Southwest Florida Astronomical Society
SWFAS

The Eyepiece
February 2015

Contents:

A MESSAGE FROM THE PRESIDENT

February is a very busy month. We have a lot of major events occurring and need help at these events. If you can come out to any of the daytime events, we always need people, even if you don't bring a telescope. Major events such as the Edison Day of Discovery and Burrowing Owl Festival are primary public outreach events. We also have the Cape Coral Parks and Rec Star Party, which has always been a nice event. We start the month with the Shell Point Star Party and if you can help there, contact Doug (Email on last page). For the other events, please contact whoever is coordinating the event.

We had several very nice school nights in January. Carol and Johnnie would like to thank all those who helped at Oasis and at Allen Park. I was alone at Country Oaks but had a great time with a lot of interested kids and adults. I have another school night coming up in Lehigh and could use some additional help. Heather has several events going on at the Planetarium and she could use some help on the 14^{th}.

Kelly could use some help at her Astronomy for Amateurs event this month.

Thanks again to Ron for getting the newsletter ready!

Our program this Thursday by Prof. Derek Buzasi should be quite interesting. It is open to the general public, so please let anyone interested know about it. We will have a shorter business meeting beforehand, so the notes above about upcoming events will be all that I present on them. I am still in need of a March program, so if you have something to present or an idea, please email me.

Don't forget, it is annual dues times. Please pay Tony at the meeting or events or mail it to our PO Box:
Southwest Florida Astronomical Society, Inc. P.O. Box 100127 Cape Coral, FL 33910
Dues are $20.00 (If you paid in the last quarter of the year, you have paid for 2015)

Brian

In the Sky this Month

Moon: February – Full, 3rd; Last Quarter, 11th; New, 18th; 1st Quarter, 25th.

The Planets:
Venus and Mars are visible all month and will provide stark contrasts. Venus shines at a brilliant -3.9 magnitude while Mars is 1.2 to 1.3. That's more than 100 X difference in brightness. Early in the month, Venus will be about 10° above the horizon with Mars another 8° above. They will draw closer during the month with their closest at 0.4° on February 21st. The Moon joins them on February 20th.
Uranus is found 4° above Venus near end of the month and will difficult to see in the glare of dusk. It is 6th magnitude.
Neptune will be more difficult to see as an 8th magnitude object in the light of dusk. Finder charts for Neptune and Uranus are located at **skypub.com/urnep**.
Jupiter will be featured all month long at magnitude -2.6. It will be at opposition this month, so it is positioned for optimum viewing.
Saturn will be rising at 2-3 am early in the month and a couple of hrs earlier by months end. It shines at a magnitude of 0.5 in front of Scorpius.
Mercury is a morning star during February and March.

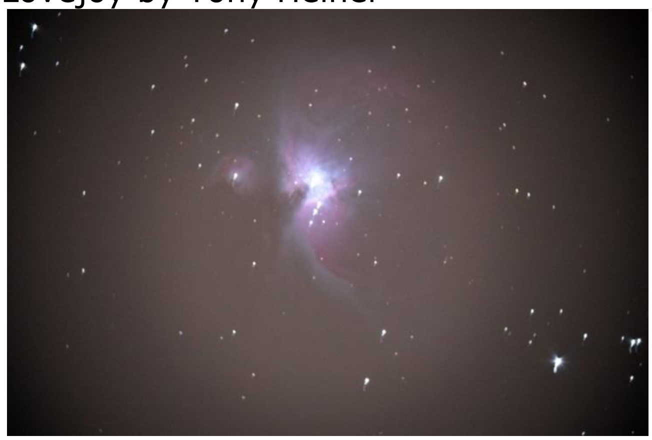
Comet Lovejoy – The comet will still be bright enough for binocular viewing early in February. See last months Newsletter for finder charts.

R Geminorum Variable Star – A long period red variable will be brightening from minimum of 13.2 last October to 9.5 to 9.0 by first of January on its way to maximum brightness of 7.1 by early February.

International Space Station: Several opportunities for viewing this month.
Feb 1st at 7:29 pm from SSW to SE; max alt 50°; for 3 minutes at -3.0 mag.
Feb 2nd at 6:38 pm from S to ENE; max alt 21°; for 2 minutes at -1.8 mag.
Feb 3rd at 7:21 pm from WSW to NNE; max alt 42°; for 5 minutes at -2.3 mag.
Feb 5th at 7:16 pm from WNW to NW; max alt 15°; for 4 minutes at -0.6 mag.
Feb 23rd at 7:52 pm from NW to NNW; max alt 63°; for 3 minutes at -3.1 mag.
Feb 24th at 7:00 pm from NNW to NE; max alt 34°; for 6 minutes at -2.6 mag.
Feb 25th at 7:44 pm from WNW to SW; max alt 26°; for 5 minutes at -1.2 mag.
Feb 26th at 6:52 pm from NW to SSE; max alt 67°; for 6 minutes at -2.9 mag.

Photos from Members

Comet Lovejoy by Tony Heiner



Orion Nebula by Phil Jansen

Comet Lovejoy by Chuck Pavlick

Future Events

Upcoming Meetings

Our next monthly meeting will be February 5th. Brief meeting is followed by the talk:
***Exoplanets: Hot, Cold, and Habitable,* given by Prof. Derek Buzasi**

Abstract: Driven by NASA's Kepler mission, in the past two decades the number of planets outside our solar system has grown from a handful to thousands. Surprisingly, many of these new solar systems are very unlike our own; they include "Super-Earths", "hot Jupiters", and ice giants, along with gas giants like those in our solar system — and a very few Earth-like planets. In this talk, Derek Buzasi will discuss how exoplanets are detected and characterized, the current exoplanet census, and our current understanding of how planetary systems form and evolve. He will also explore the future prospects for detecting habitable worlds around other stars.

