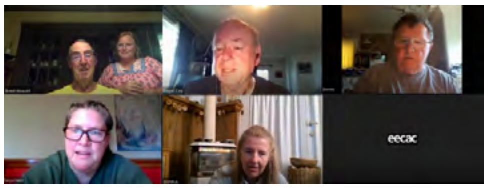
AOH Newsletter

Autumn 2022

News and Notes

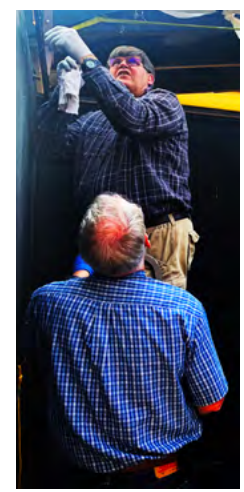
Recent Activities:



A small but loyal cadre of AOH members continues to meet monthly on Zoom on the Saturday nearest the full moon. Sometimes we even talk about astronomy.

And meetings have started up at Kneeland—in June and July we observed at the airport and in August we went to the school for an observatory-cleaning work party and picnic dinner.

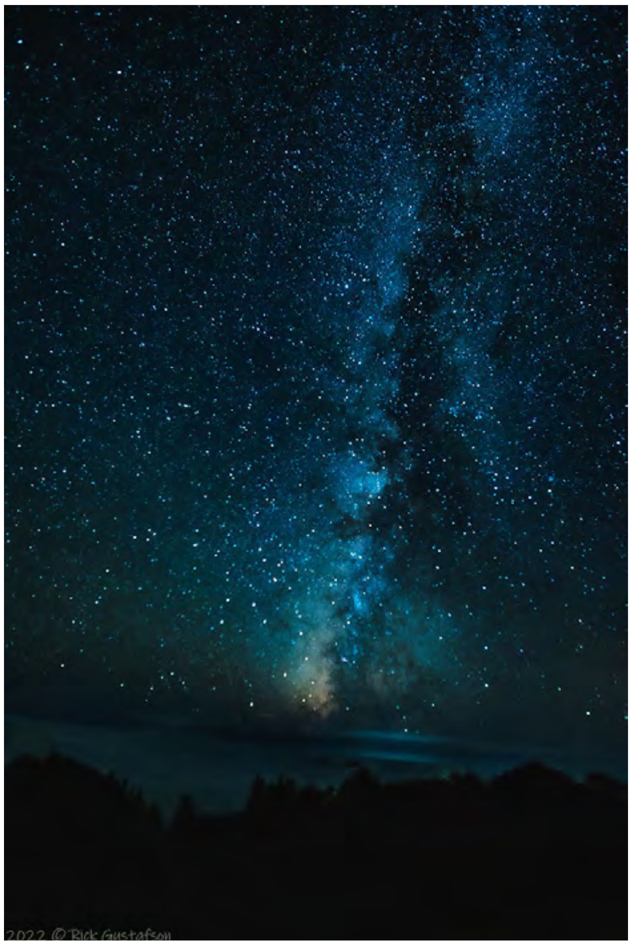
There are more photos on the following pages.

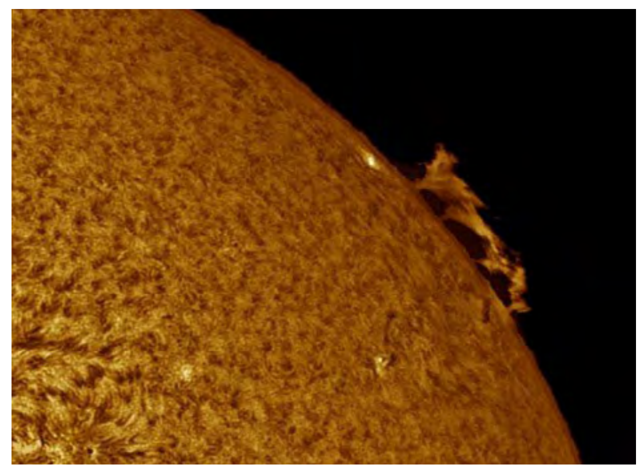


Recent Photos:

AOH members, both at our observing sessions and elsewhere, have been busy doing astrophotography.

The Milky Way, the Wild Duck Cluster (M11), the Whirlpool Galaxy (M51), and the smoky Moon at moonset are by Rick Gustafson, taken in July and August. The Trifid Nebula (M20), the Dumbbell Nebula (M27), and the hydrogen-alpha Sun and prominence are by Joe Eiers, taken in June.





And here are more photos.

The Sombrero Galaxy (M104), the Fireworks Galaxy (NGC6946), the globular cluster (M3), and the Sunflower Galaxy (M63) are also by Joe Eiers, taken in June. The Kneeland sunset is by Catrina Howatt, taken in July. The Golden Handle of the Moon is by Ken Yanosko, taken in September. Jupiter with the Galilean Moons is by Grace Wheeler, taken in September.

Also see the photographs in Grace's article beginning on page 6.

Upcoming Activities:

Weather permitting, we will hold observing sessions at Kneeland on September 24, October 22, and November 26. There will be Zoom meetings on October 8 and December 10. There will be public viewing at the Gazebo on Arts Alive nights on October 1 (which is also IOMN—see below), November 5, and December 3. As usual, check the website for last-minute changes.

The Annual General Membership meeting, featuring the election of next year's Board of Directors, is scheduled for November 12. We'll decide later whether that meeting will be in-person or on Zoom.

Look for meteors in the fall. The Orionids peak the night of October 20-21, the double-peaked Taurids on November 4-5 and November 11-12, the Leonids on November 17-18, and the usually spectacular Geminids on December 13-14.

Saturn and Jupiter will be our evening planets, joined later at night, or later in the season, by Mars; use this map at https://theskylive.com/uranus-info to find Uranus among them. And in mid-December both Venus and Mercury will be low in the west at sunset.

And there will be a total lunar eclipse in the early morning hours of Tuesday November 8. We got clouded out last Spring—keep your fingers crossed for this one.

	Pacific Standard Time
Penumbral Eclipse begins	12:02:15 am
Partial Eclipse begins	01:09:12 am
Full Eclipse begins	02:16:39 am
Maximum Eclipse	02:59:11 am
Full Eclipse ends	03:41:36 am
Partial Eclipse ends	04:49:03 am
Penumbral Eclipse ends	05:56:09 am

IOMN 2022:

AOH will participate in International Observe the Moon Night by holding a public observing session at the Gazebo in Eureka on October 1 from 6 to 9 pm. Bring your scope or binoculars to share views with the public.

School Outreach:

We have at least four invitations for afternoon or evening visits to schools; watch your email for calls for volunteers. Or contact Brent at brent@astrohum.org for more information.

Thanks:

A big "Thank you!" to all who helped put the Newsletter together—Mark and Grace for writing articles; Catrina, Rick, Joe, and Grace for photos; Susie for her cartoon; and Susan for proofreading.

Ken

A Fall Encounter

by Mark Wilson

In the last newsletter I provided a list of non-Messier Deep Space/ Dark Sky Objects (DSOs) to search for during the summer months. Here is a list of challenges for the fall months of September, October and November. You should be able to see all of these with an eight inch telescope with good eyes and a dark sky.

These fall objects lie in the sky centered around 0 hours of Right Ascension: from 4 hrs RA to the right of the fall constellation Pegasus to 20 hrs RA on Pegasus's left. The RA of 0 hrs is overhead directly north/ south at (solar) midnight, i,e, midnight standard time, on the fall equinox, September 22.

From my experience, Astrohumers observe from the onset of darkness, the beginning of astronomical twilight, to around 1:00 am. With this in mind I used a planisphere to customize the objects list to that time frame. If you start observing at the end of astronomical twilight, 8:42 pm (dark sky), September 24, our new moon observing date, at Kneeland, you can still observe some of the summer objects such as M13 in Hercules, which is at the center of the 8 hours of RA that cover the summer section of sky. If you observe until 1:00 am you will notice the winter constellations of Orion and Gemini rising in the east. Our other fall new moon observing dates, October 22 and November 26 have end of astronomical twilight times of 7:57 pm and 6:27 pm respectively.

