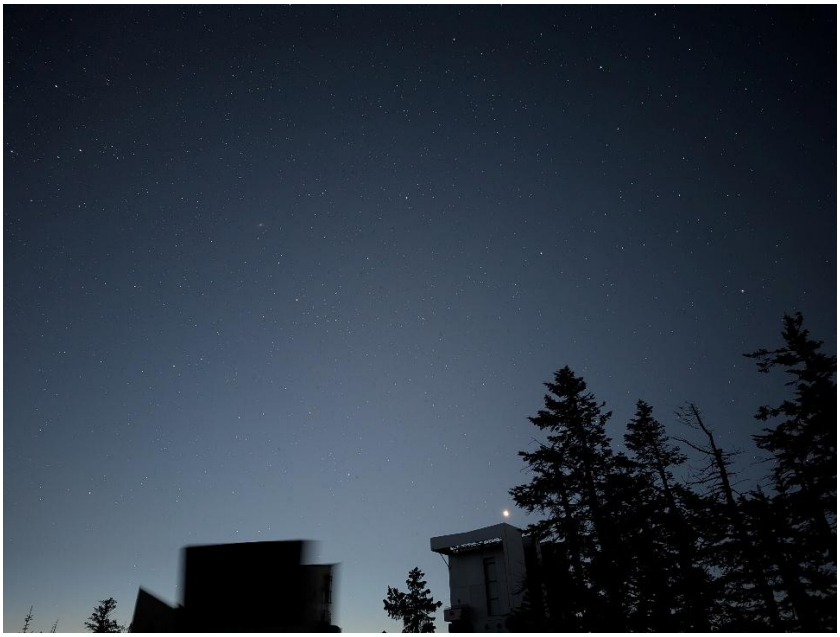
Education & Public Outreach
June 2025, Part 2

June's Full Moon:

Again, I sometimes miss events of interest. The upcoming Full Moon (the morning of June 11) will be the lowest Full Moon in 18.6 years. This is called a lunar standstill. This happens thanks to the tilt of the axis of the Earth and the tilt of the Moon's orbit relative to the plane of the Solar System. This will help us for our upcoming observing run as it also means the Moon will be above the horizon for a shorter time.

Pictures:

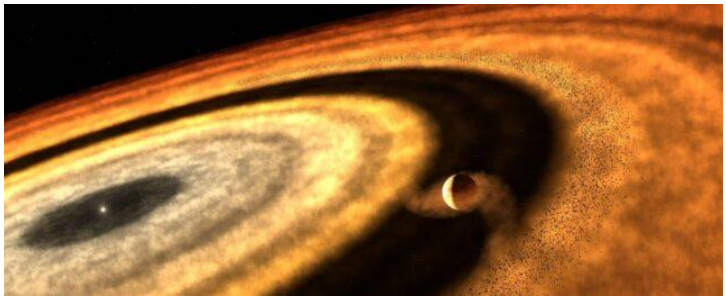
I was on Mt. Graham last week and will be going back there on Wednesday. We did very little the first few nights, thanks to high humidity. The weather finally improved, and we were able to observe 10 asteroids. This includes one asteroid that had not been observed in over a year. I consider that a successful run. Here are three pictures from the platform outside the observers' area. The first picture was taken during the day, but the first two nights were mostly the same, high humidity, and we were usually in the clouds. In the first picture, the Submillimeter Telescope can just be seen through the clouds and the Large Binocular Telescope is completely hidden by the clouds. In the second picture, taken on the third night, you can see both scopes and the Andromeda Nebula directly over the Submillimeter Telescope (moving during the picture). That is Venus rising over the Large Binocular Telescope. The bottom picture was taken the last morning. Again, you can see Andromeda. You can also see an airplane contrail. What is hard to see is what is at the bottom center. If you look carefully, you can see a bunch of streaks. There were more than a dozen Starlink satellites that could be seen. I have a time lapse version of this if you are interested in seeing what they look like in motion!



