COMING EVENTS
PUBLIC OBSERVING

POST BAND CONCERT
SOUTH PARK
West of MASS. ST.
July 12
9:15PM

President
Rick Heschmeyer
rickheschmeyer@gmail.com

ALCOR
William Winkler
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University Advisor
Dr. Bruce Twarog
btwarog@ku.edu

Report from the Officers
The unpredictable weather continues as we approach the final summer observing session after the Band Concert downtown. Despite the high likelihood of thunderstorms for each of the previous observing sessions, clearing skies at the appropriate time, short-lived though they may be, have allowed some form of observing at each of the last three sessions. As always, check with Rick via email and/or Facebook for the latest of the last observing session.

Speaking of Rick and email, Rick Heschmeyer had some issues with email on his previous address and has switched to a new address. So, if you are attempting to communicate with Rick, please note that his new address is rickheschmeyer@gmail.com

Club Alcor, Bill Winkler, has noted that the July 3 issue of Time magazine includes a

The Curious Case of the Warped Kuiper Belt
(Another chapter in the ongoing saga to understand the solar system beyond Neptune and the search for Planet 9)

An unknown, unseen "planetary mass object" may lurk in the outer reaches of our solar system, according to new research on the orbits of minor planets. This object would be different from -- and much closer than -- the so-called Planet Nine, a planet whose existence yet awaits confirmation. Kat Volk and Renu Malhotra of the University of Arizona's Lunar and Planetary Laboratory, or LPL, present compelling evidence of a yet-to-be-discovered planetary body with a mass somewhere between that of Mars and Earth. The mysterious mass, the authors show, has given away its presence -- for now -- only by controlling the orbital planes of a population of space rocks known as Kuiper Belt objects, or KBOs, in the icy outskirts of the solar system.

While most KBOs -- debris left over from the formation of the solar system -- orbit the sun with orbital tilts (inclinations) that average out to what planetary scientists call the invariable plane of the solar system, the most distant of the Kuiper Belt's
About the Astronomy Associates of Lawrence

The club is open to all people interested in sharing their love for astronomy. Beginning in Fall 2016, monthly meetings are typically on the last Sunday of each month and often feature guest speakers, presentations on the latest in optical & radio astronomy. The featured speaker: Maria Hamilton, Physics Professor at Marshall University, will give the "Keynote Presentation" Saturday evening. Clinics and additional presentations held daily (indoors) on multiple subjects including Astrophotography. If you have an interest, deadlines for registration are approaching fast, so go to their website and see if this suits your interests: http://www.greenbankstarquest.org/

For those of you who enjoy the company and interaction of large star parties and are looking for a reason to travel to the lovely mountains of West Virginia, the 14th Annual OPTICAL and RADIO ASTRONOMY Star Party will be held at the Green Bank Observatory, Green Bank WV from July 19th - 22nd, 2017. They will have a distinguished keynote speaker EVERY evening, with presentations on the latest in optical & radio astronomy. The featured speaker: Maria Hamilton, Physics Professor at Marshall University, will give the "Keynote Presentation" Saturday evening. Clinics and additional presentations held daily (indoors) on multiple subjects including Astrophotography. If you have an interest, deadlines for registration are approaching fast, so go to their website and see if this suits your interests: http://www.greenbankstarquest.org/

Any suggestions for improving the club or the newsletter are always welcome.

(Continued from page 8)

objects do not. Their average plane, Volk and Malhotra discovered, is tilted away from the invariable plane by about eight degrees. In other words, something unknown is warping the average orbital plane of the outer solar system. "The most likely explanation for our results is that there is some unseen mass," says Volk, a postdoctoral fellow at LPL and the lead author of the study. "According to our calculations, something as massive as Mars would be needed to cause the warp that we measured."

The Kuiper Belt lies beyond the orbit of Neptune and extends to a few hundred Astronomical Units, or AU, with one AU representing the distance between Earth and the sun. Like its inner solar system cousin, the asteroid belt between Mars and Jupiter, the Kuiper Belt hosts a vast number of minor planets, mostly small icy bodies (the precursors of comets), and a few dwarf planets. For the study, Volk and Malhotra analyzed the tilt angles of the orbital planes of more than 600 objects in the Kuiper Belt in order to determine the common direction about which these orbital planes all precess. Precession refers to the slow change or "wobble" in the orientation of a rotating object.

