hole's pull. These data are used to calculate the mass of the unseen black hole.

Black holes are gravitationally collapsed, ultracompact objects that have a gravitational pull so strong that even light cannot escape. Supermassive black holes — those with the mass of at least 1 million stars like our Sun — are thought to be at the centers of many galaxies.

The black hole at the center of our Milky Way galaxy has the mass of 4 million suns, but as heavy as that is, it is less than 0.01 percent of the Milky Way's total mass. By comparison, the supermassive black hole at the center of M60-UCD1 is a stunning 15 percent of the small galaxy's total mass. "That is pretty amazing, given that the Milky Way is 500 times larger and more than 1,000 times heavier than the dwarf galaxy M60-UCD1," Seth said.

One explanation is that M60-UCD1 was once a large galaxy containing 10 billion stars, but then it passed very close to the center of an even larger galaxy, M60, and in that process all the stars and dark matter in the outer part of the galaxy got torn away and became part of M60.

The team believes that M60-UCD1 may eventually be pulled back to merge with the center of M60, which has its own monster black hole, weighing a whopping 4.5 billion solar masses (more than 1,000 times bigger than the black hole in our galaxy). When that happens, the black hole in M60-UCD1 will merge with the far more massive black hole in M60. The galaxies are 50 million light-years away.
Hubble Finds Companion Star Hidden for 21 Years in a Supernova's Glare

Astronomers using NASA's Hubble Space Telescope have discovered a companion star to a rare type of supernova. This observation confirms the theory that the explosion originated in a double-star system where one star fueled the mass-loss from the aging primary star.

This detection is the first time astronomers have been able to put constraints on the properties of the companion star in an unusual class of supernova called Type IIb. They were able to estimate the surviving star's luminosity and mass, which provide insight into the conditions that preceded the explosion.

"A binary system is likely required to lose the majority of the primary star's hydrogen envelope prior to the explosion. The problem is that, to date, direct observations of the predicted binary companion star have been difficult to obtain since it is so faint relative to the supernova itself," said lead researcher Ori Fox of the University of California (UC) at Berkeley.

Astronomers estimate that a supernova goes off once every second somewhere in the universe. Yet they don't fully understand how stars explode. Finding a "smoking gun" companion star provides important new clues to the variety of supernovae in the universe. "This is like a crime scene, and we finally identified the robber," quipped team member Alex Filippenko, professor of astronomy at UC Berkeley. "The companion star stole a bunch of hydrogen before the primary star exploded."

The explosion happened in the galaxy M81, which is about 11 million light-years away from Earth in the direction of the constellation Ursa Major (the Great Bear). Light from the supernova was first detected in 1993, and the object was designated SN 1993J. It was the nearest known example of this type of supernova, called a Type IIb, due to the specific characteristics of the explosion. For the past two decades astronomers have been searching for the suspected companion, thought to be lost in the glare of the residual glow from the explosion.

Observations made in 2004 at the W.M. Keck Observatory on Mauna Kea, Hawaii, showed circumstantial evidence for spectral absorption features that would come from a suspected companion. But the field of view is so crowded that astronomers could not be certain if the spectral absorption lines were from a companion object or from other stars along the line of sight to SN 1993J. "Until now, nobody was ever able to directly detect the glow of the star, called continuum emission," Fox said.

The companion star is so hot that the so-called continuum glow is largely in ultraviolet (UV) light, which can only be detected above Earth's absorbing atmosphere. "We were able to get that UV spectrum with Hubble. This conclusively
shows that we have an excess of continuum emission in the UV, even after the light from other stars has been sub-
tracted," said team member Azalee Bostroem of the Space Telescope Science Institute (STScI), in Baltimore, Mary-
land.

When a massive star reaches the end of its lifetime, it burns though all of its material and its iron core collapses.
The rebounding outer material is seen as a supernova. But there are many different types of supernovae in the uni-
verse. Some supernovae are thought to have exploded from a single-star system. Other supernovae are thought to
arise in a binary system consisting of a normal star with a white dwarf companion, or even two white dwarfs. The
peculiar class of supernova called Type IIb combines the features of a supernova explosion in a binary system with
what is seen when single massive stars explode.

SN 1993J, and all Type IIb supernovae, are unusual because they do not have a large amount of hydrogen present
in the explosion. The key question has been: how did SN 1993J lose its hydrogen? In the model for a Type IIb su-
pernova, the primary star loses most of its outer hydrogen envelope to the companion star prior to exploding, and
the companion continues to burn as a super-hot helium star.

"When I first identified SN 1993J as a Type IIb supernova, I hoped that we would someday be able to detect its sus-
pected companion star," said Filippenko. "The new Hubble data suggest that we have finally done so, confirming
the leading model for Type IIb supernovae."

The team combined ground-based data for the optical light and images from two Hubble instruments to collect ultra-
violet light. They then constructed a multi-wavelength spectrum that matched what was predicted for the glow of a
companion star.

Fox, Filippenko, and Bostroem say that further research will include refining the constraints on this star and defini-
tively showing that the star is present.

Using this strategy, Hubble was able to detect water vapor in HAT-P-11b. But before the team could celebrate
clear skies on the exo-Neptune, they had to show that starspots -- cooler "freckles" on the face of stars -- were not
the real sources of water vapor. Cool starspots on the parent star can contain water vapor that might erroneously
appear to be from the planet.

The team turned to Kepler and Spitzer. Kepler had been observing one patch of sky for years, and HAT-P-11b
happens to lie in the field. Those visible-light data were combined with targeted Spitzer observations taken at infra-
red wavelengths. By comparing these observations, the astronomers figured out that the starspots were too hot to
have any steam. It was at that point the team could celebrate detecting water vapor on a world unlike any in our
solar system. This discovery indicates the planet did not have clouds blocking the view, a hopeful sign that more
cloudless planets can be located and analyzed in the future.

"We think that exo-Neptunes may have diverse compositions, which reflect their formation histories," said study co-
author Heather Knutson of the California Institute of Technology in Pasadena. "Now with data like these, we can
begin to piece together a narrative for the origin of these distant worlds."

The results from all three telescopes demonstrate that HAT-P-11b is blanketed in water vapor, hydrogen gas and
likely other yet-to-be-identified molecules. Theorists will be drawing up new models to explain the planet's makeup
and origins.

"We are working our way down the line, from hot Jupiters to exo-Neptunes," said Drake Deming, a co-author of
the study who is also from the University of Maryland. "We want to expand our knowledge to a diverse range of
exoplanets."

The astronomers plan to examine more exo-Neptunes in the future, and hope to apply the same method to super-
Earths -- massive, rocky cousins to our home world with up to 10 times the mass. Although our solar system
doesn't have a super-Earth, NASA's Kepler mission is finding them in droves around other stars. NASA's James
Webb Space Telescope, scheduled to launch in 2018, will search super-Earths for signs of water vapor and other
molecules; however, finding signs of oceans and potentially habitable worlds is likely a ways off.

"The work we are doing now is important for future studies of super-Earths and even smaller planets, because we
want to be able to pick out in advance the planets with clear atmospheres that will let us detect molecules," said
Knutson.

Once again, astronomers will be crossing their fingers for clear skies.