Astronomy in the News

NASA, ESA, and Other Missions:

JWST, Hot Jupiter Formation:



An artist's impression of the formation of Tylos. (T. Müller/MPIA/HdA/CC BY-SA)

I usually do not give "artist's impressions," as they can be very misleading or very wrong, but this one aligns with what the scientists thought the forming planetary system might have looked like. For the Jupiter-sized exoplanets, there are three primary models for their formation—disk instability (a portion of the protoplanetary disk collapses and forms a star or giant planet, mostly hydrogen and helium), core accretion (a solid of iron and rock forms out of protoplanetary bodies; at some point the large cores accrete their hydrogen and helium atmospheres), pebble accretion (the most recent model that solves some of the issues with the other two models but does not solve all of them). Both the core accretion and pebble accretion models would have significant silicate cores. WASP-121 (formally named Dilmun after the ancient civilization) is 860 light-years from us. It is a solar -type star that is 1.3 times the mass of the Sun, 1.5 times the diameter of the Sun, and 1,000 K hotter than the Sun. It is orbited by a gas giant exoplanet, Tylos (the

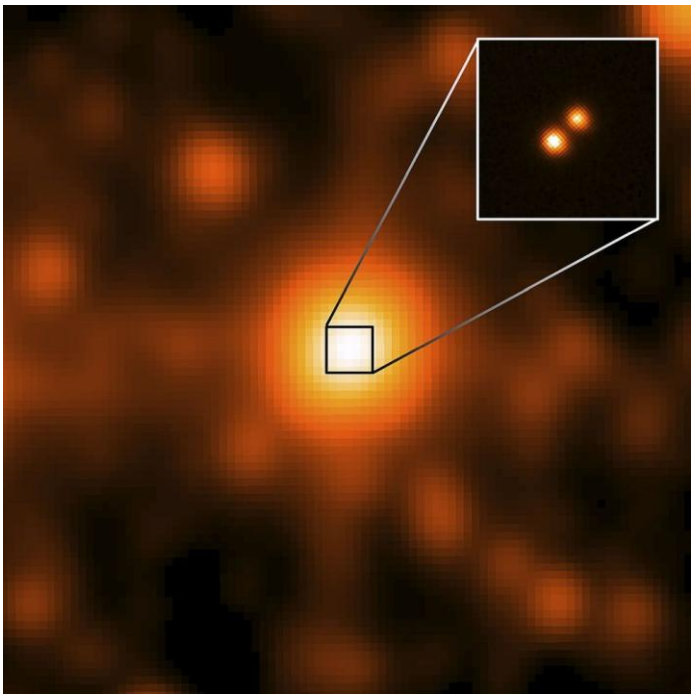
ancient Greek name for Bahrain). It is 1.2 times the mass of Jupiter and 1.8 times the diameter of Jupiter (half the density of Saturn). Tylos orbits its host star at a distance of 0.026 AU with an orbital period of 1.27 days. It has an atmospheric temperature of 2,600 K (4,200 °F). Tylos transits Dilmun, so astronomers have been able to study its atmosphere. It was the first exoplanet discovered to have a stratosphere (the upper atmosphere is heated) and the first where water was detected (one of the molecules that contribute to the atmospheric heating). Since the discovery of Tylos, other molecules have been tentatively discovered in its atmosphere. The JWST observative report conclusive evidence of silicon monoxide, along with water, carbon monoxide, and methane. The implication is that astronomers are seeing molecules that once formed the core of Tylos, implying that Tylos has a rocky core, supporting the core accretion and pebble accretion models.

https://www.sciencealert.com/tiny-pebbles-created-one-of-the-most-extreme-worlds-in-the-galaxy

https://www.spacedaily.com/reports/Space_pebbles_and_rocks_play_pivotal_role_in_giant_planets_formation_999.html

JWST, Brown Dwarf Atmospheres:

As we have talked about in the past, brown dwarfs are objects that are not massive enough to fuse hydrogen into helium but are massive enough to fuse deuterium (a hydrogen atom with a neutron) into helium. However, this process cannot be sustained as with normal stars, the pressure and temperature is too low. Their masses range from about 13 to 80 times the mass of Jupiter. The two closest brown dwarfs are WISE 1049 AB (Luhman 16). At 6.5 light-years only the Sun, the Alpha Centauri system, and Barnard's Star are closer to us. Using JWST, twice, seven months apart, the astronomers monitored the rotational variation of the atmospheres of the two brown dwarfs over a period of seven hours (a rotational period). There was significant spectral variation for the two dwarfs, and they differed from one to the other. The astronomers were observing weather patterns on the two brown dwarfs, caused by variations in the molecular gases and silicate grains in their atmospheres.



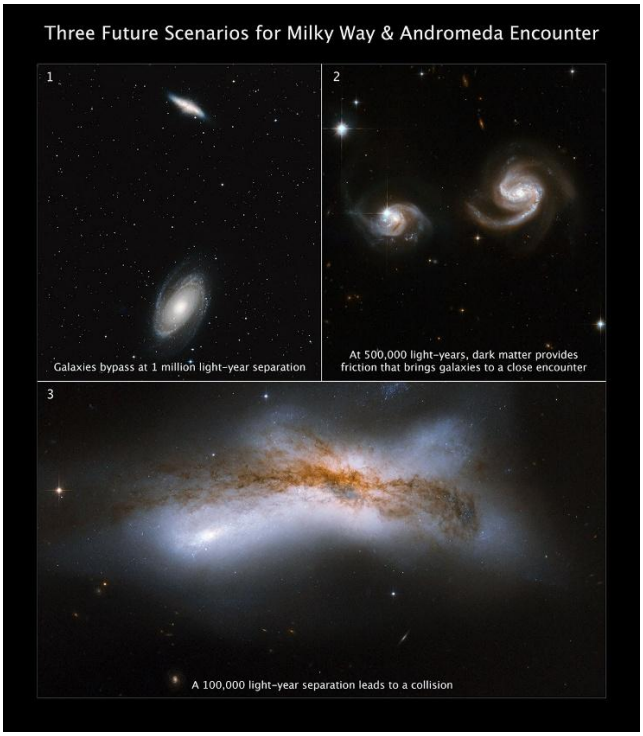
WISE 1049 AB, also known as Luhman 16, is the closest binary pair of brown dwarfs to the Sun. Studying their atmospheres gives astronomers a window into both exoplanets and stars. Image Credit: By NASA/JPL/Gemini Observatory/AURA/NSF http://www.nasa.gov/mission_pages/WISE/multimedia/pia16872.html https://commons.wikimedia.org/w/index.php?curid=25087371

Of the 130 nearest Main Sequence stars, brown dwarfs, and white dwarfs, 21 of them are brown dwarfs. They are faint, so there may be more, especially older ones that have cooled off after billions of years. Eleven are on their own, there are 2 binary pairs, there is one binary pair of a star and a brown dwarf, there are two three-object systems of a star and two brown dwarfs, and there is one four object system with three stars and one brown dwarf.https://www.universetoday.com/articles/webb-watches-dramatic-weather-changes-on-a-pair-of-nearby-brown-dwarfs

HST, Will Andromeda Meet the Milky Way?:

For about a hundred years, it has been believed that the Andromeda Galaxy would collide with the Milky Way Galaxy in less than 5 billion years. As Don McCarthy always points out, galaxies are relatively close together and so collisions are common in the Universe. The authors of this paper reanalyzed existing data and created 100,000 different simulations using 22 different parameters. They have determined that there is only a 50-50 chance that the two galaxies will collide, in part due to interactions with the Large Magellanic Cloud and Andromeda's own satellite dwarf galaxy M33.

