COMING EVENTS
Monthly Meeting
Wetlands Discovery Center
Sunday December 03
7:00 PM
Gravitational Waves & Neutron Stars

PUBLIC OBSERVING
after meeting: SUNDAY
December 03
President
Rick Heschmeyer
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Report from the Officers
Hopefully some of you were able to take part in the international celebration of Dark Matter Day, either at KU on Friday evening or at the followup presentation on the Sunday before Halloween. There were nice crowds at both, though the AAL meeting drew a slightly younger audience. It must have been popular downtown because the Dark Matter Gelato on sale at Crema Dolce at 7th and Mass was gone by early evening. Following on this rather exotic topic in astrophysics, we have another popular but often equally confusing contribution to our presentations scheduled for the December meeting. Again, to avoid the Thanksgiving holiday, our next and last meeting of the year is scheduled for Dec. 03, the first Sunday of the month. Our speaker will be Dr. Anthony-Twarog of KU, shedding some light on the recent extraordinary observation of gravitational waves from a pair of merging neutron stars. Over and above the technical issues of detecting gravitational waves, this discovery was observed at multiple wavelengths and, from an astrophysics standpoint, has serious implications for the creation of heavy elements in the Universe (and us!). So come by that Sunday, learn something new and observe the sky after the meeting. Turns out that the night of our meeting is also the night of the supermoon, the 2nd one in the last year and a half. For more details on what that means, check out the November 2016 Celestial Mechanic, on-line at the AAL website.

Speaking of observing, the club over the years has begun to accumulate some older but still functional telescopes, including an 8-inch Celestron Polaris refurbished by (Continued on page 2)

Another close-by planetary system? Welcome to the Neighborhood!
Proxima Centauri is the closest star to the Sun. It is a faint red dwarf lying just four light-years away in the southern constellation of Centaurus (The Centaur). It is orbited by the Earth-sized temperate world Proxima b, discovered in 2016 and the closest planet to the Solar System. But there is more to this system than just a single planet. The new ALMA observations reveal emission from clouds of cold cosmic dust surrounding the star. The lead author of the new study, Guillem Anglada, explains the significance of this find: “The dust around Proxima is important because, following the discovery of the terrestrial planet Proxima b, it's the first indication of the presence of an elaborate planetary system, and not just a single planet, around the star closest to our Sun.”

Dust belts are the remains of material that did not form into larger bodies such as planets. The particles of rock and ice in these belts vary in size from the tiniest dust grain, smaller than a millimeter across, up to asteroid-like bodies many kilometers in diameter. Dust appears to lie in a belt that extends a few hundred million kilometers from Proxima Centauri and has a total mass of about one hundredth of the Earth’s mass. This belt is estimated to have a temperature of about -230 degrees Celsius, as cold as that of the Kuiper Belt in the outer Solar System. There are also hints in the ALMA data of another belt of even colder dust about ten times further out. If confirmed, the nature of an outer belt is intriguing, given its very cold environment far from a star that is cooler and fainter than the Sun. Both belts are much further from Proxima Centauri than the planet Proxima b, which orbits at just four million kilometers from its parent star.

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The club is open to all people interested in sharing their love for astronomy. Beginning in Fall 2016, monthly meetings are scheduled edin@gmail.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 Sundays when events are scheduled. The change amateur astronomy tips. These meetings and the public observing sessions that follow are scheduled at the Baker Wetlands Discovery Center, south of Lawrence. All events and meetings are free and open to the public. Periodic star parties are scheduled as well. For more information, please contact the club officers: **President**, Rick Heschmeyer at rickheschmeyer@gmail.com; **AlCor**, William Winkler at billwink10@yahoo.com; **NSN Coordinator**, Howard Edin at howard.edin@gmail.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 Sundays when events are scheduled. The information about AAL can be found at [http://www.physics.ku.edu/AAL/](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/newsletter](http://www.physics.ku.edu/AAL/newsletter).
For the first time, NASA scientists have detected light tied to a gravitational-wave event, thanks to two merging neutron stars in the galaxy NGC 4993, located about 130 million light-years from Earth in the constellation Hydra.