KBOs operate in an analogous way to spinning tops, explains Malhotra, who is a Louise Foucar Marshall Science Research Professor and Regents' Professor of Planetary Sciences at LPL. "Imagine you have lots and lots of fast-spinning tops, and you..."
Hubble Captures Massive Dead Disk Galaxy that Challenges Theories of Galaxy Evolution

By combining the power of a "natural lens" in space with the capability of NASA's Hubble Space Telescope, astronomers made a surprising discovery—the first example of a compact yet massive, fast-spinning, disk-shaped galaxy that stopped making stars only a few billion years after the big bang. Finding such a galaxy early in the history of the universe challenges the current understanding of how massive galaxies form and evolve, say researchers.

When Hubble photographed the galaxy, astronomers expected to see a chaotic ball of stars formed through galaxies merging together. Instead, they saw evidence that the stars were born in a pancake-shaped disk. This is the first direct observational evidence that at least some of the earliest so-called "dead" galaxies — where star formation stopped — somehow evolve from a Milky Way-shaped disk into the giant elliptical galaxies we see today. This is a surprise because elliptical galaxies contain older stars, while spiral galaxies typically contain younger blue stars. At least some of these early "dead" disk galaxies must have gone through major makeovers. They not only changed their structure, but also the motions of their stars to make a shape of an elliptical galaxy.

"This new insight may force us to rethink the whole cosmological context of how galaxies burn out early on and evolve into local elliptical-shaped galaxies," said study leader Sune Toft of the Dark Cosmology Center at the Niels Bohr Institute, University of Copenhagen, Denmark. "Perhaps we have been blind to the fact that early "dead" galaxies could in fact be disks, simply because we haven't been able to resolve them."

Previous studies of distant dead galaxies have assumed that their structure is similar to the local elliptical galaxies they will evolve into. Confirming this assumption in principle requires more powerful space telescopes than are currently available. However, through the phenomenon known as "gravitational lensing," a massive, foreground cluster of galaxies acts as a natural "zoom lens" in space by magnifying and stretching images of far more distant background galaxies. By joining this natural lens with the resolving power of Hubble, scientists were able to see into the center of the dead galaxy.

The remote galaxy is three times as massive as the Milky Way but only half the size. Rotational velocity measurements made with the European Southern Observatory's Very Large Telescope (VLT) showed that the disk galaxy is spinning more than twice as fast as the Milky Way.

Using archival data from the Cluster Lensing And Supernova survey with Hubble (CLASH), Toft and his team were able to determine the stellar mass, star-formation rate, and the ages of the stars.

Why this galaxy stopped forming stars is still unknown. It may be the result of an active galactic nucleus, where energy is gushing from a supermassive black hole. This energy inhibits star formation by heating the gas or expelling it from the galaxy. Or it may be the result of the cold gas streaming onto the galaxy being rapidly compressed and heated up, preventing it from cooling down into star-forming clouds in the galaxy's center.

But how do these young, massive, compact disks evolve into the elliptical galaxies we see in the present-day universe? "Probably through mergers," Toft said. "If these galaxies grow through merging with minor companions, and these minor companions come in large numbers and from all sorts of different angles onto the galaxy, this would eventually randomize the orbits of stars in the galaxies. You could also imagine major mergers. This would definitely also destroy the ordered motion of the stars."
The Shape of the Solar System  By Marcus Woo

When Stamatios (Tom) Krimigis was selected for the Voyager mission in 1971, he became the team’s youngest principal investigator of an instrument, responsible for the Low Energy Charged Particles (LECP) instrument. It would measure the ions coursing around and between the planets, as well as those beyond. Little did he know, though, that more than 40 years later, both Voyager 1 and 2 still would be speeding through space, continuing to literally reshape our view of the solar system. The solar system is enclosed in a vast bubble, carved out by the solar wind blowing against the gas of the interstellar medium. For more than half a century, scientists thought that as the sun moved through the galaxy, the interstellar medium would push back on the heliosphere, elongating the bubble and giving it a pointy, comet-like tail similar to the magnetospheres—bubbles formed by magnetic fields—surrounding Earth and most of the other planets.

"We in the heliophysics community have lived with this picture for 55 years," said Krimigis, of The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "And we did that because we didn't have any data. It was all theory."