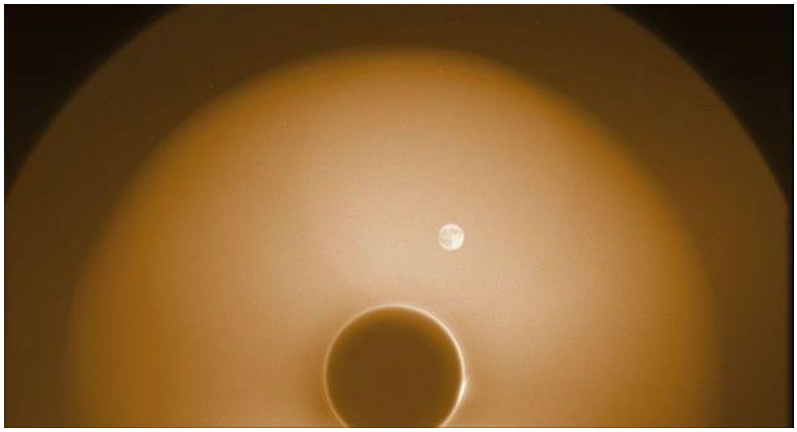
https://science.nasa.gov/missions/hubble/apocalypse-when-hubble-casts-doubt-on-certainty-of-galactic-collision/



"These galaxy images illustrate three possible encounter scenarios between our Milky Way and the neighboring Andromeda galaxy. Top left: Galaxies M81 and M82. Top right: NGC 6786, a pair of interacting galaxies. Bottom: NGC 520, two merging galaxies.
Science: NASA, ESA, STScI, DSS, Till Sawala (University of Helsinki); Image Processing: Joseph DePasquale (STScI)"

Punch, Image of Solar Atmosphere and Moon:

From the PUNCH website: "The PUNCH (Polarimeter to Unify the Corona and Heliosphere) mission is a NASA mission that uses a constellation of four small satellites [in a polar orbit] to study the Sun's outer atmosphere (corona) and its transition into the solar wind." This is a very interesting image, once you know what you are looking at. Three of the satellites are equipped with wide-angle cameras to study the region around the Sun from 4.5 degrees to 45 degrees from the Sun. One satellite has a narrow-angle camera to study the corona from 1.5 degrees to 8 degrees from the Sun (the image on the right). Normally, an occulting disk is designed to just cover the Sun, but this disk is 6 times larger (the hidden Sun is the same size as the Moon). At the same time, the Moon in this image is a New Moon, so what we are seeing is the Moon in earthshine (it is a New Moon). My thanks to Bob Marcialis for helping me make sense of the image.



"An image of stray sunlight and the moon taken on April 27 by the PUNCH mission's Narrow Field Imager during commissioning. The sun is mostly blocked out by the instrument's occulter, which creates a dark, circular shadow over the sun. (Image credit: Southwest Research Institute)."

https://www.sciencealert.com/nasa-mission-captures-eerie-new-view-of-the-moon-and-sun

https://www.livescience.com/space/the-sun/nasa-spacecraft-snaps-eerie-image-of-eclipsed-sun-with-an-extra-moon-overhead-whats-going-on

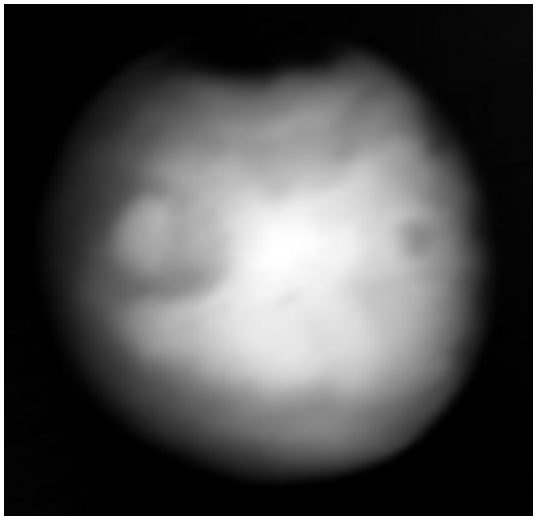
https://science.nasa.gov/blogs/punch/2025/05/12/nasas-punch-catches-first-rainbow-and-other-new-images/