Are you confused yet? Some of the above information and some objects in the fall list came from the website In-The-Sky.org. This is a great resource; it even has a guide for a pub crawl in Cambridge, England. Ken recently added it as a link on our web site.

Other sources for this list include:

K: Krzywonski, Mike. *The Messier Observer's Planisphere.*

O: O'Meara, Stephen. *Deep-Sky Companions: Hidden Treasures.*

S: Seronik, Gary. *Binocular Highlights.*

	ID	Source	Name	Const	Type	Mag
1	1981	O,S		Orn	OC	4.2
2	IC 4665	S		Oph	OC	4.2
3	6633	O,S		Oph	OC	4.6
4	869		Double Cluster (h)	Per	OC	5.3
5	884	K	Double Cluster (χ)	Per	OC	6.1
6	6819	O	Fox Head Cluster	Cyg	OC	7
7	6811		Smoke Ring Cluster	Cyg	OC	6.8
8	6866	O	Frigate Bird Cluster	Cyg	OC	7.6
9	6826		Blinking PN	Cyg	PN	9.8
10	6960	K	Witch's Broom	Gyg	BN/SNR	7
11	6979		Veil Nebula	Cyg	BN/SNR	7
12	6992	K	Eastern Veil	Cyg	BN/SNR	7
13	6995		Veil Nebula	Cyg	BN/SNR	7
14	7027	O	Pink Pillow	Cyg	PN	8.5
15	6888	K	Crescent Nebula	Cyg	EN/HII	7.5
16	IC 5146		Cocoon Nebula	Cyg	BN	10
17	6946			Cyg	Gal	9.7
18	HD 226868		Cygnus X-1	Cyg	black hole	8.9
19	908	O		Cet	Gal	10.1
20	925			Tri	Gal	10.4
21	957			Per	OC	7.6
22	7331	K	Deer Lick	Peg	Gal	10.3
23	1023	O	Perseus Lenticular	Per	Gal	9.3
24	IC 1848		Baby/Soul Nebula	Cas	BN	6.8
25	7293	K,S	Helix Nebula	Aqr	BN	7.5
26	281	O	Pacman Nebula	Cas	BN	7.8
27	1333	O	Embryo Nebula	Per	BN	5.7
28	7008	K,O	Coat Button	Cyg	PN	10.7

Solar Viewing and an Impromptu Outreach with Cal Fire

by Grace Wheeler

The space news for August 26 was buzzing with reports of a Jupiter-size prominence and solar flares erupting from two active regions on the sun (3089, 3088). Since the fog in Eureka made it impossible to view the sun from town, I drove to the Kneeland Airport where I knew the skies were clear, and there were no trees to block the late afternoon sun.

As I was setting up my solar telescope in the parking lot, Blaine from Cal Fire walked up to introduce himself and asked about my equipment. Blaine said that Cal Fire had been camping at the airport, and were surprised by the number of people showing up in the parking lot to observe with their telescopes. Earlier in the week they had met Jack Hopkins and his astrophotography group. Jack had shown the Cal Fire crew a number of deep sky images that they were working on (Jack had been working on the Elephant Nebula). In the spirit of astronomy outreach, I invited Blaine and the Cal Fire crew to look at the sun through the hydrogen-alpha telescope. I was expecting only a handful of people to show up, but over the course of an hour, about a dozen crew members came by to observe. The view of the sun through a hydrogen-alpha telescope is quite dynamic, and one of the comments I heard was how the sun appeared to be boiling. I pointed out the prominences (the huge one impressed them), filaments, sunspots, and active regions where solar storms were occurring. While we didn't see any solar flares, i.e., intense brightening of the active regions or erupting plumes of plasma, the sun still put on a good show.

It has been over a year since I have done any outreach, and I had forgotten how satisfying it is to spend time with an enthusiastic audience. Below is a sampling of what we observed with the telescopes, and what topics were covered.

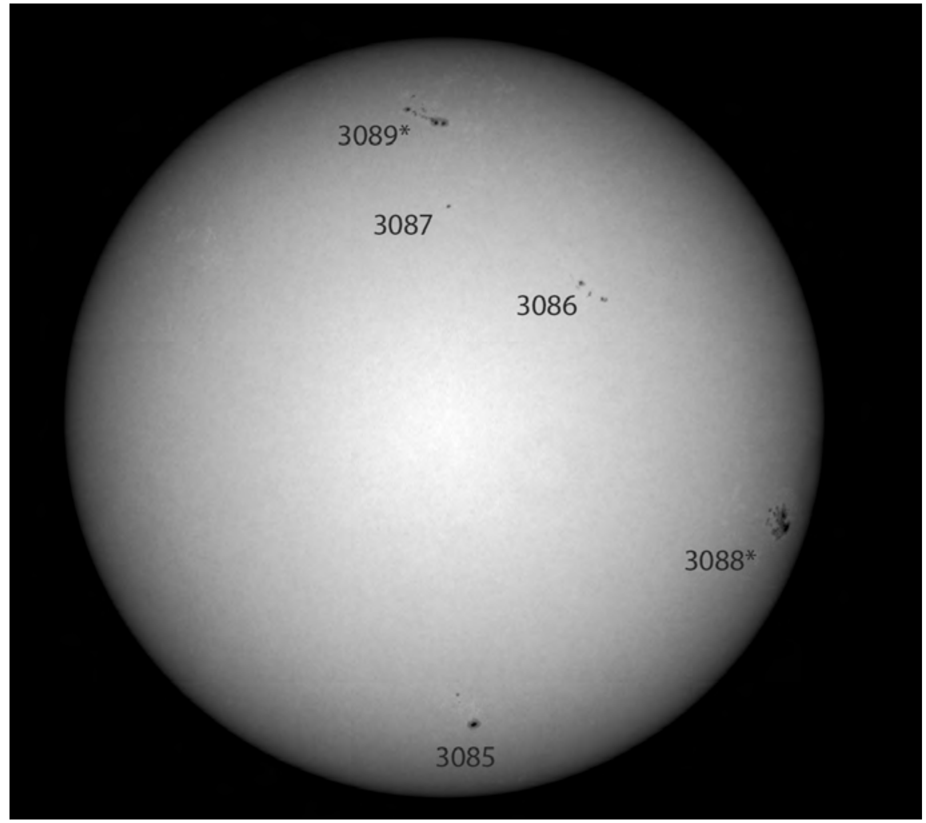


fig. 1. Imaging of the photosphere was done with small telescope and a white-light solar filter. There were five active regions that contained sunspots. Active regions 3089 and 3088 were of interest because of the recent eruptions of solar flares from these areas.

Sunspots are regions where the magnetic field distortions occur. Because of the fast rotation of the sun, magnetic field lines deep within the sun become tangled and can break apart. Pieces of these field lines make it to the surface and become islands of localized magnetic fields. Sunspots form when the convection of internal heat to the surface of the sun is slowed down by the magnetic field. Sunspots are dark because these are cooler than their surroundings. Solar storm activity on the sun is gauged by the number and size of sunspots appearing on the photosphere.