But now, he and his colleagues have the data. New measurements from Voyager and the Cassini spacecraft suggest that the bubble isn't pointy after all. It's spherical. Their analysis relies on measuring high-speed particles from the heliosphere boundary. There, the heated ions from the solar wind can strike neutral atoms coming from the interstellar medium and snatch away an electron. Those ions become neutral atoms, and ricochet back toward the sun and the planets, uninhibited by the interplanetary magnetic field.

Voyager is now at the edge of the heliosphere, where its LECP instrument can detect those solar-wind ions. The researchers found that the number of measured ions rise and fall with increased and decreased solar activity, matching the 11-year solar cycle, showing that the particles are indeed originating from the sun. Meanwhile, Cassini, which launched 20 years after Voyager in 1997, has been measuring those neutral atoms bouncing back, using another instrument led by Krimigis, the Magnetosphere Imaging Instrument (MIMI). Between 2003 and 2014, the number of measured atoms soared and dropped in the same way as the ions, revealing that the latter begat the former. The neutral atoms must therefore come from the edge of the heliosphere. If the heliosphere were comet-shaped, atoms from the tail would take longer to arrive at MIMI than those from the head. But the measurements from MIMI, which can detect incoming atoms from all directions, were the same everywhere. This suggests the distance to the heliosphere is the same every which way. The heliosphere, then, must be round, upending most scientists' prior assumptions. It's a discovery more than four decades in the making. As Cassini ends its mission this year, the Voyager spacecraft will continue blazing through interstellar space, their remarkable longevity having been essential for revealing the heliosphere's shape.

"Without them," Krimigis says, "we wouldn't be able to do any of this."
They created a job for me," he said.

Pyle, whose background is in Hollywood special effects, joined Hurt in 2004. Hurt turns to Pyle for artistic inspiration, while Pyle relies on Hurt to check his science.

"Robert and I have our desks right next to each other, so we're constantly giving each other feedback," Pyle said. "We're each upping each other's game, I think."

The TRAPPIST-1 worlds offered both of them a unique challenge. The two already had a reputation for illustrating many exoplanets - planets around stars beyond our own -- but never seven Earth-sized worlds in a single system. The planets cluster so close to their star that a "year" on each of them -- the time they take to complete a single orbit -- can be numbered in Earth days. And like the overwhelming majority of the thousands of exoplanets found so far, they were detected using indirect means. No telescope exists today that is powerful enough to photograph them.

Real science informed their artistic vision. Using data from the telescopes that reveal each planet's diameter as well as its "weight," or mass, and known stellar physics to determine the amount of light each planet would receive, the artists went to work. Both consulted closely with the planets' discovery team as they planned for a NASA announcement to coincide with a report in the journal Nature.

"When we're doing these artist's concepts, we're never saying, 'This is what these planets actually look like,'" Pyle said. "We're doing plausible illustrations of what they could look like, based on what we know so far. Having this wide range of seven planets actually let us illustrate almost the whole breadth of what would be plausible. This was going to be this incredible interstellar laboratory for what could happen on an Earth-sized planet."

For TRAPPIST-1b, Pyle took Jupiter's volcanic moon, Io, as an inspiration, based on suggestions from the science team. For the outermost world, TRAPPIST-1h, he chose two other Jovian moons, the ice-encased Ganymede and Europa. After talking to the scientists, Hurt portrayed TRAPPIST-1c as dry and rocky. But because all seven planets are probably tidally locked, forever presenting one face to their star and the other to the cosmos, he placed an ice cap on the dark side. TRAPPIST-1d was one of three that fall inside the "habitable zone" of the star, or the right distance away from it to allow possible liquid water on the surface.

"The researchers told us they would like to see it portrayed as something they called an 'eyeball world,'" Hurt said. "You have a dry, hot side that's facing the star and an ice cap on the back side. But somewhere in between, you have (a zone) where the ice could melt and be sustained as liquid water."

At this point, Hurt said, art intervened. The scientists rejected his first version of the planet, which showed liquid water intruding far into the "dayside" of TRAPPIST-1d. They argued that the water would most likely be found well within the planet's dark half.

"Then I kind of pushed back, and said, 'If it's on the dark side, no one can look at it and understand we're saying there's water there,'" Hurt said. They struck a compromise: more water toward the dayside than the science team might expect, but a better visual representation of the science.