Europa Clipper, Thermal Images of Mars:

The Europa Clipper was launched in October and made a gravity assist flyby of Mars in May. It will make its final gravity assist of Earth in December 2026 before going into orbit around Jupiter in 2030. In its prime mission, it will make 49 close approaches Europa. It was decided not to attempt to go into orbit around Europe because of Jupiter's strong radiation field. The goal of the mission is to investigate a possible subsurface ocean underneath Europa's ice crust. During its close approach to Mars, 884 km, 550 miles, scientists tested out the thermal camera, E-THEMIS. It was not intended to be a perfect picture, just a test, so does not look that good in comparison to other spacecraft images of Mars. For one thing, it did not slew as the pictures were taken, so the images are somewhat blurred. However, the camera works, so the astronomers were happy with what they saw.

https://www.nasa.gov/missions/europa-clipper/nasas-europa-clipper-captures-mars-in-infrared/

https://skyandtelescope.org/astronomy-news/europa-clipper-successfully-passed-by-mars-en-route-to-jupiter/



This picture of Mars is a composite of several images captured by Europa Clipper's thermal imager on March 1. Bright regions are relatively warm, with temperatures of about 32 degrees Fahrenheit (0 degrees Celsius). Darker areas are colder. The darkest region at the top is the northern polar cap and is about minus 190 F (minus 125 C). NASA/JPL-Caltech/ASU

https://www.nasa.gov/missions/europa-clipper/nasas-europa-clipper-captures-mars-in-infrared/

https://skyandtelescope.org/astronomy-news/europa-clipper-successfully-passed-by-mars-en-route-to-jupiter/

Meteors, Meteorites, Asteroids, and Comets:

As of June 10, 2025, there are 1,452,286 known minor planets (4,424 added since May 11). Of these, 793,066 are numbered (no change). There are 4,596 known comets (6 added). Of these, 598 have good orbits and have been numbered. There are 38,613 (163 more) Near-Earth Objects (NEOs) and 123 Near-Earth Comets (no change). [A note: there are two sources for these numbers, and they never agree exactly, even if they are updated the same day. JPL has more total asteroids by over 10 thousand and the IAU has more NEOs by a few hundred. I use JPL for total asteroids and IAU for total NEOs.] 1,190 NEOs have been discovered since the beginning of the year. A potentially hazardous asteroid is an asteroid whose orbit could bring it with 0.05 AU of Earth and is estimated to be at least 140 meters in diameter. However, many of these have orbits that are fairly-well characterized so there is little to no risk of their hitting Earth. ESA lists just those that have some potential chance of hitting Earth, usually due to orbital uncertainties. This is why my team observes them on the VATT so that we can reduce these uncertainties. ESA's "At Risk" list as of June 10, 2025, is 1,792 Near-Earth Objects (10 more).

Asteroid Close Approaches:

In the last 30 days,11 asteroids have been **observed** to have come closer to the Earth than the distance to the Moon (LD) with estimated diameters from about 1.4 meters in diameter to about 30 meters in diameter (if high or low reflectivity, respectively). There were 6 additional asteroids observed that came as close as 1.0 to 2.0 times the distance of the Moon, with estimated diameters between 4.8 and 30 meters. In the next 60 days, no asteroids are **predicted** to come closer to us than the Moon and none between 1.0 and 2.0 times the distance to the Moon. I have not looked all of these up to determine when they were first observed. Most were first observed within days of their closest approaches, but some were not observed until after their close approaches.