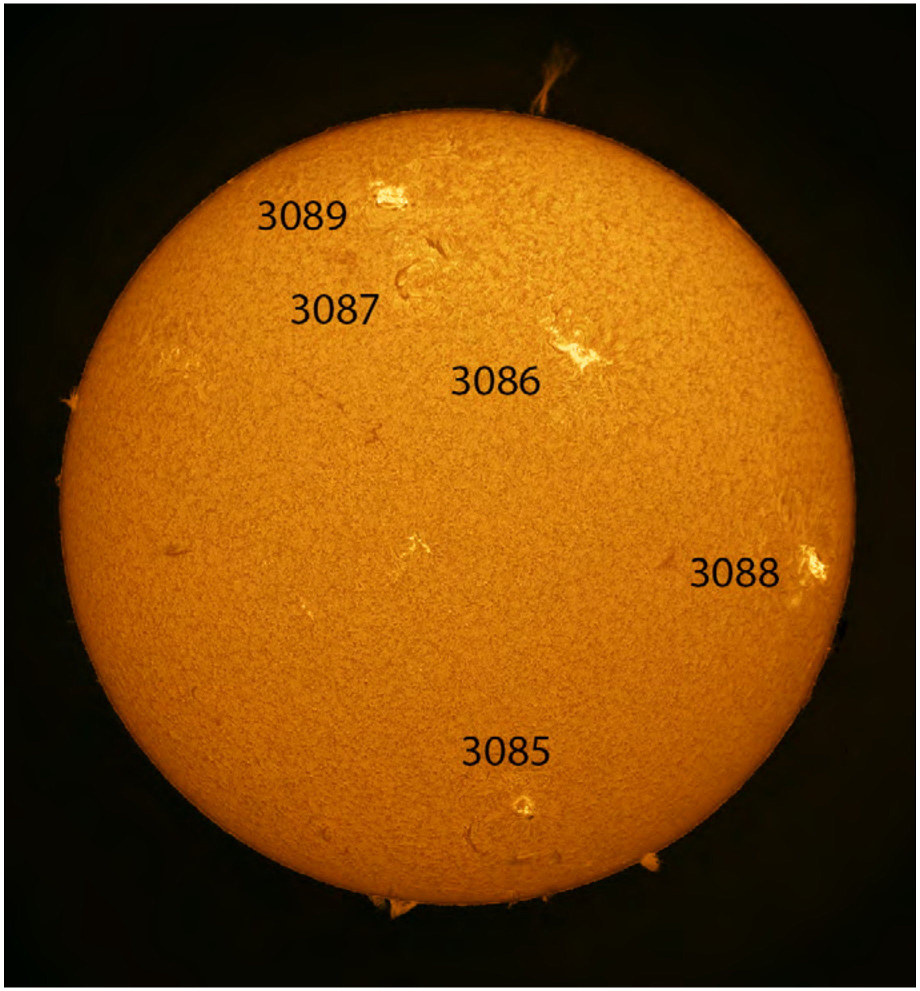


fig. 2. The chromosphere, the thin layer of the atmosphere above the photosphere, was observed with a hydrogen-alpha solar telescope. The sun is mostly composed of hydrogen, and the high temperature of the chromosphere excites these atoms into a higher energy orbit. As excited atoms return to their original orbit, light is emitted at 656 nm. The emitted light is hydrogen-alpha and corresponds to the red part of the visible light spectrum. The red glow of the chromosphere is normally invisible because of the brightness of the underlying photosphere. A hydrogen-alpha telescope allows us to see the sun at this wavelength which gives us a more dynamic view.

The sun on August 26th showed several prominences on the limb including one the size of Jupiter. Prominences are threads of plasma (ionized hydrogen and helium) that are anchored to the surface by the magnetic field. Prominences often get mistaken for solar flares which are also made of plasma, and project into space during eruptions. Prominences are stable structures that can persist for days, whereas solar flares are energized enough to break free of the sun with eruptions lasting from a few minutes to hours. (The best way to see solar flares is at https://sdo.gsfc.nasa.gov).

The chromosphere surface contained several bright active regions (3085-3089), filaments, and sunspots. The brightness of active regions is due to plage (French for beach) which have weak magnetic fields (weaker than sunspots) but bright emissions. The glow of the plage defines the active regions on the chromosphere.

Filaments are dark threads of plasma found on the disk and are equivalent to prominences. Like prominences, these are tethered to the surface by the magnetic field. Filaments were found throughout the chromosphere with some residing in active regions (See AR 3087). These filaments can become solar flares if enough energy is developed in the active region.

A hydrogen-alpha telescope can detect sunspots on the photosphere as these also emit light in the hydrogen-alpha wavelength. Sunspots are relatively cool so less light is emitted compared to other parts are the chromosphere.

A more detailed look at these structures is given in the next section.

Notes: The photosphere was imaged with a six-inch SCT with a white-light solar filter. The chromosphere was imaged with an 80 mm double-stacked hydrogen-alpha solar telescope. Video images of the sun were taken with a ZWO ASI294mc planetary camera and captured with Sharpcap. The frames were stacked with either Registax or Autostakkert. ImPPG (Imaging Post Processing) was used to sharpen the images, and to create inverted images of the chromosphere. Photoshop was used in the final steps of processing: additional sharpening, tone adjustment, and false color.

References: https://sdo.gsfc.nasa.gov; https://www.solarham.net; https://www.vaticanobservatory.org/wp-content/uploads/2018/05/9781461480143-c1-3.pdf

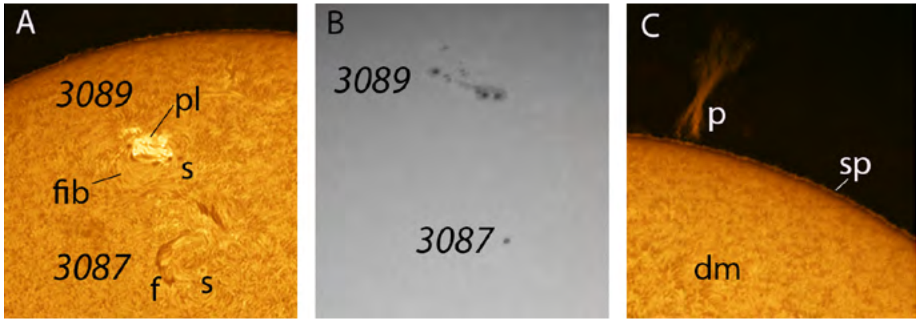


fig. 3.

A. Image of Active Regions 3089 and 3087 (hydrogen-alpha). Plage (pl) accounts for the brightness of active regions. It was noticeable that AR 3087 was dimmer than 3089 as if the plage was more diffuse in the former. There is a grouping of four sunspots in AR 3089 which corresponds to what is seen in the photosphere (See panel B). Likewise, there is a single sunspot in AR 3087 (Panels A and B) There is a pair of filaments (f) seen in AR 3087. Fibrils (fib) of plasma found near active regions become arranged into bundles if the underlying magnetic field is strong enough. A close look at AR 3089 showed the bending of fibrils between sunspots. These fibers presumably run parallel to magnetic field lines between sunspots in the photosphere.

B. The sunspots in AR 3089 and 3087 as seen on the photosphere (white-light solar filter).

C. Prominences and plasma jets of the chromosphere (hydrogen-alpha). Prominences are threads of plasma that are held in place by the magnetic field; these are stable and can persist for days. The chromosphere also contains small jets of plasma that are called spicules (sp) on the limb and dark mottle (dm) when viewed on the surface. Unlike prominences, dark mottle and spicules are short-lived and last only for ten minutes before sinking back into the chromosphere.