The same push and pull between science and art extends to other forms of astronomical visualization, whether it's a Valentine's Day cartoon of a star pulsing like a heart in time with its planet, or materials for the blockbuster announcement of the first detection of gravitational waves by the Laser Interferometer Gravitational-Wave Observatory in February 2016. They've also illustrated asteroids, neutron stars, pulsars and brown dwarfs. Visualizations based on data can also inform science, leading to genuine scientific insights. The scientists' conclusions about TRAPPIST-1 at first seemed to suggest the planets would be bathed in red light, potentially obscuring features like blue-hued bodies of water.

"It makes it hard to really differentiate what is going on," Hurt said.

Hurt decided to investigate. A colleague provided him with a spectrum of a red dwarf star similar to TRAPPIST-1. He overlaid that with the "responsivity curves" of the human eye, and found that most of the scientists' "red" came from infrared light, invisible to human eyes. Subtract that, and what is left is a more reddish-orange hue that we might see standing on the surface of a TRAPPIST-1 world -- "kind of the same color you would expect to get from a low-wattage light bulb," Hurt said. "And the scientists looked at that and said, 'Oh, ok, great, it's orange.' When the math tells you the answer, there really isn't a lot to argue about."

For Hurt, the real goal of scientific illustration is to excite the public, engage them in the science, and provide a snapshot of scientific knowledge.

"If you look at the whole history of space art, reaching back many, many decades, you will find you have a visual record," he said. "The art is a historical record of our changing understanding of the universe. It becomes a part of the story, and a part of the research, I think."
Mini-Flares Potentially Jeopardize Habitability of Planets Circling Red Dwarf Stars

Cool dwarf stars are hot targets for exoplanet hunting right now. The discoveries of planets in the habitable zones of the TRAPPIST-1 and LHS 1140 systems, for example, suggest that Earth-sized worlds might circle billions of red dwarf stars, the most common type of star in our galaxy. But, like our own sun, many of these stars erupt with intense flares. Are red dwarfs really as friendly to life as they appear, or do these flares make the surfaces of any orbiting planets inhospitable?

To address this question, a team of scientists has combed 10 years of ultraviolet observations by the Galaxy Evolution Explorer (GALEX) spacecraft looking for rapid increases in the brightnesses of stars due to flares. Flares emit radiation across a wide swath of wavelengths, with a significant fraction of their total energy released in the ultraviolet bands where GALEX observed. At the same time, the red dwarfs from which the flares arise are relatively dim in the ultraviolet. This contrast, combined with the time resolution of the GALEX detectors, allowed the team to measure events with less total energy than many previously detected flares. This is important because, although individually less energetic and therefore less hostile to life, smaller flares might be much more frequent and add up over time to produce a cumulative effect.

“What if planets are constantly bathed by these smaller, but still significant, flares?” asked Scott Fleming of the Space Telescope Science Institute (STScI) in Baltimore, Maryland. “There could be a cumulative effect.”

To detect and accurately measure these flares, the team had to slice the GALEX data into very high time resolution. From images with exposure times of nearly half an hour, the team was able to reveal stellar variations lasting just seconds.

First author Chase Million of Million Concepts in State College, Pennsylvania, led a project called gPhoton that reprocessed more than 100 terabytes of GALEX data held at the Mikulski Archive for Space Telescopes (MAST), located at STScI. The team then used custom software developed by Million and Clara Brasseur (STScI) to search several hundred red dwarf stars and detected dozens of flares.

This illustration shows a red dwarf star orbited by a hypothetical exoplanet. Red dwarfs tend to be magnetically active, displaying gigantic arcing prominences and a wealth of dark sunspots. Red dwarfs also erupt with intense flares that could strip a nearby planet’s atmosphere over time, or make the surface inhospitable to life as we know it. By mining data from the Galaxy Evolution Explorer spacecraft, a team of astronomers identified dozens of flares at a range of durations and strengths. The team measured events with less total energy than many previously detected flares from red dwarfs. This is important because, although individually less energetic and therefore less hostile to life, smaller flares might be much more frequent and add up over time to produce a cumulative effect on an orbiting planet.
The moon hanging in the night sky sent Robert Hurt's mind into deep space -- to a region some 40 light years away, in fact, where seven Earth-sized planets crowded close to a dim, red sun. Hurt, a visualization scientist at Caltech's IPAC center, was walking outside his home in Mar Vista, California, shortly after he learned of the discovery of these rocky worlds around a star called TRAPPIST-1 and got the assignment to visualize them. The planets had been revealed by NASA's Spitzer Space Telescope and ground-based observatories.

"I just stopped dead in my tracks, and I just stared at it," Hurt said in an interview. "I was imagining that could be, not our moon, but the next planet over -- what it would be like to be in a system where you could look up and see continental features on the next planet."