Dr. Buzasi is Professor of Physics and the Whitaker Eminent Scholar in Science at Florida Gulf Coast University. He spent four years serving on the Kepler Science team, and remains actively involved with NASA's K2 mission.

Saturday, February 14th 7:00 – 9:00 pm
Sky Full of Stars: Love Songs, Sky Shows and Special Messages in the Planetarium

Looking for something unusual to do for Valentine's Day? You could write your love across the sky – or even across the Milky Way, in our planetarium! Special planetarium shows on themes of gravitational attraction, music of love and astronomy, and for a small donation, your message of love displayed on our 44' dome for a whole galaxy to see! For an even bigger statement, see our staff about placing your message on our lighted, elevated, scrolling sign at the corner of Colonial and Ortiz! A fun and frivolous after-dinner or before-nightlife treat for your romantic day!

Wednesday February 18th at noon: "Interacting Galaxies" -- a planetarium talk. In keeping with our February Valentine's theme of "Gravitational Attraction," join our planetarium director Heather Preston for a presentation (and video) on interacting galaxies at noon on Wednesday Feb. 18th. One of the interesting aspects of galaxy interactions/collisions is that sometimes the interaction can bring a large amount of disk gas and dust from one of the galaxies into contact with the supermassive black hole at the center of the other of the galaxies. That's called "feeding the monster" -- come find out why!

Several other events are happening as shown in schedule following:

Star Party and Event Schedule

Date	Event	Location	Time	Info/Contact
Thursday, February 5th	Monthly Meeting	Calusa Nature Center & Planetarium	7:30 pm	Brian Risley
Saturday, February 7th	Shell Point Star Party	Shell Point Village	Dusk	Doug Heatherly
Friday February 13th	Cape Coral Star Party	Rotary Park	Dusk–10 pm	Brian Risley Katie Locklin
Saturday, February 14th	Edison Day of Discovery STEMtastic	Centennial Park/Harborside Event Center	10am –3pm (Setup by 8 am)	Brian Risley
Saturday, February 14th	Sky Full of Stars	Calusa Nature Center & Planetarium	7 - 9 pm	Heather Preston
Wednesday, February 18th	Interacting Galaxies	Calusa Nature Center & Planetarium	Noon	Heather Preston
Thursday, February 19th	Harn's Marsh Elementary Science Night	Harn's Marsh Elementary Lehigh	5 – 7:30 pm	Brian Risley
Friday, February 20th	Astronomy for Amateurs	Hickey's Creek Park	7:00 pm	Kelly Flaherty
Saturday, February 21st	Star Party	CRP	Dusk	Bruce Dissette
Saturday, February 28th	Burrowing Owl Festival	Rotary Park	8am – 4 pm	Brian Risley
Thursday, March 5th	Monthly Meeting	Calusa Nature Center & Planetarium	7:30 pm	Brian Risley
Saturday March 21st	Star Party	CRP	Dusk	Bruce Dissette
Thursday April 2nd	Monthly Meeting – Program: Jack Berninger	Calusa Nature Center & Planetarium	7:30program followed by business meeting	Brian Risley
April 18th	Star Party		Dusk	Bruce Dissette
May 16th	Star Party		Dusk	Bruce Dissette
June 13th	Star Party		Dusk	Bruce Dissette
July 18th	Star Party		Dusk	Bruce Dissette
August 15th	Star Party		Dusk	Bruce Dissette
Sept. 12th	Star Party		Dusk	Bruce Dissette
October 10th	Star Party		Dusk	Bruce Dissette
November 14th	Star Party		Dusk	Bruce Dissette
December 12th	Star Party		Dusk	Bruce Dissette

Minutes of December SWFAS Meeting – December 4th, 2014

Chuck Pavlick gave a great presentation on how to improve success at astro-imaging. Following is a brief summary of his main points – provided by Chuck:

Mount: This is the most important part of the imaging system. Make sure it has a guiding port and can handle all of the weight of your imaging system. Don't buy cheap mounting hardware for your guiding scope because the equipment could flex and can cause elongated stars.

Telescope and guide scope: Choose a scope that will fit your needs. If you want to image wide field an Apochromatic refractor is your best choice. Don't buy an achromat because you will get blue halos around stars. If using a doublet or triplet refractor most likely you will need a field flattener, not totally necessary because you can crop the edges where the elongated stars are but there are times when you will need the full image so a field flattener will be needed. To give an idea of image scale the Andromeda Galaxy, M31 with M32 and M110 will fit in the field of view of a 600mm focal length scope and a typical dslr camera. If you like to image galaxies with the exception of M31, most other galaxies are small when using a dslr camera and you will have to crop the image. SCT's are good for planetary, planetary nebula and galaxies. You will have to use dew strips for your guide scope and imaging scope. I use the orion mini guider with the orion autoguiding camera. It is light and does a good job up for up to 1500mm.

Cameras: DSLR or CCD for deep sky images are the choice you will have to make but modified dslr cameras take beautiful deep sky images. The modification will make the camera more sensitive to the red which is great for nebula. You can pick up a used dslr camera fairly cheap and send it out for a modification. There are several people who offer this service online. Hap Griffin is the person I used. Modification require the IR block filter to be removed and replaced with a clear glass or other types of filters. You would have to choose from the options available. Modification prices range from 200 to 350. You can also use the camera for normal photography with certain modification when using the custom white balance. You will also need a t-ring to connect your dslr to the telescope. If using a ccd camera and a field flattener you will need to add extension tubes between the field flattener and the camera. There are also light pollution filters available which clip on in front of the mirror of the camera or thread on to the end of the field flattener. You will also need a guide camera.