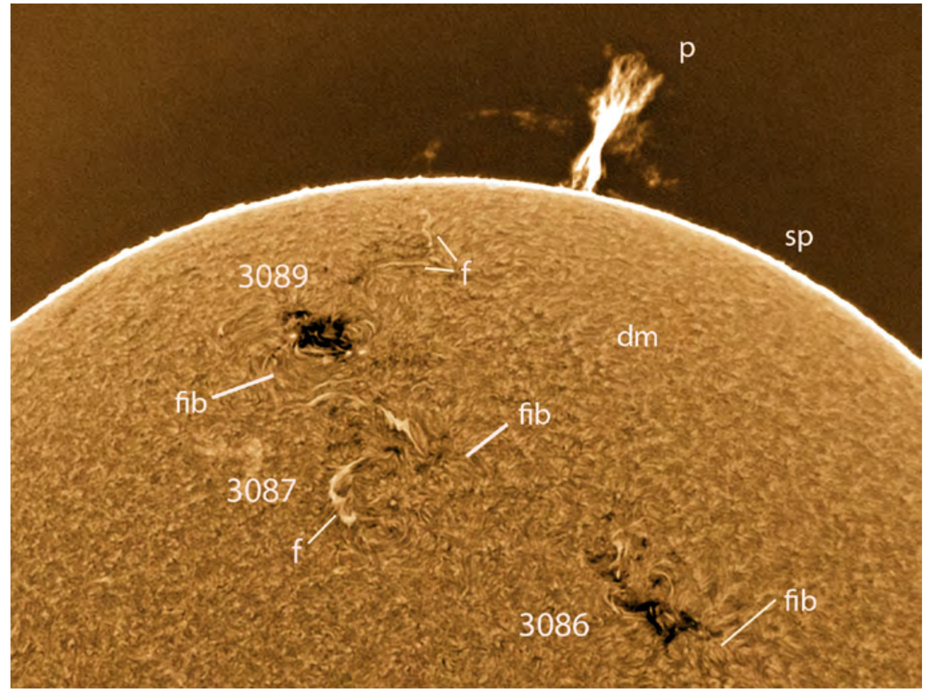


fig. 4. Inverting a positive image of the chromosphere into a negative is a post-processing step used in hydrogen-alpha solar imaging. In the inverted image, surface features such as fibrils and filaments appear to be elevated above the surface which makes these structures stand out.

1. The filaments (f) in AR 3087 appear be lifted off the surface and anchor points can be seen between the filaments and the surface.
2. Dark mottle (dm) are small jets of plasma seen on the surface of the chromosphere. In the inverted image, these light-colored structures have a furry texture (some likened it to carpet).
3. Fibrils (fib) associated with active regions (3089, 3087, 3086) appear to be organized in bundles. This arrangement of fibrils is due to the underlying magnetic field in active regions.

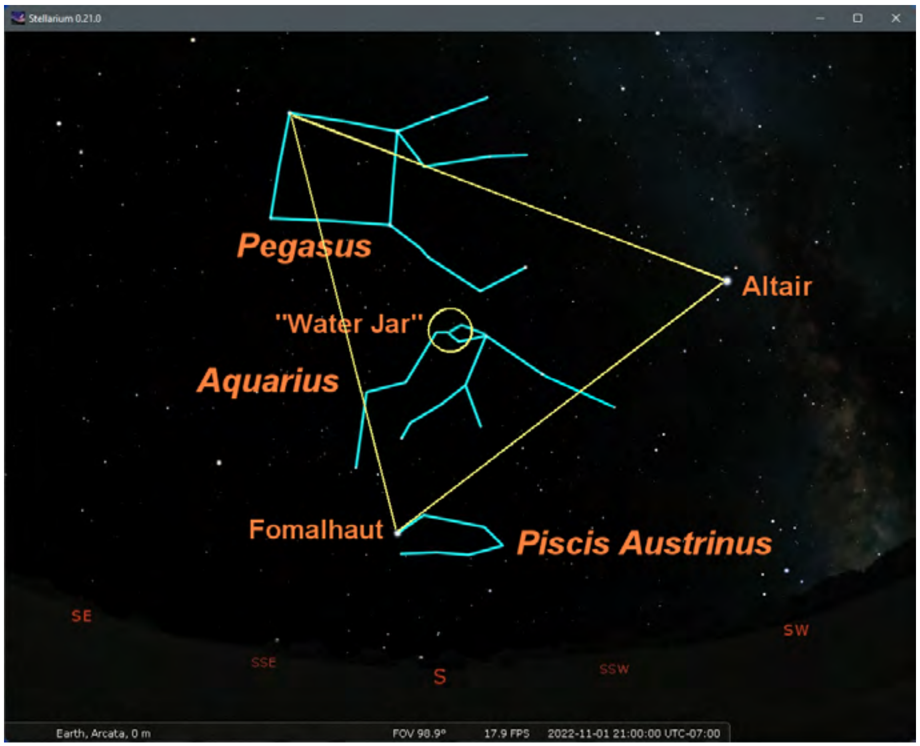
On the edge of the solar disc is a large prominence (p) and several spicules (sp). Spicules are equivalent to dark mottles, i.e., small jets of plasma. Although these are not marked, the sunspots in AR 3089 and 3087 can be clearly seen on the inverted image.

The Water Boy

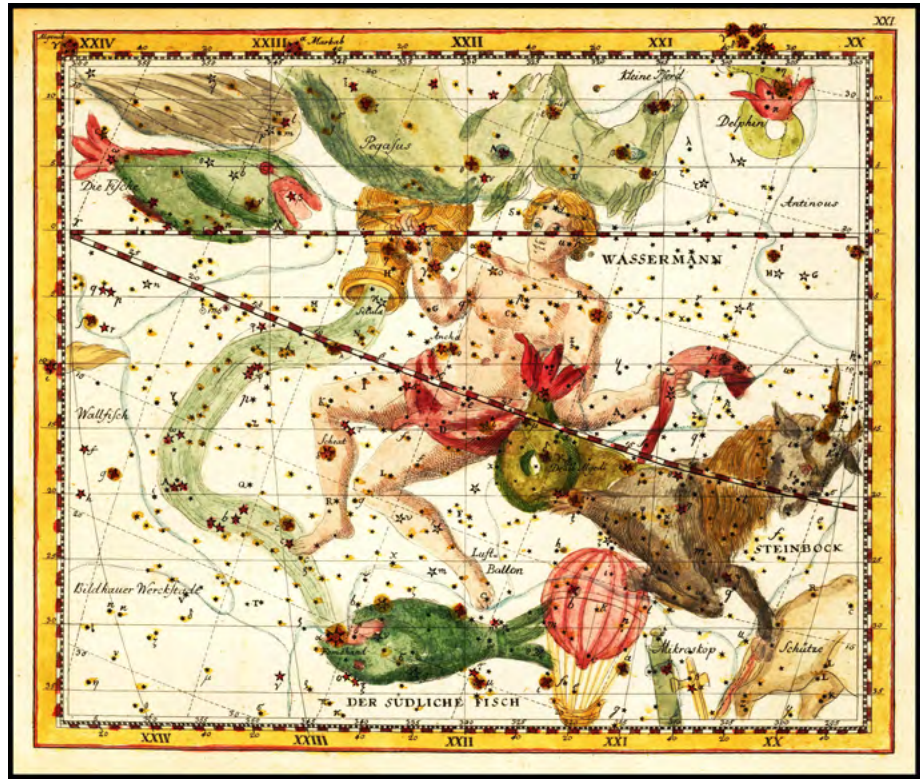
by Ken Yanosko

Let's look southward on an Autumn evening—not at the Milky Way, and not (as of this year) at the bright planets Jupiter and Saturn—but at a constellation that everyone knows about, but not everyone can actually find. Here's what we'll do.

Last Fall we wrote about Pegasus, the Winged Horse ([AOH Newsletter, Autumn 2021, page 5]) so you should be able to find the Great Square. To the right of the square is Altair, the easternmost star in the Summer Triangle. And far to the south is Fomalhaut (Arabic for "Mouth of the Fish"), in Piscis Austrinus, the Southern Fish. (Note that Piscis Austrinus is not to be confused with that other piscine constellation, Pisces—the Fishes—which are up around the Square.) Now imag-



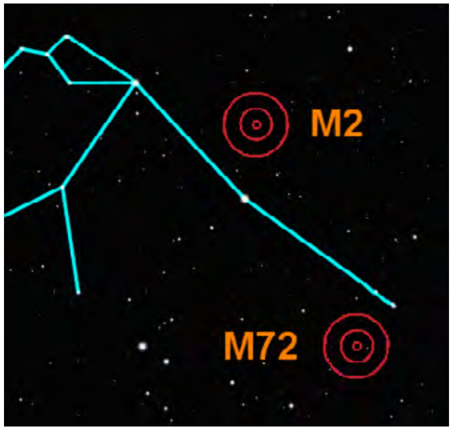
How to find Aquarius. From Stellarium.