So began a kind of inspirational avalanche. Hurt and his colleague, multimedia producer Tim Pyle, developed a series of arresting, photorealistic images of what the new system's tightly packed planets might look like -- so tightly packed that they would loom large in each other's skies. Their visions of the TRAPPIST-1 system would appear in leading news outlets around the world.

Artists like Hurt and Pyle, who render vibrant visualizations based on data from Spitzer and other missions, are hybrids of sorts, blending expertise in both science and art. From squiggles on charts and columns of numbers, they conjure red, blue and green worlds, with half-frozen oceans or bubbling lava. Or they transport us to the surface of a world with a red-orange sun fixed in place, and a sky full of planetary companions.

"For the public, the value of this is not just giving them a picture of something somebody made up," said Douglas Hudgins, a program scientist for the Exoplanet Exploration Program at NASA Headquarters in Washington. "These are real, educated guesses of how something might look to human beings. An image is worth a thousand words."

Hurt says he and Pyle are building on the work of artistic pioneers.

"There's actually a long history and tradition for space art and science-based illustration," he said. "If you trace its roots back to the artist Chesley Bonestell (famous in the 1950s and '60s), he really was the artist who got this idea: Let's go and imagine what the planets in our solar system might actually look like if you were, say, on Jupiter's moon, Io. How big would Jupiter appear in the sky, and what angle would we be viewing it from?"

To begin work on their visualizations, Hurt divided up the seven TRAPPIST-1 planets with Pyle, who shares an office with him at Caltech's IPAC center in Pasadena, California. Hurt holds a Ph.D. in astrophysics, and has worked at the center since he was a post-doctoral researcher in 1996 - when astronomical art was just his hobby.

(Continued on page 5)
give each one a slight nudge," she says. "If you then take a snapshot of them, you will find that their spin axes will be at different orientations, but on average, they will be pointing to the local gravitational field of Earth. "We expect each of the KBOs' orbital tilt angle to be at a different orientation, but on average, they will be pointing perpendicular to the plane determined by the sun and the big planets."

If one were to think of the average orbital plane of objects in the outer solar system as a sheet, it should be quite flat past 50 AU, according to Volk. "But going further out from 50 to 80 AU, we found that the average plane actually warps away from the invariable plane," she explains. "There is a range of uncertainties for the measured warp, but there is not more than 1 or 2 percent chance that this warp is merely a statistical fluke of the limited observational sample of KBOs." In other words, the effect is most likely a real signal rather than a statistical fluke. According to the calculations, an object with the mass of Mars orbiting roughly 60 AU from the sun on an orbit tilted by about eight degrees (to the average plane of the known planets) has sufficient gravitational influence to warp the orbital plane of the distant KBOs within about 10 AU to either side.

"The observed distant KBOs are concentrated in a ring about 30 AU wide and would feel the gravity of such a planetary mass object over time," Volk said, "so hypothesizing one planetary mass to cause the observed warp is not unreasonable across that distance." This rules out the possibility that the postulated object in this case could be the hypothetical Planet Nine, whose existence has been suggested based on other observations. That planet is predicted to be much more massive (about 10 Earth masses) and much farther out at 500 to 700 AU.

"That is too far away to influence these KBOs," Volk said. "It certainly has to be much closer than 100 AU to substantially affect the KBOs in that range." Because a planet, by definition, has to have cleared its orbit of minor planets such as KBOs, the authors refer to the hypothetical mass as a planetary mass object. The data also do not rule out the possibility that the warp could result from more than one planetary mass object.

So why haven't we found it yet? Most likely, according to Malhotra and Volk, because we haven't yet searched the entire sky for distant solar system objects. The most likely place a planetary mass object could be hiding would be in the galactic plane, an area so densely packed with stars that solar system surveys tend to avoid it. "The chance that we have not found such an object of the right brightness and distance simply because of the limitations of the surveys is estimated to be to about 30 percent," Volk said. A possible alternative to an unseen object that could have ruffled the plane of outer Kuiper Belt objects could be a star that buzzed the solar system in recent (by astronomical standards) history, the authors said. "A passing star would draw all the 'spinning tops' in one direction," Malhotra said. "Once the star is gone, all the KBOs will go back to precessing around their previous plane. That would have required an extremely close passage at about 100 AU, and the warp would be erased within 10 million years, so we don't consider this a likely scenario." Humankind's chance to catch a glimpse of the mysterious object might come fairly soon once construction of the Large Synoptic Survey Telescope is completed. Run by a consortium that includes the UA and scheduled for first light in 2020, the instrument will take unprecedented, real-time surveys of the sky, night after night.