Shortly after 8:41 a.m. EDT on Aug. 17, NASA’s Fermi Gamma-ray Space Telescope picked up a pulse of high-energy light from a powerful explosion, which was immediately reported to astronomers around the globe as a short gamma-ray burst. The scientists at the National Science Foundation’s Laser Interferometer Gravitational-Wave Observatory (LIGO) detected gravitational waves dubbed GW170817 from a pair of smashing stars tied to the gamma-ray burst, encouraging astronomers to look for the aftermath of the explosion. Shortly thereafter, the burst was detected as part of a follow-up analysis by ESA’s (European Space Agency’s) INTEGRAL satellite.

NASA’s Swift, Hubble, Chandra, and Spitzer missions, along with dozens of ground-based observatories, including the NASA-funded PanSTARRS survey, later captured the fading glow of the blast’s expanding debris.

"This is extremely exciting science," said Paul Hertz, director of NASA’s Astrophysics Division at the agency’s headquarters in Washington. "Now, for the first time, we've seen light and gravitational waves produced by the same event. The detection of a gravitational-wave source's light has revealed details of the event that cannot be determined from gravitational waves alone. The multiplier effect of study with many observatories is incredible."

Neutron stars are the crushed, leftover cores of massive stars that previously exploded as supernovas long ago. The merging stars likely had masses between 10 and 60 percent greater than that of our Sun, but they were no wider than Washington, D.C. The pair whirled around each other hundreds of times a second, producing gravitational waves at the same frequency. As they drew closer and orbited faster, the stars eventually broke apart and merged, producing both a gamma-ray burst and a rarely seen flare-up called a "kilonova."

"This is the one we've all been waiting for," said David Reitze, executive director of the LIGO Laboratory at Caltech in Pasadena, California. "Neutron star mergers produce a wide variety of light because the objects form a maelstrom of hot debris when they collide. Merging black holes — the types of events LIGO and its European counterpart, Virgo, have previously seen — very likely consume any matter around them long before they crash, so we don't expect the same kind of light show."

"The favored explanation for short gamma-ray bursts is that they're caused by a jet of debris moving near the speed of light produced in the merger of neutron stars or a neutron star and a black hole," said Eric Burns, a member of Fermi's Gamma-ray Burst Monitor team at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "LIGO tells us there was a merger of compact objects, and Fermi tells us there was a short gamma-ray burst. Together, we know that what we observed was the merging of two neutron stars, dramatically confirming the relationship."

Within hours of the initial Fermi detection, LIGO and the Virgo detector at the European Gravitational Observatory near Pisa, Italy, greatly refined the event's position in the sky with additional analysis of gravitational wave data. Ground-based observatories then quickly located a new optical and infrared source — the kilonova — in NGC 4993.

To Fermi, this appeared to be a typical short

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Spooky in Space: NASA Images for Halloween

By Linda Hermans-Killiam

Have you ever seen a cloud that looks sort of like a rabbit? Or maybe a rock formation that looks a bit like an elephant? Although you know that a cloud isn’t really a giant rabbit in the sky, it’s still fun to look for patterns in images from nature. Can you spot some familiar spooky sites in the space images below?

This might look like the grinning face of a jack-o’-lantern, but it’s actually a picture of our Sun! In this image, taken by NASA’s Solar Dynamics Observatory, the glowing eyes, nose and mouth are some of the Sun’s active regions. These regions give off lots of light and energy. This causes them to appear brighter against the rest of the Sun. Active regions are constantly changing locations on the Sun. On the day this image was captured, they just happened to look like a face!

This is a Hubble Space Telescope image of Jupiter. Do you notice something that looks like a big eye peeking back at you? That’s actually the shadow of Jupiter’s moon Ganymede as it passed in front of the planet’s Great Red Spot. Jupiter’s Great Red Spot is a gigantic, oval shaped storm that is larger than Earth and is shrinking. It has been on Jupiter for several hundred years, and its winds can swirl up to 400 miles per hour!

Can you see the profile of a witch in this image? This image, from NASA’s Wide-Field Infrared Survey Explorer, shows the Witch Head nebula. The nebula is made up of clouds of dust heated by starlight. These dust clouds are where new stars are born. Here, the dust clouds happen to be in the shape of an open mouth, long nose and pointy chin.

The Black Widow Nebula looks like a giant spider in space. It is a huge cloud of gas and dust containing massive young stars. Radiation and winds from these stars push the dust and gas around, creating a spider-like shape. This image is from NASA’s Spitzer Space Telescope.