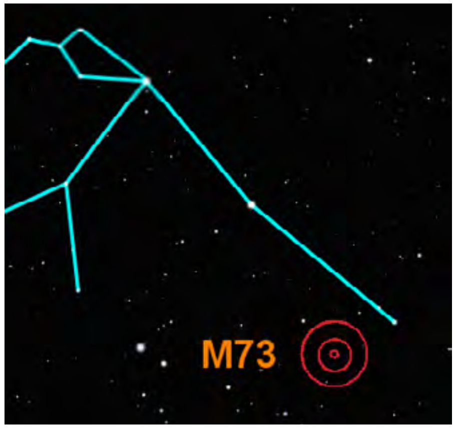


Aquarius, as depicted in Johan Bode's Vorstellung der Gestirne auf XXXIV Tafeln, *1805. Public domain.*

ine a large triangle formed by Altair, Fomalhaut, and the upper left star of the Square. Right in the middle of this triangle is a Y-shaped asterism known at The Water Jar. The Jar is borne by Aquarius, the Water Carrier, whose stick-figure outline is to the right of the Jar, and who is spilling out from the Jar a faint stream of stars down toward Fomalhaut.

In Greek mythology, Aquarius was a young man named Ganymede (who also has a Jovian moon named after him) who was drafted by the god Zeus to be his water (and wine) server. It seems to me that he is carelessly spilling the water down to where the Southern Fish can enjoy it. Nevertheless, as a reward for his service, Zeus granted Ganymede immortality and a place in the sky. You can get all the details in Ian Ridpath's Star Tales.





Finder charts for the Messier and NGC objects in Aquarius. From Stellarium.

Messier and NGC Objects

Among the stars of Aquarius we can see a number of deep-space objects. Charles Messier found globular clusters M2 and M72 lying above and below Aquarius's left arm, respectively. M2 is the bigger and brighter one of the pair. And just 100 arcminutes to the east of M72 is the "cluster" M73, which Messier described as an open cluster with four bright stars surrounded by some nebulosity. Later John Herschel agreed that it was a cluster, but without nebulosity. The status remained controversial until the year 2000 when Giovanni Carraro of the University of Padua showed that the four stars in question are at widely varying distances from us and are moving in different directions, and that the dimmer background stars are no more concentrated than would be expected for random stars in that part of the sky. [https://adsabs.harvard.edu/full/2000A%26A...357..145C]

Above left: NGC 7009, the "Saturn Nebula" posted on Cloudy Nights by JoeR; above right: Saturn itself, posted on Cloudy Nights by Wargrafix. Right: NGC 7293, the "Helix Nebula" posted on Cloudy Nights by Jon_Doh.

So it turns out that a correct description of M73 should be "a chance asterism of four stars."

Two planetary nebulae in Aquarius, which are within reach of our amateur telescopes, are both interesting. NGC7009 (two degrees northeast of M73) is called the "Saturn Nebula." It has two lobes that give it an uncanny resemblance to a ringed body. And although it's only magnitude 8, it's about the same angular size as Saturn itself, which happens this year to be in the same part of the sky (right next door in Capricornus). Check them out. And NGC 7293, at Aquarius's feet, just northwest of Fomalhaut, is called the "Helix Nebula" for its twisted appearance. This nebula is much larger than "Saturn" and is supposed to be brighter, but its light is spread out more. Which of these two planetaries do you find easier to see?

The Age of Aquarius

So what about this "Age of Aquarius" that we sometimes hear about? Is this something astronomical, or just New Age astrology? Well, here's the deal.

In the third century BC, the Babylonian astronomers noticed that at the time of the Spring Equinox, the Sun was in the part of the sky on the boundary between the constellations Aries and Pisces. Since the Sun's apparent annual motion across the sky, relative to the background stars, is from west to east, this was the time that the Sun appeared to be just entering Aries. So the Babylonians denoted this point on their star charts as "The First Point of Aries."

Today we recognize this point as one of the points on the sky where the celestial equator, which is the projection onto the sky of the Earth's equator, crosses the ecliptic, which is the apparent path of the Sun across the sky.

Five hundred years later, the Greek astronomer Hipparchus, who had copies of the Babylonian records, noticed that the First Point of Aries was no longer on the Aries-Pisces border, but had moved well into Pisces. We now know that the Earth wobbles, or "precesses," on its axis, like a spinning top. This causes the Earth's north pole, which in our era is pointing to Polaris, to swing around in a large circle so that in other millenia it points elsewhere. As a result, the points of intersection of the equatorial plane and the ecliptic also move. This motion is noticeable century-by-century (one complete loop around the sky takes 26,000 years). Hipparchus is credited with the discovery of this "precession of the equinoxes."

Hipparchus, and his armillary sphere, on a 1965 Greek postage stamp.

Note that both Hipparchus and later astronomers kept the term "First Point of Aries," despite the migration of this point away from the constellation Aries. Note, too, that this phenomenon of precession explains why, on your birthday, the Sun really isn't in the constellation representing your "sun sign."

The ecliptic (orange line), passes through the constellations Aries, Pisces, and Aquarius. The different locations of the celestial equator (blue lines) show how the "First Point of Aries" precesses along the ecliptic as the centuries go by. In 300 BC this intersection point was at the boundary of Aries and Pisces; 500 years later it was well into Pisces; in 1967 it was still in Pisces; in 2600 it will reach the Pisces-Aquarius boundary. From Stellariium.

But what about Aquarius? Well, in 1967 a bunch of hippies, in the Broadway musical "Hair," declared that *their* era was the "Dawning of the Age of Aquarius." Apparently the songwriters, misled by the pseudo-scientists of the day, were anticipating that the First Point of Aries would have moved, by then, all the way across the constellation Pisces and into Aquarius. It turns out they had jumped the gun somewhat. According to the International Astronomical Union's official constellation boundaries, the First Point of Aries won't hit Aquarius until around the year 2600.

But you don't have to wait until then. Go out and look southward on an Autumn evening, and you too can experience the

> "Mystic crystal revelation
> And the mind's true liberation
> Aquarius!
> Aquarius!"

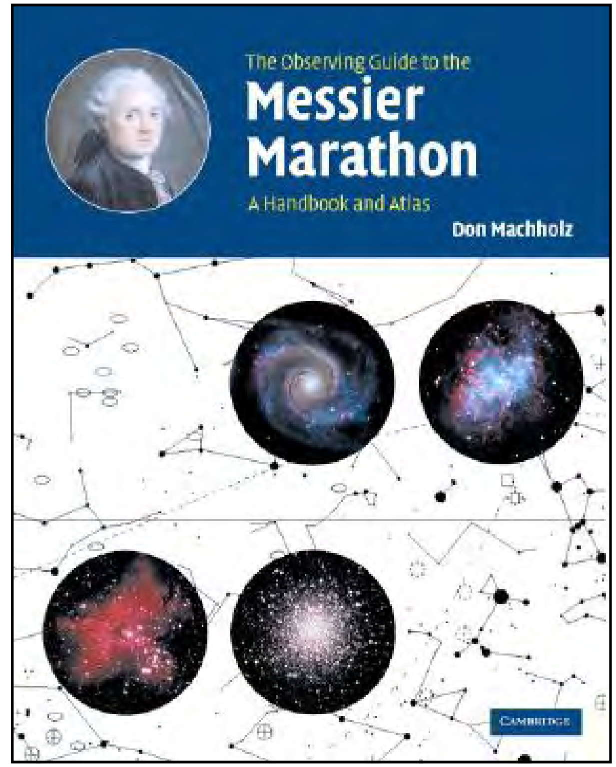
Book Review

by Ken Yanosko

Don Machholz, who died on August 9, 2022, in Arizona, was considered to be one of the inventors of the Messier marathon. He himself completed 50 marathons in 40 years. In seven of these he viewed all 110 objects, and in the latter six of these he did it from memory—without a printed list and without charts.