CCD cameras are made for astronomy and are cooled to control noise. They come in mono and one shot color. Mono camera are more sensitive and require a set of red, green and blue filters and a filter wheel so you can change filter without taking out the camera. They also have filters available, hydrogen alpha, OIII and SII, to image in a light polluted areas with the moon out. One shot color ccd have the filters built into the chips and are less sensitive than mono camera which means longer exposure. You can also use filters to image in light polluted area which can be added between the camera and telescope.

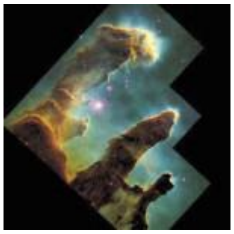
Webcams: Webcams are used to take video of planets, sun and the moon. They can take up to 120 frames per second. There is software that process the images to take sort the best frames and stack the frames to get a sharper image. I use Registax for my stacking of the images. They are available in mono and color. You would need color filters and filter wheel for the mono cameras. Mono cameras are more sensitive and produce sharper images.

To travel to a dark site to image be prepared to take a minimum 2 hours to set up polar align, frame and focus the image and start taking pictures. I would highly recommend a capture sofware for dslr cameras. You will be able to see the image on the computer screen when focusing and capturing the image. CCD and wecams usually come with capture software. I use Nebulosity from Starks Labs for both ccd and dslr cameras, which is available online. I also use PHD guiding from Starks Labs for the guiding software.To process the images Photoshop, Paint Shop Pro are good processing software and there are many tutorial on You Tube on processing astro images.

New Look at Eagle Nebula

By: Camille M. Carlisle

The Hubble Space Telescope is commemorating its 25th anniversary with a second look at the Pillars of Creation — but there's hard science behind these pretty pictures.



Giant gas pillars in M16, the Eagle Nebula, as seen by Hubble in 1995.

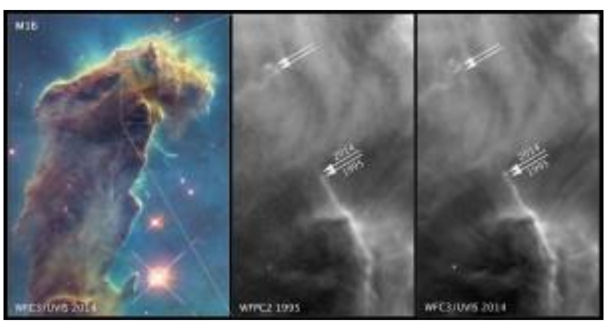
In 1995, astronomers released what is now an iconic image of M16, an open star cluster and nebulous region sculpted by stellar winds and radiation. Also known as the Eagle Nebula, the star-forming region sits 6,500 light-years away in the constellation Serpens Cauda, stuffed in between Scutum and Ophiuchus about 12° north of the Sagittarius teapot lid.

But Hubble has had a lot of updates since 1995. So astronomers took a second look at the Eagle Nebula, this time through both visible-light and near-infrared filters with the space telescope's Wide Field Camera 3, which in 2009 replaced the Wide Field and Planetary Camera 2 that took the original composite image. The results appear below.

The Hubble Space Telescope produced these visible-light (left) and near-infrared composite images of these fingers of gas in the Eagle Nebula, also known as the Pillars of Creation. The visible image is color-coded for chemical composition: blue is doubly ionized oxygen, green is ionized hydrogen, and reddish orange is ionized sulfur. The infrared image cuts through much of the gas and reveals stars inside.
NASA / ESA / Hubble Heritage Team (STScI / AURA)

Like the 1995 version, the new visible-light composite image is color-coded not for realism but for physics. The colors reveal the chemical composition of various parts of the nebula: blue is doubly ionized oxygen, green is ionized hydrogen, and reddish-orange is ionized sulfur. Along with the infrared view, the chemical makeup reveals the gas density in different parts of the region and also how energetic the photons are (it takes a lot of energy to rip two electrons off an oxygen atom, which is why the cavity around the young, intense stars is blue — the stars are above the region pictured).

The infrared composite view — which I personally think is the most beautiful of the bunch — bypasses all but the densest dusty gas, making it look like the gas has disappeared. The infrared image also makes more obvious why the pillars exist in the first place: they're actually gas that's hiding in the "shadow" of dense clouds at the pillars' tops, which are shielding the gas from the stars' destructive ultraviolet radiation and stellar winds. In effect, the stars are pouring down stellar acidic rain that's eroding any gas it can reach; only the material shielded by the cloud umbrellas is safe.



Observations of the Eagle Nebula in 1995 and 2014 show changes in this star-forming region. As clouds collapse down to form stars, they create a number of jets as the system tries to dump its angular momentum and accrete material. Such jets are signposts announcing, "We just made a star right HERE," said Paul Scowen (Arizona State University in Tempe). The movement of the jet ends between 1995 and 2014 will enable astronomers to determine whether the gas motions are consistent with expectations for stellar collapse models.
NASA / ESA / Hubble Heritage Team (STScI / AURA)

Both these images and the original observations from 1995 gave astronomers a much-desired look at what happens at the edge of the cavity surrounding these HII regions (so called because the hydrogen is ionized by the newly born stars). Astronomers estimate that it's taken a few hundred thousand to a few million years to wipe out the gas between the pillars, which is about the same length of time the hottest, most massive stars spend fusing hydrogen in their cores.

The new view has twice the resolution and peers roughly 10 times as deep as the old one in the same exposure time. The pillars' edges were sharp at the limit of the 1995 resolution; surprisingly, in the new observations they're *still* sharp, meaning that it only takes 100 Earth-Sun distances to transition from being inside the pillar to outside. In comparison, the pillars are about 5 light-years tall, or 3,160 times bigger.