"We expect LSST to bring the number of observed KBOs from currently about 2000 to 40,000," Malhotra said. "There are a lot more KBOs out there -- we just have not seen them yet. Some of them are too far and dim even for LSST to spot, but because the telescope will cover the sky much more comprehensively than current surveys, it should be able to detect this object, if it's out there."
effect is like looking at objects at the bottom of a swimming pool. The water distorts your view, just as the lensing galaxies' gravity stretches the shapes of the distant galaxies. "We need to understand the nature and scale of those lensing effects to interpret properly what we're seeing in the distant, early universe," Lowenthal said. "This applies not only to these brightest infrared galaxies, but probably to most or maybe even all distant galaxies."

Lowenthal's team is halfway through its Hubble survey of 22 galaxies. An international team of astronomers first discovered the galaxies in far-infrared light using survey data from the European Space Agency's (ESA) Planck space observatory, and some clever sleuthing. The team then compared those sources to galaxies found in ESA's Herschel Space Observatory's catalog of far-infrared objects and to ground-based radio data taken by the Very Large Array in New Mexico. The researchers next used the Large Millimeter Telescope (LMT) in Mexico to measure their exact distances from Earth. The LMT's far-infrared images also revealed multiple objects, hinting that the galaxies were being gravitationally lensed. These bright objects existed between 8 billion and 11.5 billion years ago, when the universe was making stars more vigorously than it is today. The galaxies' star-birth production is 5,000 to 10,000 times higher than that of our Milky Way. However, the ultra-bright galaxies are pumping out stars using only the same amount of gas contained in the Milky Way.

So, the nagging question is, what is powering the prodigious star birth? "We've known for two decades that some of the most luminous galaxies in the universe are very dusty and massive, and they're undergoing bursts of star formation," Lowenthal said. "But they've been very hard to study because the dust makes them practically impossible to observe in visible light. They're also very rare: they don't appear in any of Hubble's deep-field surveys. They are in random parts of the sky that nobody's looked at before in detail. That's why finding that they are gravitationally lensed is so important." These galaxies may be the brighter, more distant cousins of the ultra-luminous infrared galaxies (ULIRGS), hefty, dust-cooed, starburst galaxies, seen in the nearby universe. The ULIRGS' star-making output is stoked by the merger of two spiral galaxies, which is one possibility for the stellar baby boom in their more-distant relatives. However, Lowenthal said that computer simulations of the birth and growth of galaxies show that major mergers occur at a later epoch than the one in which these galaxies are seen.

Another idea for the star-making surge is that lots of gas, the material that makes stars, is flooding into the faraway galaxies. "The early universe was denser, so maybe gas is raining down on the galaxies, or they are fed by some sort of channel or conduit, which we have not figured out yet," Lowenthal said. "This is what theoreticians struggle with: How do you get all the gas into a galaxy fast enough to make it happen?"

The research team plans to use Hubble and the Gemini Observatory in Hawaii to try to distinguish between the foreground and background galaxies so they can begin to analyze the details of the brilliant monster galaxies. Future telescopes, such as NASA's James Webb Space Telescope, an infrared observatory scheduled to launch in 2018, will measure the speed of the galaxies' stars so that astronomers can calculate the mass of these ultra-luminous objects.

"The sky is covered with all kinds of galaxies, including those that shine in far-infrared light," Lowenthal said. "What we're seeing here is the tip of the iceberg: the very brightest of all."

"We have found dwarf star flares in the whole range that we expected GALEX to be sensitive to, from itty bitty baby flares that last a few seconds, to monster flares that make a star hundreds of times brighter for a few minutes," said Million.

The flares GALEX detected are similar in strength to flares produced by our own sun. However, because a planet would have to orbit much closer to a cool, red dwarf star to maintain a temperature friendly to life as we know it, such planets would be subjected to more of a flare's energy than Earth. Large flares can strip away a planet's atmosphere. Strong ultraviolet light from flares that penetrates to a planet's surface could damage organisms or prevent life from arising. Currently, team members Rachel Osten (STScI) and Brasseur are examining stars observed by both the GALEX and Kepler missions to look for similar flares. The team expects to eventually find hundreds of thousands of flares hidden in the GALEX data.