Machholz was also known as the most prolific visual comet discoverer; he is credited with the discovery of 12 comets, fittingly, the same number that Messier discovered. From 1978 until 2000, Machholz wrote a monthly column titled "Comet Comments" for ALPO, the Association of Lunar and Planetary Observers, where he was the Comet Recorder for 12 years. This column was distributed free of charge to astronomy clubs; it was a regular feature of the AOH Newsletter.

Don Machholz with his homemade 29 x 130 binoculars.
[*https://donmachholz.com/biography/*](https://donmachholz.com/biography/)



Machholz's The Observing Guide to the Messier Marathon *(2002) Cambridge University Press. This book is now out of print, but is available, used, for under $20.*

He was an author of several astronomy publications, including *The Observing Guide to the Messier Marathon* published in 2002 by Cambridge University Press.

Subtitled *A Handbook and Atlas*, this book begins with a brief biography of Charles Messier, and follows with a description of Messier's catalog and its "add-ons" by other astronomers. It then goes into details of the Messier Marathon. It includes: a table of optimal dates (up to the year 2050), charts showing how one's expectations during a marathon have to be tempered because of the observer's latitude (If you want to see all 110 objects you had better be somewhere south of 35 degrees north latitude), and an optimal search sequence for goto telescopes.

In the atlas part of the book each page spread contains, on the left, a wide-field chart with guide stars to use with your finder scope, and, on the right, a close-up chart with tips for zeroing in at the eyepiece. These charts are in marathon order, but a table at the beginning lets you easily find the right chart for any object by Messier number.

Sadly, the book has gone out of print; but used copies can be found on the internet. You don't need to pay "rare book" prices either; I got mine, a perfectly good unmarked library deaccession, for under twenty bucks.

To search for alien life, astronomers will look for clues in the atmospheres of distant planets – and the James Webb Space Telescope just proved it's possible to do so

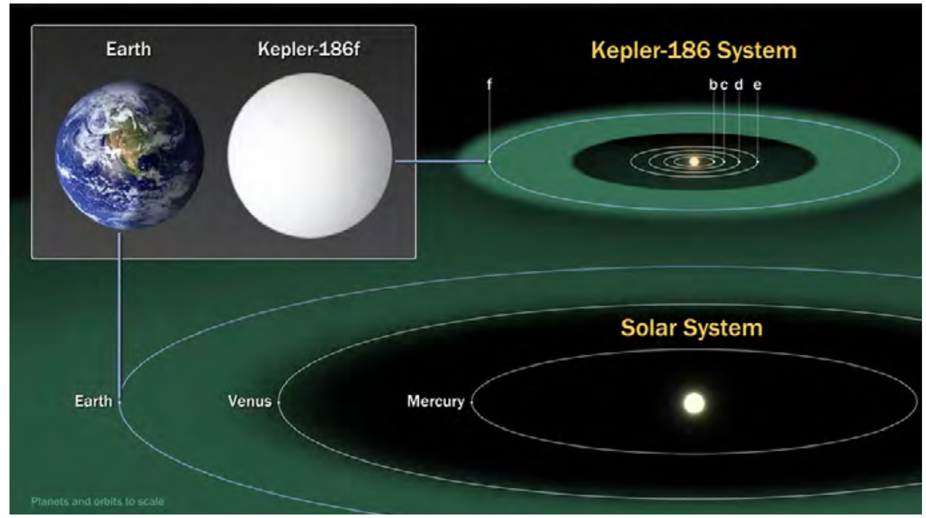
by Chris Impey and Daniel Apai

The ingredients for life are spread throughout the universe. While Earth is the only known place in the universe with life, detecting life beyond Earth is a major goal of modern astronomy and planetary science.

We are two scientists who study exoplanets and astrobiology. Thanks in large part to next-generation telescopes like James Webb, researchers like us will soon be able to measure the chemical makeup of atmospheres of planets around other stars. The hope is that one or more of these planets will have a chemical signature of life.

Habitable exoplanets

Life might exist in the solar system where there is liquid water – like the subsurface aquifers on Mars or in the oceans of Jupiter's moon Europa. However, searching for life in these places is incredibly difficult, as they are hard to reach and detecting life would require sending a probe to return physical samples.



There are many known exoplanets in habitable zones – orbits not too close to a star that the water boils off but not so far that the planet is frozen solid – as marked in green for both the solar system and Kepler-186 star system with its planets labeled b, c, d, e and f. [*NASA Ames/SETI Institute/JPL-Caltech/Wikimedia Commons*]

Many astronomers believe there's a good chance that life exists on planets orbiting other stars, and it's possible that's where life will first be found.

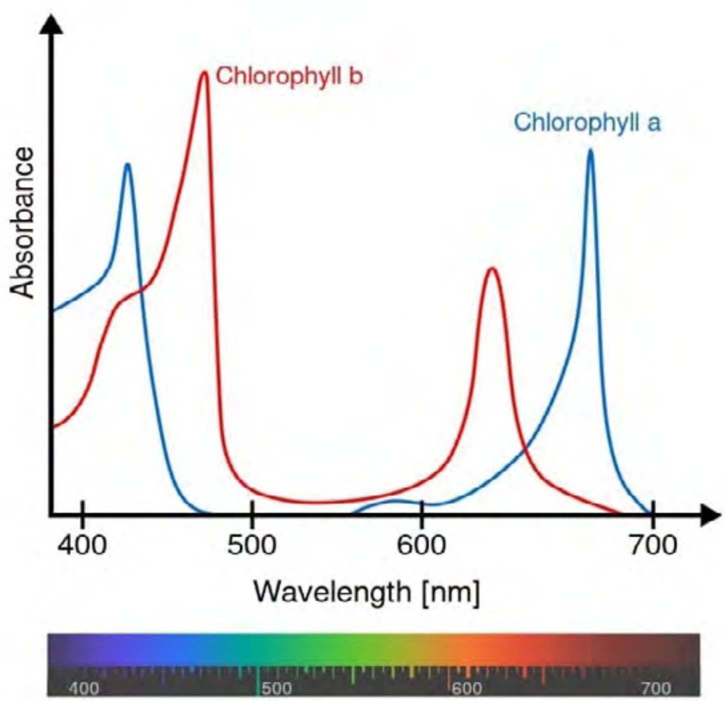
Theoretical calculations suggest that there are around 300 million potentially habitable planets in the Milky Way galaxy alone and several habitable Earth-sized planets within only 30 light-years of Earth – essentially humanity's galactic neighbors. So far, astronomers have discovered over 5,000 exoplanets, including hundreds of potentially habitable ones, using indirect methods that measure how a planet affects its nearby star. These measurements can give astronomers information on the mass and size of an exoplanet, but not much else.

Looking for biosignatures

To detect life on a distant planet, astrobiologists will study starlight that has interacted with a planet's surface or atmosphere. If the atmosphere or surface was transformed by life, the light may carry a clue, called a "biosignature."

For the first half of its existence, Earth sported an atmosphere without oxygen, even though it hosted simple, single-celled life. Earth's biosignature was very faint during this early era. That changed abruptly 2.4 billion years ago when a new family of algae evolved. The algae used a process of photosynthesis that produces free oxygen – oxygen that isn't chemically bonded to any other element. From that time on, Earth's oxygen-filled atmosphere has left a strong and easily detectable biosignature on light that passes through it.