The infrared observations also enable astronomers to peer inside little nodules on the pillars, inside which stars should be growing. In the 1995 image, astronomers found about 60 to 70 nodules; in the infrared, only 5 to 10 of those in fact have infrared sources at their hearts, meaning that star formation in this environment has only a 10% success rate. That's because instead of a secondary stellar nativity in the cavity wall, which would be spurred when forming stars compressed the wall's gas, the radiation and stellar winds are excavating the little globules before they've finished collapsing. Essentially, the poor things needed more time in the oven and didn't get it.

- See more at: http://www.skyandtelescope.com/astronomy-news/new-look-at-eagle-nebula-0112201423/?et_mid=717089&rid=246752253#sthash.WtrNTEXS.dpuf

Hubble's Long Look at Distant Galaxies

By: Ramin Skibba

Hubble Space Telescope observations are enlightening astronomers about the evolution of galaxies in the distant universe.

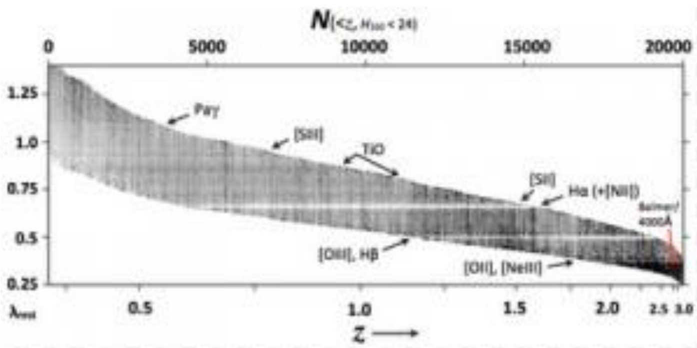
3D-HST adds spectroscopy, and hence the third dimension, to this stunning two-dimensional image from the CANDELS Ultra Deep Survey. Our version doesn't do the data justice - click the image for a zoomable version.
NASA / ESA / A. van der Wel / H. Ferguson / A. Koekemoer / the CANDELS team

Astronomers are studying growing galaxies in the early years of the universe using a unique Hubble Space Telescope survey, and they presented a host of results at the winter meeting of the American Astronomical Society (AAS).

The survey, known as 3D-HST and led by Pieter van Dokkum (Yale University), fleshes out an existing set of Hubble images with spectroscopy, adding a third dimension to a previously two-dimensional view.

Hubble spent about a month collecting near-infrared spectra of galaxies living in a universe less than half its current age. The short observing time netted an incredible amount of data: "The unique 'slitless' nature of the 3D-HST observations provides simultaneous high-quality spectra of everything in the HST field-of-view," says Gabriel Brammer (Space Telescope Science Institute).

The precise distance measurements add a third dimension to tens of thousands of galaxies detected in CANDELS, Hubble's single largest observing program, featured in *Sky & Telescope*'s June 2014 issue.

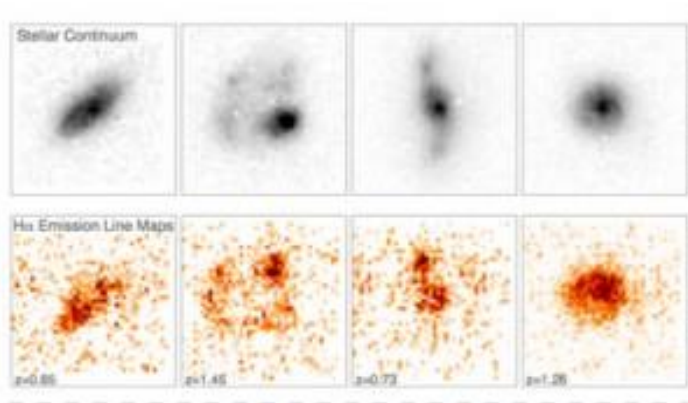


The spectra for 20,000 3D-HST galaxies are collapsed into a single figure. Arrows point out absorption lines that indicate star formation activity, active galactic nuclei activity, and stellar age. A galaxy at z=3 is observed when the universe was 11.6 billion years younger. *G. Brammer*

In a younger universe, star formation and the galaxies' growth spurts that accompany it are at their peak. By measuring galaxies' spectra, the 3D-HST team homes in on galaxies' hey-day to learn about their masses and star-formation histories. Combining those data with observations at other wavelengths, such as X-ray and radio, researchers have started exploring how galaxies formed their stars — and why they stopped.

Erica Nelson (Yale University) has been using 3D-HST to analyze the shapes and structures of star-forming galaxies similar to the Milky Way. Since stars ionize hydrogen gas in their vicinity, creating an H-alpha spectral line (which may be familiar to solar observers who view the Sun through H-alpha filters), tracking H-alpha emission traces the birth of stars.

Nelson mapped H-alpha in a thousand disk galaxies in a universe half its current age. She found that these galaxies grow by forming stars along their entire pancake-like structures. That's unlike the precursors to modern-day elliptical galaxies, also studied with 3D-HST, which first form stars in their central bulges before star formation spreads outward.



Nelson and colleagues studied galaxies with pancake-like disk structures and spiral arms, comparing light from existing stars to light from gas ionized by forming stars. They find that stars are forming at all radii, rather than from the inside out.
Nelson & others

Astronomers are also using 3D-HST to investigate what causes a galaxy to leave its fiery youth behind and enter a leisurely retirement. Though “retired” galaxies were once thought to be rare in the distant universe, Katherine Whitaker (NASA Goddard Space Flight Center) and Gabriel Brammer (Space Telescope Science Institute) presented significant samples of quiescent massive galaxies with stars older than 1 billion years. These galaxies have stopped forming stars, and detailed analysis shows that some had already shut down star formation before the universe had turned 3 billion years old, earlier than previously thought.