"These results show the value of a survey mission like GALEX, which was instigated to study the evolution of galaxies across cosmic time and is now having an impact on the study of nearby habitable planets," said Don Neill, research scientist at Caltech in Pasadena, California, who was part of the GALEX collaboration. "We did not anticipate that GALEX would be used for exoplanets when the mission was designed."

New and powerful instruments like the James Webb Space Telescope, scheduled for launch in 2018, ultimately will be needed to study atmospheres of planets orbiting nearby red dwarf stars and search for signs of life. But as researchers pose new questions about the cosmos, archives of data from past projects and missions, like those held at MAST, continue to produce exciting new scientific results.
Bizarro Comet Challenging Researchers

Scientists pursue research through observation, experimentation and modeling. They strive for all of these pieces to fit together, but sometimes finding the unexpected is even more exciting. That's what happened to University of Central Florida's astrophysicist Gal Sarid, who studies comets, asteroids and planetary formation and earlier this year was part of a team that published a study focused on the comet 174P/Echeclus. It didn't behave the way the team was expecting. "This is another clue that Echeclus is a bizarre solar system object," said University of South Florida physics research Professor Maria Womack, who leads the team.

Comets streak across the sky and as they get closer to the sun look like bright fuzz balls with extended luminous trails in their wake. However, comets are actually bulky spheres of mixed ice and rock, many of them also rich in other frozen volatile compounds, such as carbon monoxide, carbon dioxide, hydrogen cyanide and methanol. Comets heat up as they get closer to the sun, losing their icy layers by sublimation and producing emission jets of water vapor, other gases and dust expelled from the comet nucleus, Sarid said.

Once they move away from the sun, they cool off again. But some comets start showing emission activity while still very far from the sun, where heating is low.

That's what Sarid and Womack research as they study these kinds of distantly active comets. Womack and graduate student Kacper Wierzchos used the Arizona Radio Observatory Submillimeter telescope to observe Echeclus last year as it approached the sun. This work will be part of Wierzchos' doctoral dissertation in applied physics at USF. Sarid provided theoretical expertise for interpreting the observational results. Echeclus is part of the population of objects called centaurs, which have orbits around the sun at distances between that of Jupiter and Neptune. It is also part of a special group within the centaurs, which sometimes exhibit comet-like activity. Previous research indicated that Echeclus might have been spewing carbon monoxide as its icy material changed phases.

The team found that the levels of carbon monoxide were nearly 40 times lower than typically expected from other comets at similar distances from the sun. This suggests that Echeclus and similar active Centaurs may be more fragile than other comets. Echeclus may have gone through a different physical process from most comets that caused it to lose a lot of its original carbon monoxide, or it may have had less of that substance to begin with. Understanding the composition of comets and how they work will help researchers understand how our solar system was formed. It will also aid space explorers plan for their travels -- things to avoid and perhaps hidden resources found within the nucleus of comets that may be useful on deep space missions.

"These are minor bodies that we are studying, but they can provide major insights," Sarid said. "We believe they are rich in organics and could provide important hints of how life originated." Sarid is determined to solve the puzzle. This week he hosts a group of comet experts at UCF to discuss the mysterious activity of Echeclus and other similar bodies. The idea for the workshop is to capitalize on the local expertise in observation, laboratory and theoretical work that is required to fully understand the mysteries of active comets at great distances from the sun. The inaugural Florida Distant Comets workshop was held a year ago at USF. "I guess I've always liked challenges," Sarid said from his office at the Florida Space Institute at UCF, where he spends his days trying to decipher the models and mathematical equations related to his work.

Sarid has a Ph.D. in geophysics and planetary Sciences from Tel Aviv University in Israel and completed postdoctoral work at the Institute for Astronomy and the NASA Astrobiology Institute in Hawaii, followed by a second postdoctoral research appointment at Harvard University. He was a part of a team that used the telescopes in Hawaii for several years chasing comets and asteroids for NASA observing campaigns and space missions before joining UCF in 2014. He teamed up with Womack in 2016 and on this most recent study provided theoretical expertise for interpreting the observational results. The National Science Foundation funds the project, under a grant awarded to USF, with Womack as the principal investigator and Sarid as a co-investigator. They will continue to look at centaur-type comets and measure the level of their carbon monoxide emission and related activity.
Jackpot! Cosmic Magnifying-Glass Effect Captures Universe’s Brightest Galaxies

Boosted by natural magnifying lenses in space, NASA's Hubble Space Telescope has captured unique close-up views of the universe's brightest infrared galaxies, which are as much as 10,000 times more luminous than our Milky Way.