When light bounces off the surface of a material or passes through a gas, certain wavelengths of the light are more likely to remain trapped in the gas or material's surface than others. This selective trapping of wavelengths of light is why objects are different colors. Leaves are green because chlorophyll is particularly good at absorbing light in the red and blue wavelengths. As light hits a leaf, the red and blue wavelengths are absorbed, leaving mostly green light to bounce back into your eyes.



Every material absorbs certain wavelengths of light, as shown in this diagram depicting the wavelengths of light absorbed most easily by different types of chlorophyll. Daniele Pugliesi/Wikimedia Commons, CC BY-SA

The pattern of missing light is determined by the specific composition of the material the light interacts with. Because of this, astronomers can learn something about the composition of an exoplanet's atmosphere or surface by, in essence, measuring the specific color of light that comes from a planet.

This method can be used to recognize the presence of certain atmospheric gases that are associated with life – such as oxygen or methane – because these gasses leave very specific signatures in light. It could also be used to detect peculiar colors on the surface of a planet. On Earth, for example, the chlorophyll and other pigments plants and algae use for photosynthesis capture specific wavelengths of light. These pigments produce characteristic colors that can be detected by using a sensitive infrared camera. If you were to see this color reflecting off the surface of a distant planet, it would potentially signify the presence of chlorophyll.

Telescopes in space and on Earth

It takes an incredibly powerful telescope to detect these subtle changes to the light coming from a potentially habitable exoplanet. For now, the only telescope capable of such a feat is the new James Webb Space Telescope. As it began science operations in July 2022, James Webb took a reading of the spectrum of the gas giant exoplanet WASP-96b. The spectrum showed the presence of water and clouds, but a planet as large and hot as WASP-96b is unlikely to host life.

The James Webb Space Telescope is the first telescope able to detect chemical signatures from exoplanets, but it is limited in its capabilities. NASA/Wikimedia Commons

However, this early data shows that James Webb is capable of detecting faint chemical signatures in light coming from exoplanets. In the coming months, Webb is set to turn its mirrors toward TRAPPIST-1e, a potentially habitable Earth-sized planet a mere 39 light-years from Earth.

Webb can look for biosignatures by studying planets as they pass in front of their host stars and capturing starlight that filters through the planet's atmosphere. But Webb was not designed to search for life, so the telescope is only able to scrutinize a few of the nearest potentially habitable worlds. It also can only detect changes to atmospheric levels of carbon dioxide, methane and water vapor. While certain combinations of these gasses may suggest life, Webb is not able to detect the presence of unbonded oxygen, which is the strongest signal for life.

Leading concepts for future, even more powerful, space telescopes include plans to block the bright light of a planet's host star to reveal starlight reflected back from the planet. This idea is similar to using your hand to block sunlight to better see something in the distance. Future space telescopes could use small, internal masks or large, external, umbrella-like spacecraft to do this. Once the starlight is blocked, it becomes much easier to study light bouncing off a planet.

There are also three enormous, ground-based telescopes currently under construction that will be able to search for biosignatures: the Giant Magellen Telescope, the Thirty Meter Telescope and the European Extremely Large Telescope. Each is far more powerful than existing telescopes on Earth, and despite the handicap of Earth's atmosphere distorting starlight, these telescopes might be able to probe the atmospheres of the closest worlds for oxygen.

Is it biology or geology?

Even using the most powerful telescopes of the coming decades, astrobiologists will only be able to detect strong biosignatures produced by worlds that have been completely transformed by life.

Unfortunately, most gases released by terrestrial life can also be produced by nonbiological processes – cows and volcanoes both release methane. Photosynthesis produces oxygen, but sunlight does, too, when it splits water molecules into oxygen and hydrogen. There is a good chance astronomers will detect some false positives when looking for distant life. To help rule out false positives, astronomers will need to understand a planet of interest well enough to understand whether its geologic or atmospheric processes could mimic a biosignature.

Animals, including cows, produce methane, but so do many geologic processes. Jernej Furman/ Wikimedia Commons, CC BY

The next generation of exoplanet studies has the potential to pass the bar of the extraordinary evidence needed to prove the existence of life. The first data release from the James Webb Space Telescope gives us a sense of the exciting progress that's coming soon.

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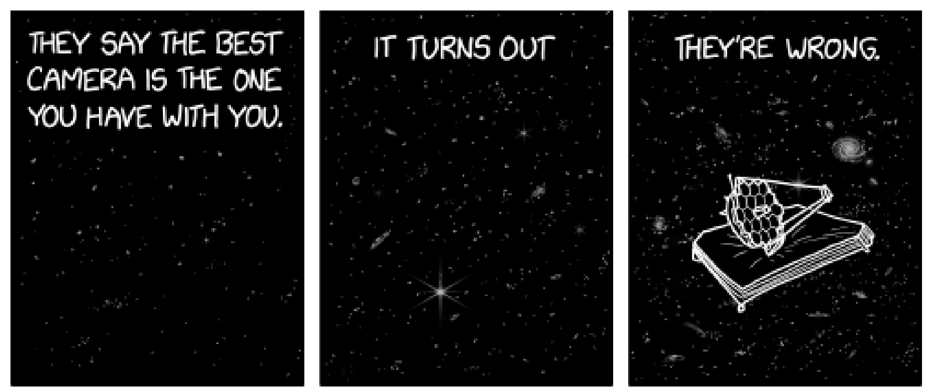

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This article is distributed by the [NASA Night Sky Network](), a coalition of hundreds of astronomy clubs across the US dedicated to astronomy outreach.

You Can Help Discover Exoplanets!

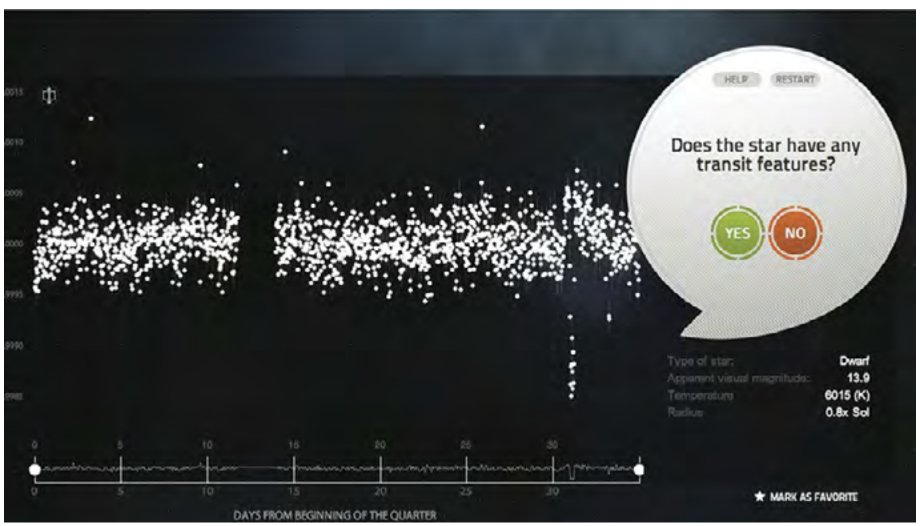
Hunting for exoplanets is not just for astronomers with years of training and specialized equipment-you too can join the hunt for worlds around other stars! There are many citizen science projects you can join to help find more planets and assist in the search for life around other stars. Amateur astronomers also help confirm exoplanets from their own backyard telescopes, and have even made a few discoveries of their own.

Want to help NASA find exoplanets - with your own equipment? You can use your telescope to observe transit events and share your data as part of the Exoplanet Watch citizen science project! No telescope of your own, or using it for other projects? Not a problem! You can also use remote robotic telescopes to observe and submit data. Dig into the program's details and ready your telescopes for some transit runs by checking out the official Exoplanet Watch website.