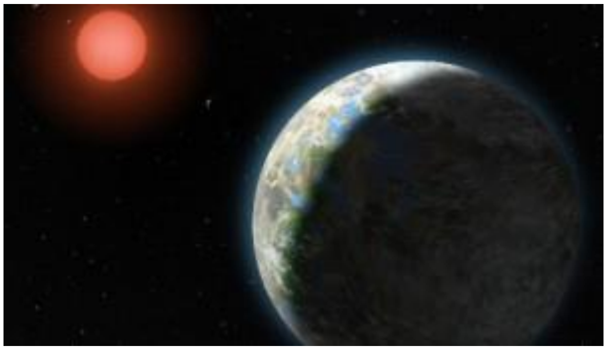
But why did stars stop forming in these galaxies? One possibility is that these galaxies’ central supermassive black hole feeds energy back into the galaxy, stirring up gas and preventing it from condensing into stars. Whitaker, Brammer, and others will continue 3D-HST research to investigate this and other possibilities.

Finally, research with 3D-HST and CANDELS will guide observations planned for the James Webb Space Telescope (JWST), Hubble’s successor scheduled for launch in 2018, and Wide-Field Infrared Survey Telescope (WFIRST), which might launch in the early 2020s. Both of NASA’s largest upcoming missions will find and study many more galaxies in the universe’s distant past.

Do Atmospheres Spin Worlds to Habitability?

By: Shannon Hall

The best place to look for nearby Earth-size planets are around the smallest, coolest stars. New research shows that any exoplanets tightly circling their stars might have a better chance of being habitable than previously thought.



This artist's conception shows the planet GJ 581g, which has a 37-day orbit right in the middle of the star's habitable zone and is only three to four times the mass of Earth, circling its red dwarf star.
Lynette Cook

In the hunt for Earth 2.0, many astronomers are pointing their telescopes toward smaller, cooler stars. Not only are these so-called red dwarfs the most abundant type of star in the galaxy, but they're also roughly one-quarter the Sun's mass, bringing their habitable zones closer in and making it easier to spot any Goldilocks planets, either via their gravitational tugs on the star or when the planet passes in front of the star from our perspective.

There's just one catch. A planet that orbits close enough to its dim star to be in the habitable zone could become tidally locked. Just as our planet sees one side of the Moon at all times, red dwarfs will only see one side of a close-in planet at all times. So one side of the planet will likely see continuous day and the other perpetual darkness, potentially destabilizing chemical exchanges between the atmosphere and surface or even (in extreme instances) causing the atmosphere to collapse. In short, tidally locked planets are likely uninhabitable.

New research, however, suggests not all is lost for tightly orbiting planets. Jérémy Leconte (University of Toronto and Pierre Simon Laplace Institute, France) and his colleagues think that an atmosphere's effect might be strong enough to break any tidal locking, allowing the planet to rotate freely and exhibit a day-night cycle similar to Earth's.

Leconte and his colleagues created a three-dimensional climate model (similar to those used in analyzing climate change on Earth) to predict the effect of a given planet's atmosphere on the speed of its rotation.

It all goes back to the amount of starlight able to penetrate the planet's atmosphere and reach the surface. Any temperature differences at the surface — between day and night and between the equator and the poles — drive winds. Those winds constantly push against the planet by running into mountains or creating waves on the ocean. Such friction then influences the rotation rate of the planet, helping to speed it up or slow it down.

“While gravitational tides and their associated torques tend to tidally lock the planet, thermal tides, produced by the star heating the atmosphere of the planet, tend to oppose the gravitational tides, and prevent the planets from becoming tidally locked,” says coauthor Norm Murray (University of Toronto).

Astronomers have long seen this effect on the planet Venus, where the atmosphere’s influence is so powerful that it forces the planet out of synchronous rotation into a slow retrograde rotation: to a Venusian, the Sun rises in the west and sets in the east. But Venus’s large atmosphere weighs in about 90 times heavier than our own, and planetary scientists didn’t think thinner atmospheres like Earth’s could throw their weight around as effectively.

Leconte’s simulations show that thinner atmospheres actually have a larger rotational effect on their planets. With less scattered sunlight, extra heat reaches the deepest atmospheric layer and creates stronger winds. If Venus were to have an atmosphere like Earth’s, it would spin 10 times faster. This is radically different from previous research, which suggested that it would spin 50 times slower.

An unlocked planet should have strong atmospheric mixing and relatively stable temperatures. “This greatly increases the chances for atmospheric stability — and, hence, for life — on any of these bodies, provided they are Earth-like in terms of mass, water content, and maybe their atmospheres,” says exoplanet expert René Heller (McMaster University, Canada).

In addition, it avoids many problems created on tidally locked planets, Take the cold trap, for example. “Liquid water on the sunny side tends to evaporate, and is thence transported by winds (driven by the temperature gradient) to the dark side, where it precipitates as snow and forms large-scale ice sheets,” says Murray. “Since the back side never sees the light of the host star, the ice sheets may well be permanent.” Eventually all the liquid water would move to the dark side, making life impossible.

Although the researchers show that a large number of known terrestrial exoplanets should have a day-night cycle, potentially rendering them habitable, the duration of their days could last between a few weeks and a few months. So Heller cautions that these planets would still be far from Earth-like, with only a few days per year.

Hopefully the theoretical results don’t remain in the observational dark for too long. Astronomers can determine the temperature of exoplanets when they pass behind their host stars. But it won’t be easy to do this for Earth-size worlds. Leconte thinks it might be within reach of the James Webb Space Telescope (slated to launch in 2018) if there is a particularly favorable planet to observe. If not, astronomers might have to wait for the European Extremely Large Telescope, whose first light is tentatively scheduled for 2024.