Did a skeleton lose one of its leg bones on Mars? Nope! It’s just an image of a Martian rock. NASA’s Curiosity rover captured this image. The rock was probably shaped to look this way over time by wind or water. If life ever existed on Mars, scientists expect that it would be small organisms called microbes. So, it isn’t likely that we’ll ever find a large fossil on Mars!
GRavitational Waves & Neutron Stars

Dr. Barbara Anthony–Twarog
Department of Physics & Astronomy, KU

Sunday December 03
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Baker Wetlands Discovery Center
Free and Open to the Public
gamma-ray burst, but it occurred less than one-tenth as far away as any other short burst with a known distance, making it among the faintest known. Astronomers are still trying to figure out why this burst is so odd, and how this event relates to the more luminous gamma-ray bursts seen at much greater distances.

NASA's Swift, Hubble and Spitzer missions followed the evolution of the kilonova to better understand the composition of this slower-moving material, while Chandra searched for X-rays associated with the remains of the ultra-fast jet.

When Swift turned to the galaxy shortly after Fermi’s gamma-ray burst detection, it found a bright and quickly fading ultraviolet (UV) source. "We did not expect a kilonova to produce bright UV emission," said Goddard’s S. Bradley Cenko, principal investigator for Swift. "We think this was produced by the short-lived disk of debris that powered the gamma-ray burst."

Over time, material hurled out by the jet slows and widens as it sweeps up and heats interstellar material, producing so-called afterglow emission that includes X-rays. But the spacecraft saw no X-rays — a surprise for an event that produced higher-energy gamma rays.

NASA’s Chandra X-ray Observatory clearly detected X-rays nine days after the source was discovered. Scientists think the delay was a result of our viewing angle, and it took time for the jet directed toward Earth to expand into our line of sight. "The detection of X-rays demonstrates that neutron star mergers can form powerful jets streaming out at near light speed," said Goddard’s Eleonora Troja, who led one of the Chandra teams and found the X-ray emission. "We had to wait for nine days to detect it because we viewed it from the side, unlike anything we had seen before."

On Aug. 22, NASA’s Hubble Space Telescope began imaging the kilonova and capturing its near-infrared spectrum, which revealed the motion and chemical composition of the expanding debris. "The spectrum looked exactly like how theoretical physicists had predicted the outcome of the merger of two neutron stars would appear," said Andrew Levan at the University of Warwick in Coventry, England, who led one of the proposals for Hubble spectral observations. "It tied this ob-

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Astronomers have identified a bumper crop of dual supermassive black holes in the centers of galaxies. This discovery could help astronomers better understand how giant black holes grow and how they may produce the strongest gravitational wave signals in the Universe. The new evidence reveals five pairs of supermassive black holes, each containing millions of times the mass of the Sun. These black hole couples formed when two galaxies collided and merged with each other, forcing their supermassive black holes close together. The black hole pairs were uncovered by combining data from a suite of different observatories including NASA's Chandra X-ray Observatory, the Wide-Field Infrared Survey Explorer (WISE), and the ground-based Large Binocular Telescope in Arizona.

"Astronomers find single supermassive black holes all over the universe," said Shobita Satyapal, from George Mason University in Fairfax, Virginia, who led one of two papers describing these results. "But even though we've predicted they grow rapidly when they are interacting, growing dual supermassive black holes have been difficult to find."

Before this study fewer than ten confirmed pairs of growing black holes were known from X-ray studies, based mostly on chance detections. To carry out a systematic search, the team had to carefully sift through data from telescopes that detect different wavelengths of light. Starting with the Galaxy Zoo project, researchers used optical data from the Sloan Digital Sky Survey (SDSS) to identify galaxies where it appeared that a merger between two smaller galaxies was underway. From this set, they selected objects where the separation between the centers of the two galaxies in the SDSS data is less than 30,000 light years, and the infrared colors from WISE data match those predicted for a rapidly growing supermassive black hole. Seven merging systems containing at least one supermassive black hole were found with this technique. Because strong X-ray emission is a hallmark of growing supermassive black holes, Satyapal and her colleagues then observed these systems with Chandra. Closely-separated pairs of X-ray sources were found in five systems, providing compelling evidence that they contain two growing (or feeding) supermassive black holes. Both the X-ray data from Chandra and the infrared observations suggest that the supermassive black holes are buried in large amounts of dust and gas.

"Our work shows that combining the infrared selection with X-ray follow-up is a very effective way to find these black hole pairs," said Sara Ellison of the University of Victoria in Canada, who led the other paper describing these results. "X-rays and infrared radiation are able to penetrate the obscuring clouds of gas and dust surrounding these black hole pairs, and Chandra's sharp vision is needed to separate them".