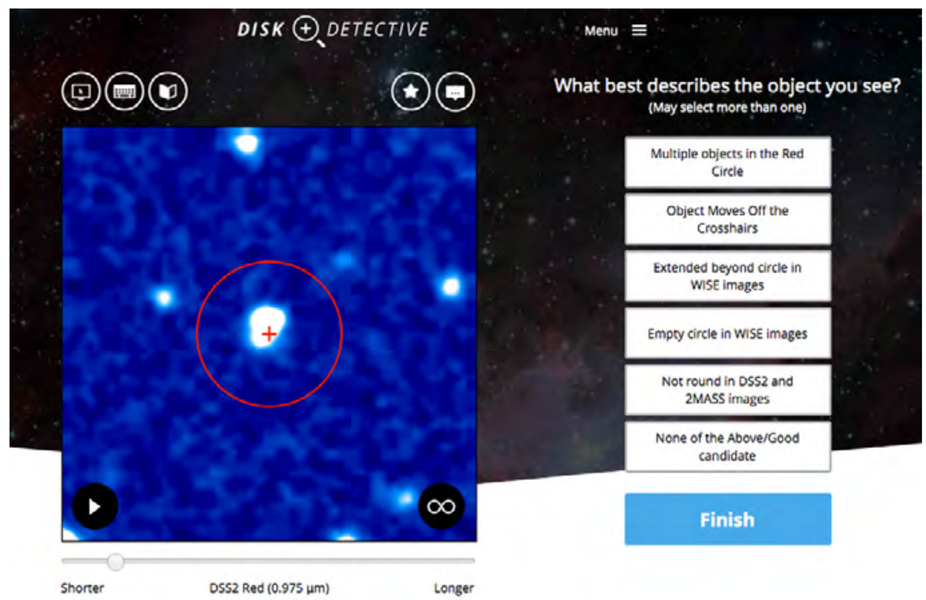
The Zooniverse project hosts some excellent citizen science programs that you can join to help find other worlds. Planethunters TESS started with data from the Kepler Mission, and now uses data from TESS. Participants use their eyes to spot suspicious light curves from stars in TESS's field of view. If you spot a suspicious blip in the light curve, mark it as a possible planet and the possible detection is followed up by astronomers to confirm or deny the detection.

Not all blips are exoplanets! A companion project, Planet Patrol, checks and rechecks possible detections to ensure that they are actually picking up signs of an orbiting planet, instead of a temporary glitch, sunspots, dust, or some other unseen, non-planetary cause for dips in their light curves. The project releases data to participants when available, so sign up for updates at the official Planet Patrol website.

Disc Detective is another project that allows citizen scientists to peek at discs of gas around other stars that may hold hidden planets, and protoplanets in the process of forming.



Discovery of a transit around the star KIC10005758 spotted via planethunters.org



Screenshot of Disk Detective in action. Credit: Marc Kuchner

A prototype of a PANOPTES unit. Image credit: Project PANOPTES

There are even more NASA-affiliated Exoplanet projects you can join- there is just so much data that scientists need as much help as they can get! Find out what Exoplanet-themed citizen science projects are available from NASA on the Exoplanet Exploration group's Citizen Science page.

Want to get behind a telescope and gather data to spot worlds on your own? You can even do that! Project PANOPTES provides a standard planet-hunting platform available to everyone. For a fairly low cost (for an advanced observatory, that is!) you can assemble your own planet finding observatory. Olivier Guyon even joined the Night Sky Network for a special telecon two years ago. Check it out here.

Want to use your own equipment to hunt for planets? You can do that too! Bruce Gary has written an excellent and free guide for amateurs wanting to start hunting and confirming exoplanets, and it is available for free, in PDF format, from his website: http://brucegary.net/book_EOA/EOA.pdf. There is also an excellent article on Astronomy Online about detecting exoplanets with amateur equipment.

One of the oldest citizen science programs on the web was also the first to invite people to search for life around other stars: SETI@home. After all, we now know that there are vast numbers of worlds in our galaxy-could some of them support life, perhaps even an intelligent, technological civilization? Data collected by SETI from radio telescopes is split up and sent to computers around the world, the results analyzed with their spare computing power, and sent back up to SETI once done. The software also featured a very hypnotic screensaver that shows the analysis in progress. While the project is currently in "hibernation" and no longer distributing work to users, that may change in the future. If so, maybe your computer will be the one that finds a signal from an alien civilization!

Citizen scientists like yourself can help to make many discoveries in the field of astronomy, as they have in many other scientific fields. Sign up to help find other worlds today!

https://nightsky.jpl.nasa.gov/news-display.cfm?News_ID=688

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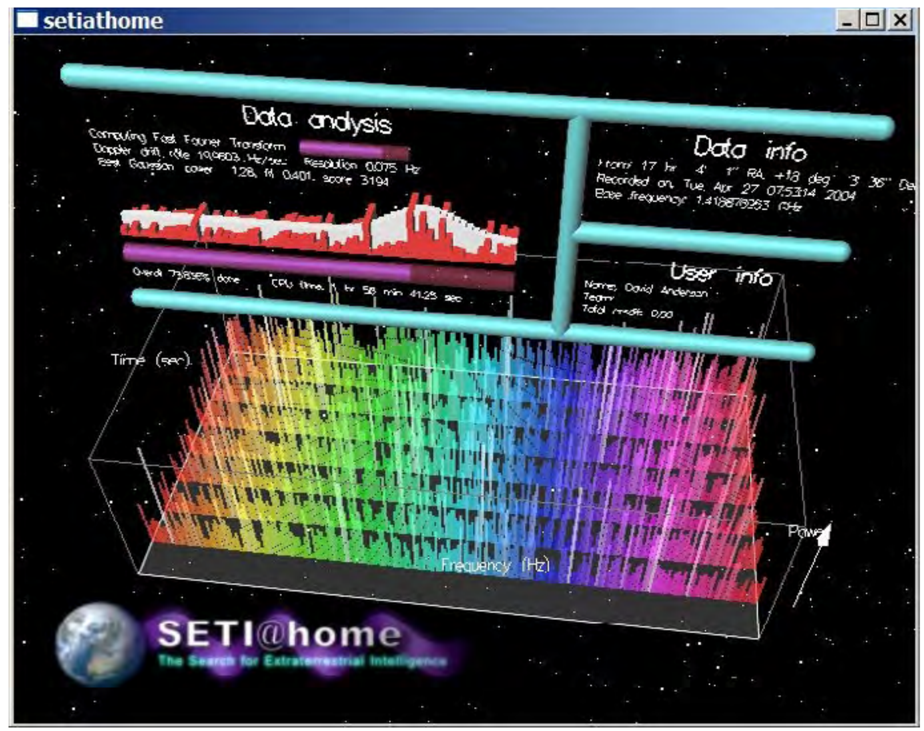

Screenshot featuring one of the graphics options for the Seti@Home client. Credit: SETI@home

After Words

"One of the saddest lessons of history is this: If we've been bamboozled long enough, we tend to reject any evidence of the bamboozle. We're no longer interested in finding out the truth. The bamboozle has captured us. It's simply too painful to acknowledge, even to ourselves, that we've been taken. Once you give a charlatan power over you, you almost never get it back."

— Carl Sagan
The Demon-Haunted World: Science as a Candle in the Dark
1996

"Astronomy, that micography of heaven, is the most magnificent of the sciences because it is mingled with a certain amount of divination. The hypothesis is one of its essentials. In all the sciences, contrasting with the general light, there is a corner of darkness. Astronomy alone has no shadows, or, to speak more truly, its very shadows are dazzling. The proved is evident, the conjectural is splendid. Astronomy has its clear side and its luminous side; on its clear side it is tinctured with algebra, on its luminous side with poetry."

— Victor Hugo
Postscriptum de ma vie
1907

Heavenly Bodies

by Susie Christian

The Monthly Meeting of the AstronoMeers
A nod to the MeerKat Radiotelescope — [SARAO]