Between May 12 (observed) and July 11 (predicted in the next 60 days), 11 asteroids with estimated diameters between about 70 meters and 700 meters in diameter have passed/will pass between 6.5 and 18.4 lunar distances of the Earth. Of the eight large asteroids that have been **observed** to pass within 20 LD (0.05 AU) of the Earth between May 12 and June 5, five were discovered prior to this year. Two were discovered

in 2003, one in 2008, and two in 2011. Three were discovered in 2025 (we observed one of them in April). Of the three asteroids that are **predicted** to pass within 20 LD (0.05 AU) of the Earth between June 17, 2025 and July 11, 2025, all three were discovered prior to 2025. One was discovered in 2000, one was discovered in 2003, and one was discovered in 2005. Of the 94 (down from 147 last Newsletter, bad weather?) asteroids that were seen or are predicted to come within 20 lunar distances of the Earth (about 0.05 AU) between May 11 and August 8, we have observed five of them (including the one large one already mentioned).

Great Fireball of July 27, 1938:

In 1938, a fireball was seen over the northeastern portion of the US. Someone on the small bodies list brought the original article to the attention of the community. I cannot provide the original Science article, but here is a summary that appeared in the New York Times. There are few, if any, proven fireballs of extra-Solar System origin. Is this one? The authors seem to make a good point as to the origin of this object.

https://www.nytimes.com/1960/01/09/archives/fireball-offers-new-solar-data-1938-flight-is-said-to-prove-that.html

Origin of Planet Nine:

One of the theories for the planets in our Solar System formed is that there was another large planet that was ejected from the Solar System. This could help explain why Mars is so small. A team of scientists have modeled the ejection of planets in planetary systems, especially ones in star clusters. They found that there is a high probability that an ejected planet would not escape completely, but could get caught in a wide orbit, a few thousand AU from their parent star. This would help explain the wide orbit exoplanets that have been discovered and could help justify the existence of Planet Nine.

https://www.psi.edu/blog/wide-orbit-planet-formation-and-the-case-for-planet-nine/

https://www.spacedaily.com/reports/How_chaotic_planet_formation_may_explain_wide_orbit_worlds_like_Planet_Nine_999.html

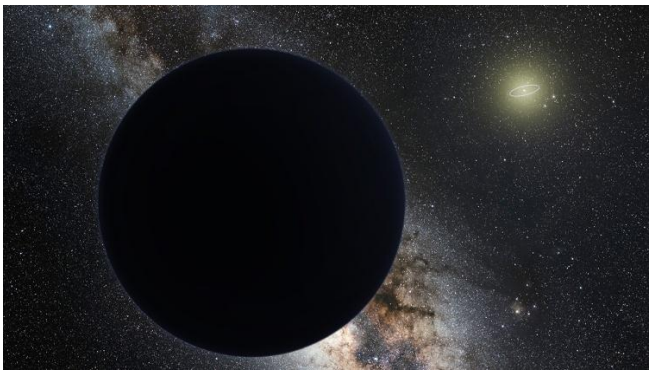
Distant Small Solar System Body:

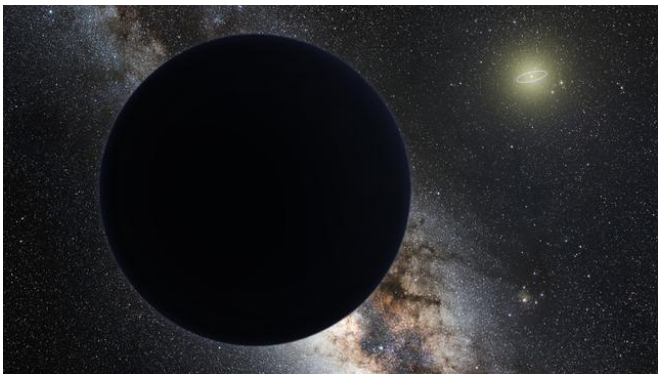
Astronomers, using archival data, have discovered a large Trans-Neptunian Object (TNO) in a very extreme orbit. They first found the object in observations from 2017 (hence the designation of 2017 FO201) and from there were able to determine a preliminary orbit, helping them find observations from 2011 to 2018, and allowing them to improve the orbit and estimate its diameter. The object has an estimated diameter between 470 and 820 kilometers (290 and 510 miles). This is large enough to make it a candidate for being a dwarf planet (it has to be round). At the moment, there are too few photometric observations (less than 20 total) to be able to determine a shape. It orbits from a distance of 45 AU out to 1,630 AU, with a mean distance of 840 AU and an orbital period of 24,000 years. Only about four other TNOs have more distant and extreme orbits. It is by far the largest of these. The authors note that the existence of this TNO puts into question the existence of Planet Nine. Because of the interaction with the hypothetical Planet Nine, the orbit of 2017 FO201 would be unstable (could not remain in this orbit for more than 100 million years). So, either 2017 FO 201 has been in this orbit for less than 100 million years, or Planet Nine does not exist. Also, because of its extreme orbit, 2017 FO201 is close enough (and thus bright enough) only 1% of its orbit. If so, how many other similar TNOs are as yet undiscovered? The Vera C. Rubin Observatory may find many more TNOs like 2017 FO201. Though full operation is months away, the first image from the telescope is expected on June 23.

https://www.space.com/astronomy/dwarf-planets/scientists-found-a-possible-new-dwarf-planet-it-could-spell-bad-news-for-planet-9-fans

https://earthsky.org/space/new-minor-planet-found-in-the-distant-solar-system-2017-of201/

Comment: As I mentioned earlier, I try to avoid Artist Rendition images, as they often tend to poorly represent what we would actually see (relative sizes, distances between asteroids, what the surface of an asteroid might look like). I would like to show you two images. The one on the left was in the Press Release about the Origin of Planet Nine. The one on the right is from the Space.com article, showing what the dwarf planet would look like.





Nearby Small Solar System Bodies:
As I write this section of the Newsletter, I am on Mt. Graham. We finally had a fairly clear night and observed eight Near-Earth Asteroids. However, there is a class of asteroids that the authors propose—Venus trojan asteroids, asteroids that share their orbits with Venus. Venus has one known trojan asteroid and about 20 other co-orbiting asteroids. Are there more? These are hard to observe because they stay close to the Sun as viewed from Earth and are fairly small and faint. Their orbits are also unstable as they interact with planets (such as the Earth. The authors attempt to assess this threat.

https://www.universetoday.com/articles/is-venus-hiding-dangerous-asteroids

https://www.livescience.com/space/asteroids/an-invisible-threat-swarm-of-hidden-city-killer-asteroids-around-venus-could-one-day-collide-with-earth-simulations-show

New Asteroid Sample Return Mission:
China has just launched its first asteroid sample return mission, Tianwen-2 (The *Heavenly Questions* or *Questions to Heaven*) the spacecraft will perform an asteroid sample return, drop off the sample and then the main spacecraft will continue on to a main belt comet. The asteroid that the spacecraft is going to is what is called a quasi-satellite of the Earth. 469219 Kamoʻoalewa (the *oscillating fragment* in Hawaiian). I wrote about this asteroid about a year ago. It is in an orbit very close to that of Earth and will, at times, appear to orbit around the Earth. It is not gravitationally attached to the Earth, which is why it is called a quasi-satellite. As I reported last year, based on orbital simulations and based on its spectral characteristics, it is thought to be the result of an impact on the Moon, a source of future lunar meteorites. The asteroid is elongated, about 40 to 100 meters (130 to 330 feet) for its mean diameter. Compositionally, it looks similar to space weathered lunar highland soil. It will be interesting to see how the spacecraft will retrieve a sample give the shape of the asteroid as well as its fast rotation of 0.47 hours, 28 minutes. The spacecraft will then continue on the comet (active asteroid) 311P/PansSTARRS. This main belt comet was seen by HST to have seven tails when first discovered. It is thought that the comet-like activity is being caused by the fast rotation of a rubble pile asteroid that is shedding material as it spins. Again, it will be interesting to see how close the spacecraft will be able to get to the comet if it is surrounded by debris (as well as a possible satellite).