The paper led by Ellison used additional optical data (Continued on page 2)
sit under an umbrella, the umbrella reduces the amount of sunlight hitting your eyes in all wavelengths. But if you wait for the sunset, the sun looks red because the blue and ultraviolet light is scattered away by tiny particles. The new study suggests the objects causing the long-period dimming of Tabby's Star can be no more than a few micrometers in diameter (about one ten-thousandth of an inch).

From January to December 2016, the researchers observed Tabby's Star in ultraviolet using Swift, and in infrared using Spitzer. Supplementing the space telescopes, researchers also observed the star in visible light during the same period using AstroLAB IRIS, a public observatory with a 27-inch-wide (68 centimeter) reflecting telescope located near the Belgian village of Zillebeke.

Based on the strong ultraviolet dip, the researchers determined the blocking particles must be bigger than interstellar dust, small grains that could be located anywhere between Earth and the star. Such small particles could not remain in orbit around the star because pressure from its starlight would drive them farther into space. Dust that orbits a star, called circumstellar dust, is not so small it would fly away, but also not big enough to uniformly block light in all wavelengths. This is currently considered the best explanation, although others are possible.

**Collaboration with Amateur Astronomers**

Citizen scientists have had an integral part in exploring Tabby's Star since its discovery. Light from this object was first identified as "bizarre" and "interesting" by participants in the Planet Hunters project, which allows anyone to search for planets in the Kepler data. That led to a 2016 study formally introducing the object, which is nicknamed for Tabetha Boyajian, now at Louisiana State University, Baton Rouge, who was the lead author of the original paper and is a co-author of the new study. The recent work on long-period dimming involves amateur astronomers who provide technical and software support to AstroLAB.

Several AstroLAB team members who volunteer at the observatory have no formal astronomy education. Franky Dubois, who operated the telescope during the Tabby's Star observations, was the foreman at a seat belt factory until his retirement. Ludwig Logie, who helps with technical issues on the telescope, is a security coordinator in the construction industry. Steve Rau, who processes observations of star brightness, is a trainer at a Belgian railway company.

Siegfried Vanaverbeke, an AstroLAB volunteer who holds a Ph.D. in physics, became interested in Tabby's Star after reading the 2016 study, and persuaded Dubois, Logie and Rau to use Astrolab to observe it.

"I said to my colleagues: 'This would be an interesting object to follow,'" Vanaverbeke recalled. "We decided to join in."

University of Arizona astronomer George Rieke, a co-author on the new study, contacted the AstroLAB group when he saw their data on Tabby's Star posted in a public astronomy archive. The U.S. and Belgium groups teamed up to combine and analyze their results.

**Future Exploration**

While study authors have a good idea why Tabby's Star dims on a long-term basis, they did not address the shorter-term dimming events that happened in three-day spurts in 2017. They also did not confront the mystery of the major 20-percent dips in brightness that Kepler observed while studying the Cygnus field of its primary mission. Previous research with Spitzer and NASA's Wide-field Infrared Survey Explorer suggested a swarm of comets may be to blame for the short-period dimming. Comets are also one of the most common sources of dust that orbits stars, and so could also be related to the long-period dimming studied by Meng and colleagues.

Now that Kepler is exploring other patches of sky in its current mission, called K2, it can no longer follow up on Tabby's Star, but future telescopes may help unveil more secrets of this mysterious object.

"Tabby's Star could have something like a solar activity cycle. This is something that needs further investigation and will continue to interest scientists for many years to come," Vanaverbeke said.

Astronomers think a kilonova's visible and infrared light primarily arises through heating from the decay of radioactive elements formed in the neutron-rich debris.Crashing neutron stars may be the universe's dominant source for many of the heaviest elements, including platinum and gold.