The galaxy images, magnified through a phenomenon called gravitational lensing, reveal a tangled web of misshapen objects punctuated by exotic patterns such as rings and arcs. The odd shapes are due largely to the foreground lensing galaxies' powerful gravity distorting the images of the background galaxies. The unusual forms also may have been produced by spectacular collisions between distant, massive galaxies in a sort of cosmic demolition derby.

"We have hit the jackpot of gravitational lenses," said lead researcher James Lowenthal of Smith College in Northampton, Massachusetts. "These ultra-luminous, massive, starburst galaxies are very rare. Gravitational lensing magnifies them so that you can see small details that otherwise are unimaginable. We can see features as small as about 100 light-years or less across. We want to understand what's powering these monsters, and gravitational lensing allows us to study them in greater detail."

The galaxies are ablaze with runaway star formation, pumping out more than 10,000 new stars a year. This unusually rapid star birth is occurring at the peak of the universe's star-making boom more than 8 billion years ago. The star-birth frenzy creates lots of dust, which enshrouds the galaxies, making them too faint to detect in visible light. But they glow fiercely in infrared light, shining with the brilliance of 10 trillion to 100 trillion suns.

Gravitational lenses occur when the intense gravity of a massive galaxy or cluster of galaxies magnifies the light of fainter, more distant background sources. Previous observations of the galaxies, discovered in far-infrared light by ground- and space-based observatories, had hinted of gravitational lensing. But Hubble's keen vision confirmed the researchers' suspicion. According to the research team, only a few dozen of these bright infrared galaxies exist in the universe, scattered across the sky. They reside in unusually dense regions of space that somehow triggered rapid star formation in the early universe. The galaxies may hold clues to how galaxies formed billions of years ago. "There are so many unknowns about star and galaxy formation," Lowenthal explained. "We need to understand the extreme cases, such as these galaxies, as well as the average cases, like our Milky Way, in order to have a complete story about how galaxy and star formation happen."

In studying these strange galaxies, astronomers first must detangle the foreground lensing galaxies from the background ultra-bright galaxies. Seeing this (Continued on page 9)
Arp 299: Galactic Goulash

What would happen if you took two galaxies and mixed them together over millions of years? A new image including data from NASA’s X-ray Observatory reveals the cosmic culinary outcome. Arp 299 is a system located about 140 million light years from Earth. It contains two galaxies that are merging, creating a partially blended mix of stars from each galaxy in the process. However, this stellar mix is not the only ingredient. New data from Chandra reveals 25 bright X-ray sources sprinkled throughout the Arp 299 concoction. Fourteen of these sources are such strong emitters of X-rays that astronomers categorize them as “ultra-luminous X-ray sources,” or ULXs.

These ULXs are found embedded in regions where stars are currently forming at a rapid rate. Most likely, the ULXs are binary systems where a neutron star or black hole is pulling matter away from a companion star that is much more massive than the Sun. These double star systems are called high-mass X-ray binaries. Such a loaded buffet of high-mass X-ray binaries is rare, but Arp 299 is one of the most powerful star-forming galaxies in the nearby Universe. This is due at least in part to the merger of the two galaxies, which has triggered waves of star formation. The formation of high-mass X-ray binaries is a natural consequence of such blossoming star birth as some of the young massive stars, which often form in pairs, evolve into these systems.

This new composite image of Arp 299 contains X-ray data from Chandra (pink), higher-energy X-ray data from NuSTAR (purple), and optical data from the Hubble Space Telescope (white and faint brown). Arp 299 also emits copious amounts of infrared light that has been detected by observatories such as NASA’s Spitzer Space Telescope, but those data are not included in this composite.

The infrared and X-ray emission of the galaxy is remarkably similar to that of galaxies found in the very distant Universe, offering an opportunity to study a relatively nearby analog of these distant objects. A higher rate of galaxy collisions occurred when the universe was young, but these objects are difficult to study directly because they are located at colossal distances. The Chandra data also reveal diffuse X-ray emission from hot gas distributed throughout Arp 299. Scientists think the high rate of supernovas, another common trait of star-forming galaxies, has expelled much of this hot gas out of the center of the system.