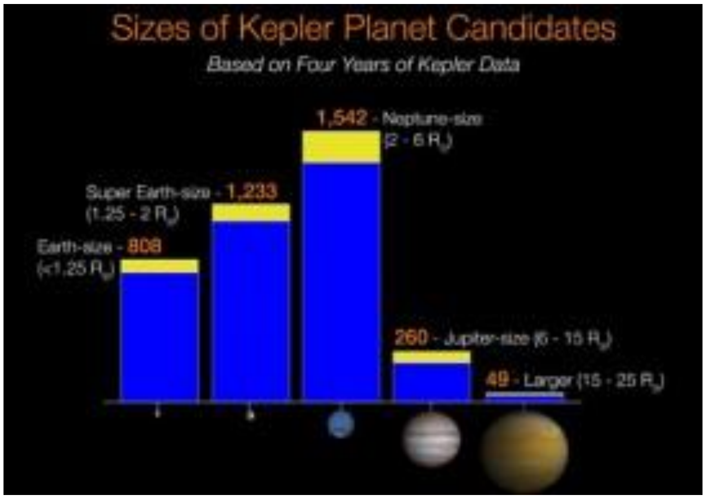
Reference:

Jérémy Leconte et al. “Asynchronous Rotation of Earth-mass Planets in the Habitable Zone of Lower-mass Stars.” *Science*. Published online January 15, 2015.

The Future of Exoplanet Hunts

By: Monica Young

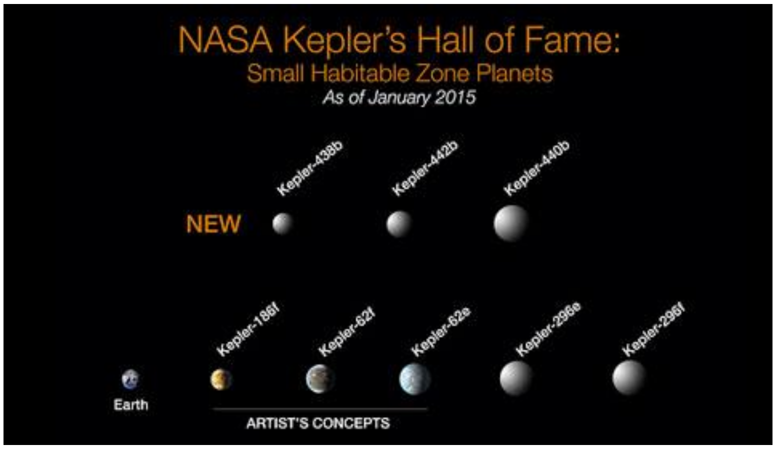
As the Kepler mission shifts into its new mode of operations, multiple new searches for exoplanets are in the works.



Icing on the cake: Kepler's newest exoplanet finds. *NASA / W. Stenzel*

Change is in the air. For the past several years, every winter meeting of the American Astronomical Society has heralded vast discoveries of exoplanet candidates, largely from the Kepler mission. At the meeting this month, Kepler announced some icing for that cake: 554 new planet candidates, 6 of them in their stars' habitable zone. Another 8 planets previously in the "candidate" column have moved to "confirmed" status.

For those keeping count, that brings the candidate total to 4,175 and the number of confirmed planets to 1,013. (The candidate total includes the confirmed planets.) Of the newest confirmations, three were no more than double Earth-size and in their star's habitable zone, bringing the number of confirmed Earth-size planets in "Goldilocks" orbits to eight.



Of the 1,013 confirmed planets found by NASA's Kepler Space Telescope, eight are less than twice Earth-size and in their stars' habitable zone. All eight orbit stars cooler and smaller than the Sun. *NASA Ames / W. Stenzel*

That's pretty impressive considering that Kepler was forced to halt its original mission in May 2013 when the second of its four reaction-control wheels failed. The new discoveries come largely from continued analysis of the treasure trove Kepler collected over its first four years.

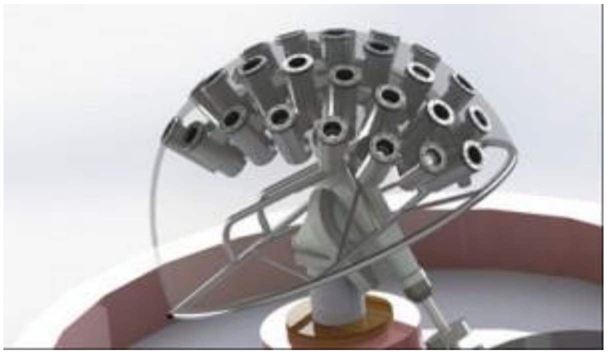
Yet real work remains to be done. As impressive as these numbers are (and even more discoveries are yet to come), Kepler's goal has always been not to merely find some planets, but to find vast numbers of them, especially Earth-size ones.

Only with large, statistical samples can astronomers begin to answer how many stars host planets, and how many of those planets have a chance of being habitable. That analysis is still under way, and Fergal Mullally (NASA Ames) says astronomers expect to spend one or two more years teasing the subtleties out of the data.

The Next Generation Transit Survey saw first light this month at the European Southern Observatory's Paranal Observatory in Chile. *ESO / G. Lambert*

Kepler's mission now continues in modified form as K2, which has already discovered four super-Earths passing in front of red dwarf stars — including three super-Earths in a single system. Meanwhile, a deluge of exoplanet-finding missions are in the works, and the sampling below is by no means exhaustive.