Because of its Earth-trailing orbit, Spitzer was uniquely situated to observe the kilonova long after the Sun moved too close to the galaxy on the sky for other telescopes to see it. Spitzer's Sept. 30 observation captured the longest-wavelength infrared light from the kilonova, which unveils the quantity of heavy elements forged.
Mysterious Dimming of Tabby's Star May Be Caused by Dust

One of the most mysterious stellar objects may be revealing some of its secrets at last. Called KIC 8462852, also known as Boyajian's Star, or Tabby's Star, the object has experienced unusual dips in brightness -- NASA's Kepler space telescope even observed dimming of up to 20 percent over a matter of days. In addition, the star has had much subtler but longer-term enigmatic dimming trends, with one continuing today. None of this behavior is expected for normal stars slightly more massive than the Sun. Speculations have included the idea that the star swallowed a planet that it is unstable, and a more imaginative theory involves a giant contraption

This illustration depicts a hypothetical uneven ring of dust orbiting KIC 8462852, also known as Boyajian's Star or Tabby's Star. Astronomers have found the dimming of the star over long periods appears to be weaker at longer infrared wavelengths of light and stronger at shorter ultraviolet wavelengths. Such reddening is characteristic of dust particles and inconsistent with more fanciful alien megastructure concepts, which would evenly dim all wavelengths of light. By studying observations from NASA's Spitzer and Swift telescopes, as well as the Belgian AstroLAB IRIS observatory, the researchers have been able to better constrain the size of the dust particles. This places them within the range found in dust disks orbiting stars, and larger than the particles typically found in interstellar dust. The system is portrayed with a couple of comets, consistent with previous studies that have found evidence for cometary activity within the system.

or "megastructure" built by an advanced civilization, which could be harvesting energy from the star and causing its brightness to decrease.

A new study using NASA's Spitzer and Swift missions, as well as the Belgian AstroLAB IRIS observatory, suggests that the cause of the dimming over long periods is likely an uneven dust cloud moving around the star. This flies in the face of the "alien megastructure" idea and the other more exotic speculations.

The smoking gun: Researchers found less dimming in the infrared light from the star than in its ultraviolet light. Any object larger than dust particles would dim all wavelengths of light equally when passing in front of Tabby's Star.

"This pretty much rules out the alien megastructure theory, as that could not explain the wavelength-dependent dimming," said Huan Meng, at the University of Arizona, Tucson, who is lead author of the new study. "We suspect, instead, there is a cloud of dust orbiting the star with a roughly 700-day orbital period."

Why Dust is Likely

We experience the uniform dimming of light often in everyday life: If you go to the beach on a bright, sunny day and

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Giant Exoplanet Hunters: Look for Debris Disks

There's no map showing all the billions of exoplanets hiding in our galaxy -- they're so distant and faint compared to their stars, it's hard to find them. Now, astronomers hunting for new worlds have established a possible signpost for giant exoplanets.

A new study finds that giant exoplanets that orbit far from their stars are more likely to be found around young stars that have a disk of dust and debris than those without disks. The study, published in The Astronomical Journal, focused on planets more than five times the mass of Jupiter. This study is the largest to date of stars with dusty debris disks, and has found the best evidence yet that giant planets are responsible for keeping that material in check.

"Our research is important for how future missions will plan which stars to observe," said Tiffany Meshkat, lead author and assistant research scientist at IPAC/Caltech in Pasadena, California. Meshkat worked on this study as a postdoctoral researcher at NASA's Jet Propulsion Laboratory in Pasadena. "Many planets that have been found through direct imaging have been in systems that had debris disks, and now we know the dust could be indicators of undiscovered worlds."

Astronomers found the likelihood of finding long-period giant planets is nine times greater for stars with debris disks than stars without disks. Caltech graduate student Marta Bryan performed the statistical analysis that determined this result.

Researchers combined data from 130 single-star systems with debris disks detected by NASA's Spitzer Space Telescope, and compared them with 277 stars that do not appear to host disks. The two star groups were between a few million and 1 billion years old. Of the 130 stars, 100 were previously scanned for exoplanets. As part of this study, researchers followed up on the other 30 using the W. M. Keck Observatory in Hawaii and the European Southern Observatory's Very Large Telescope in Chile. They did not detect any new planets in those 30 systems, but the additional data helped characterize the abundance of planets in systems with disks.

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The research does not directly resolve why the giant exoplanets would cause debris disks to form. Study authors suggest the massive gravity of giant planets causes small bodies called planetesimals to collide violently, rather than form proper planets, and remain as part of a disk.

"It's possible we don't find small planets in these systems because, early on, these massive bodies destroyed the building blocks of rocky planets, sending them smashing into each other at high speeds instead of gently combining," said co-author Dimitri Mawet, a Caltech associate professor of astronomy and a JPL senior research scientist.

On the other hand, giant exoplanets are easier to detect than rocky planets, and it is possible that there are some in these systems that have not yet been found.

Our own solar system is home to gas giants responsible for making "debris belts" -- the asteroid belt between Mars and Jupiter, shaped by Jupiter, and the Kuiper Belt, shaped by Neptune. Many of the systems Meshkat and Mawet studied also have two belts, but they are also much younger than ours -- up to 1 billion years old, compared to our system's present age of 4.5 billion years. The youth of these systems partly explains why they contain much more dust -- resulting from the collisions of small bodies -- than ours does.

One system discussed in the study is Beta Pictoris, which has been directly imaged from ground-based telescopes. This system has a debris disk, comets and one confirmed exoplanet. In fact, scientists predicted this planet's existence well before it was confirmed, based on the presence and structure of the prominent disk.

In a different scenario, the presence of two dust belts in a single debris disk suggests there are likely more planets in the system whose gravity maintains these belts, as is the case in the HR8799 system of four giant planets. The gravitational forces of giant planets nudge passing comets inward toward the star, which could mimic the period of our solar system's history about 4 billion years ago known as the Late Heavy Bombardment. Scientists think that during that period, the migration of Jupiter, Saturn, Uranus and Neptune deflected dust and small bodies into the Kuiper and asteroid belts we see today. When the Sun was young, there would have been a lot more dust in our solar system as well.

"By showing astronomers where future missions such as NASA's James Webb Space Telescope have their best chance to find giant exoplanets, this research paves the way to future discoveries," said Karl Stapelfeldt of JPL, chief scientist of NASA's Exoplanet Exploration Program Office and study co-author.
Hubble Observes Exoplanet that Snows Sunscreen

NASA’s Hubble Space Telescope has found a blistering hot planet outside our solar system where it “snows” sunscreen. The problem is the sunscreen (titanium oxide) precipitation only happens on the planet's permanent nighttime side. Any possible visitors to the exoplanet, called Kepler-13Ab, would need to bottle up some of that sunscreen, because they won’t find it on the sizzling hot, daytime side, which always faces its host star.

Hubble astronomers suggest that powerful winds carry the titanium oxide gas around to the colder nighttime side, where it condenses into crystalline flakes, forms clouds, and precipitates as snow. Kepler-13Ab’s strong surface gravity — six times greater than Jupiter’s — pulls the titanium oxide snow out of the upper atmosphere and traps it in the lower atmosphere.

Astronomers using Hubble didn’t look for titanium oxide specifically. Instead, they observed that the giant planet’s atmosphere is cooler at higher altitudes, which is contrary to what was expected. This finding led the researchers to conclude that a light-absorbing gaseous form of titanium oxide, commonly found in this class of star-hugging, gas giant planet known as a “hot Jupiter,” has been removed from the dayside’s atmosphere.

The Hubble observations represent the first time astronomers have detected this precipitation process, called a “cold trap,” on an exoplanet.

Without the titanium oxide gas to absorb incoming starlight on the daytime side, the atmospheric temperature grows colder with increasing altitude. Normally, titanium oxide in the atmospheres of hot Jupiters absorbs light and reradiates it as heat, making the atmosphere grow warmer at higher altitudes.

These kinds of observations provide insight into the complexity of weather and atmospheric composition on exoplanets, and may someday be applicable to analyzing Earth-size planets for habitability.

"In many ways, the atmospheric studies we're doing on hot Jupiters now are testbeds for how we're going to do atmospheric studies on terrestrial, Earth-like planets," said lead researcher Thomas Beatty of Pennsylvania State University in University Park. "Hot Jupiters provide us with the best views of what climates on other worlds are like. Understanding the atmospheres on these planets and how they work, which is not understood in detail, will help us when we study these smaller planets that are harder to see and have more complicated features in their atmospheres."

Beatty's team selected Kepler-13Ab because it is one of the hottest of the known exoplanets, with a dayside temperature of nearly 5,000 degrees Fahrenheit. Past observations of other hot Jupiters have revealed that the upper atmospheres increase in temperature. Even at their much colder temperatures, most of our solar system’s gas giants also exhibit this phenomenon.

Kepler-13Ab is so close to its parent star that it is tidally locked. One side of the planet always faces the star; the other side is in permanent darkness. (Similarly, our moon is tidally locked to Earth; only one hemisphere is permanently visible from Earth.)

The observations confirm a theory from several years ago that this kind of precipitation could occur on massive,