The European Southern Observatory recently announced "first light" for the Next-Generation Transit Survey, which will look for transiting planets around bright (i.e. nearby) stars in the coming years. The Transiting Exoplanet Survey Satellite (TESS), slated for launch in August 2017, aims to do the same from space. By targeting nearby stars unlike Kepler's largely distant stellar sample, these missions both hope to find exoplanets that will be easier to follow up on.

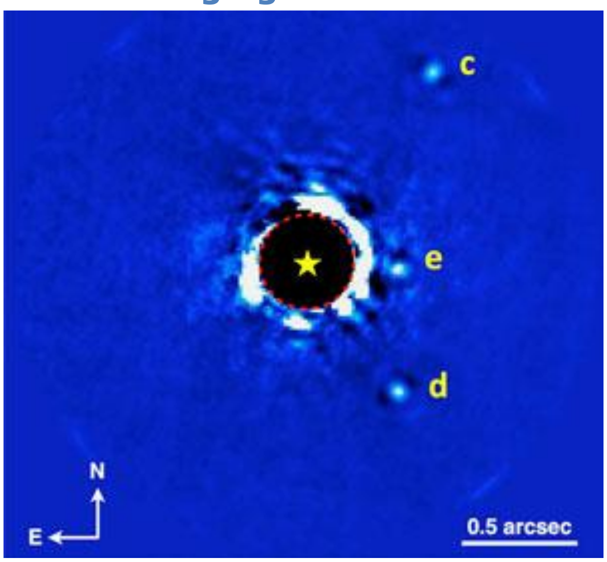


Evryscope contains 27 61-mm telescopes fitted onto a single German Equatorial mount. The instrument will take a continuous movie of the night sky, collecting data in 2-minute exposures, starting later this year. *J. Ratzloff / N. Law / UNC Chapel Hill*

Another exoplanet hunter, known as Evryscope, is in the construction phase. Led by Nicholas Law (University of North Carolina at Chapel Hill), the team proposes a vast telescope array to continuously image the entire sky. The prototype array places 27 individual telescopes into a common mount; an attached 780 million-pixel detector records a continuous movie of the entire night sky in 2-minute exposures.

Evryscope will see first light this spring or summer at the Cerro Tololo Inter-American Observatory in Chile. Among many possible applications, this instrument could detect transiting giant planets or, around nearby *M* dwarfs, rocky planets in the habitable zone.

Direct-Imaging Is the New Black



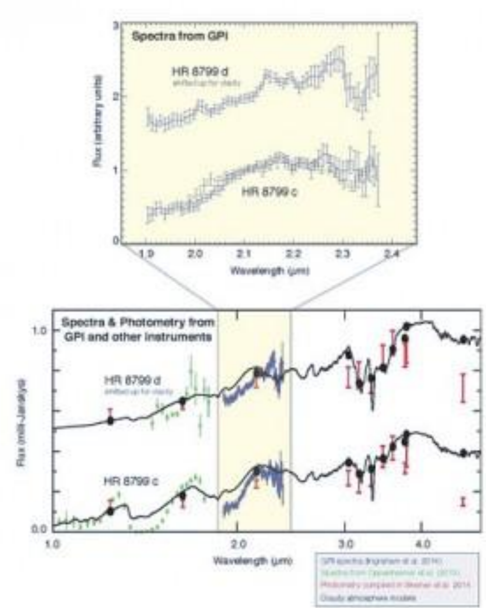
GPI imaged the planetary system HR 8799 during its first week of operation in November 2013, capturing three of four planets in near-infrared light. (Planet b is off to the left of the field of view shown here.)
C. Marois / P. Ingraham / the GPI Team.

While transit-based searches may still bring in most of the goods, direct-imaging technology is also coming into its own, and for good reason.

Imaging planets directly as they orbit their (very bright) stars naturally leads to the discovery of planets on large orbits, rather than the tight orbits typical of transit-based finds. In addition, planets found by direct imaging can also yield direct spectra that shed light on their atmosphere's composition.

So far only [26 planets have been imaged directly](#) (excluding brown dwarfs), but that should change soon. The Gemini Planet Imager (GPI, pronounced gee-pie) is perhaps the best-publicized project, but the instruments SPHERE (Spectro-Polarimetric High-contrast Exoplanet Research) and SCExAO (Subaru Coronagraphic Extreme AO) are also on the direct-imaging hunt.

During GPI's first week of observations, the instrument targeted a known system, imaging three planets (c, d, and e) in the HR 8799 system, and capturing spectra for two (c and d). The observations, to be published in the *Astrophysical Journal* and announced at the AAS, show that planets c and d, once thought to be similar in size and composition, might actually be quite different.



GPI' spectra of planets HR 8799c and d showed surprising differences. One possible explanation is that planet c has patchy cloud cover that allows a deeper look into its atmosphere.
P. Ingraham / M. Marley / D. Saumon / the GPI Team

It's not clear yet whether the differences lie in chemical composition or cloud cover. Marshall Perrin (Space Telescope Science Institute) suggested at a AAS press conference that the differences could be explained if planet c had patchy clouds that allow for a deeper look into its atmosphere.

The results are intriguing, says Jonathan Fortney (University of California, Santa Cruz), but he cautions that detailed analysis might be affected by systematics. After all, the observations were taken as part of GPI's first light, as astronomers and technicians were still working out the instrument's kinks, and under less than ideal weather conditions.

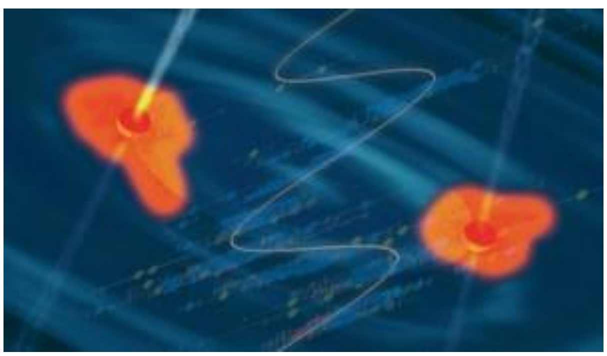
Indeed, new observations of HR 8799 are already planned for this summer, says Thayne Currie (Subaru Telescope / NAOJ). And, now that GPI has entered full operations, it will begin its survey of 600 carefully selected stars — the search for new, directly imaged exoplanets is on.

Black Hole Binary En Route to Merger?

By: Camille M. Carlisle

Astronomers poring through two decades of archival and survey observations have discovered what looks like a pair of supermassive black holes closing in for a merger.

When galaxies merge, astronomers expect the supermassive black holes lurking in the galaxies' cores to form their own dancing duos. Theorists predict that these black holes inspiral and coalesce, and such mergers undoubtedly play a role in building up the beefiest black holes (we're talking billions of solar masses).



An artist's conception of a black hole binary in a heart of a quasar, with hot accreting gas shown in orange and the data that reveal the periodic variability superposed (sinusoidal curve betwixt the black holes).
Santiago Lombeyda / Caltech Center for Data-Driven Discovery

Yet despite their theoretical abundance, black hole binaries have proven difficult to find. Astronomers have found plenty of circumstantial evidence for black hole pairs in galactic centers, but often the evidence can be interpreted in many ways, or the pair is too far apart to conclusively qualify as a merger-bound binary.

The best candidate so far has been OJ 287, which puts on a pair of optical outbursts every 12 years. These flares stand out even against the violent variability typical of blazars, quasars that point their jets right at us as OJ 287 does. OJ 287 shows up in photographic plates as far back as 1887, as seen in the Harvard College Observatory's archive, Jonathan Grindlay (Harvard-Smithsonian Center for Astrophysics) reported on January 7th at the winter American Astronomical Society meeting. Astronomers have speculated that the double-peaked outbursts might come from a supermassive black hole punching through the accretion disk around a second black hole of comparable size.

Now an even better candidate might join the very short list of known black hole binaries. Matthew Graham (Caltech) and colleagues announced their discovery of the closest-hugging black hole binary candidate yet on January 7th in *Nature* and at the AAS meeting.

Black Hole Binary in a Haystack

The source, PG 1302−102, is a "vanilla" quasar, lacking the ferocious Earth-pointing jet that can block the view of black hole dynamics. Oddly enough, it pulsates with a period of about 5 years. The team found the source within the data pouring out of the Catalina Real-time Transient Survey (CRTS), which uses three ground-based telescopes to monitor about 80% of the night sky.

PG 1302−102 is actually one of 20 periodic sources that the team found essentially on a whim. They were aiming to study quasar variability: quasars are notoriously variable at all wavelengths, but randomly so — usually, there's no regularity to the peaks and dips in brightness. Yet when the team ran algorithms to check a sample of 247,000 quasars for regular pulsations in brightness, these 20 popped up.

Statistically, the team would only have seen 1 periodic source if it were a fluke, so seeing 20 gives them confidence that the periodic phenomenon is real. The discovery rate (20 out of 247,000) is also close to that expected by theorists for binary black holes separated by less than a tenth of a light-year, as this one seems to be.

PG 1302−102 is the "best-looking" of the bunch, which is why the astronomers are presenting it first. But study coauthor S. George Djorgovski (Caltech) says they're working on the rest. "Studying the full sample would give us more confidence than any individual case."

Astronomers still don't have a good handle on what happens in the final few light-years of a black hole merger (a conundrum called the "final parsec problem"), but PG 1302−102's (purported) black holes will likely merge in a few hundred thousand to a couple million years. The elliptical galaxy they sit in has also long shown signs of being the product of a merger; it's hard to say exactly how long ago it formed, but probably a few hundred million years ago.

The team thinks most of the 20 sources it found are black hole duos en route to merging. Given the span of time CRTS has observed, the other 19 should also have periods on the order of a few years and will likely have similar separations. The exact distances between the leviathans depend on what the black hole masses are. The team can't separate those out, but they can estimate a combined mass for PG 1302−102's pair of a few hundred million solar masses.

Black hole binaries are a potential source of gravitational waves, ripples in spacetime creating by accelerating masses. Astronomers have not yet directly detected gravitational waves, although they've seen indirect evidence of them. But PG 1302–102's gravitational waves would have too low a frequency for ground- or space-based instruments to detect them. And even studies using pulsar timing arrays — which look for spacetime ripples by watching for hiccups in the neutron stars' lighthouse-like pulses — aren't currently sensitive enough. Although the gravitational wave frequency would be on the order of 10 nanohertz, which *is* where PTAs are most sensitive, PG 1302–102 is too far away and its binary isn't massive enough for detection as an individual source, explains researcher Alberto Sesana (Max Planck Institute for Gravitational Physics, Germany). The system would need to be at least 10 times more massive for next-gen PTA studies — possible, given the error bars, but a stretch. Instead, this source is likely one of several thousand that contribute to the expected "gravitational wave background" (like the cosmic microwave background, but in gravitational radiation).

Even watching for the period to shorten with time as the black holes inspiral is beyond human timescales, says Scott Hughes (MIT). Assuming for simplicity's sake that both black holes are the same mass, it would take 18,500 years for the period to shrink by 100 days. "A bit long for a PhD thesis, I'm afraid!" he says.

You can read more about the science behind the discovery in Caltech's press release.

Web editor Monica Young contributed to the reporting of this news blog.

Reference: M. J. Graham et al. "A possible close supermassive black-hole binary in a quasar with optical periodicity." *Nature*. Published online January 7, 2015.

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