https://www.spacedaily.com/reports/China_launches_Tianwen-2_asteroid_and_comet_study_mission_999.html

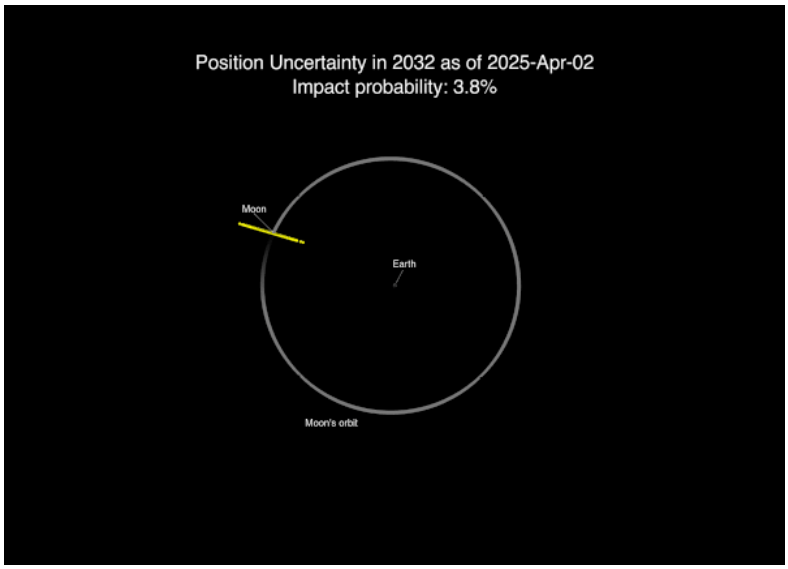
Moons and Rings:
As of June 10, 2025 (last update), there are 418 moons (satellites) orbiting six planets (2 more, 2 Jupiter moons, first discovered in 2017, have been recently confirmed). As of May 24, 2025 (last update), there are 582 asteroids, dwarf planets, Centaurs, and Trans-Neptunian Objects with companions (1 more than the last update on May 17). There are 564 binary systems (1 more), 16 triple systems (same), 1 quadruple (130 Elektra), and 1 sextuple system (Pluto), for a total of 604 companions (1 more). To break this down, 108 Near-Earth Objects (no change) have companion moons (5 have 2 moons, same), 35 Mars-Crossing Asteroids (same) have companion moons (1 with 2 moons), 289 Main Belt Asteroids (1 more) have companion moons (1 with 3 moons, 8 with two moons, and 1 with 1 moon and rings; 1 also has dual asteroid/comet designation), 8 Trojan Asteroids have companion moons (same), and 142 Outer Solar System Objects (dwarf planets, Centaurs, and Trans-Neptunian Objects) (same) have companion moons (2 with 2 moons, 1 with 5 moons). There are 4 TNOs and Centaurs with moons that have or are suspected to

have rings (same) and 1 with rings but no moons. For those of you doing the Solar System Classification activity, this is a good example of how there is overlap among planets, dwarf planets, and asteroids as to how we classify them based on characteristics (moons and rings in this case. There are more satellites/moons of asteroids than there are of planets, 582 vs. 418. There are also more asteroids with rings than there are planets with rings, 5 vs. 4.

Target, Moon:

JWST has observed the asteroid 2024 YR4 one last time. This will likely be the last observation of the asteroid until 2028. At that time, it will close enough to be observed with large telescopes (it will be 10 times farther away than its close approach to Earth in December). While the chances of hitting the Earth are now down to 1/20,000, the chances of the asteroid hitting the Moon have now gone up to 4.3% (up from 3.8%). The nominal distance from the Moon in 2032 (December 22) is now 10,680 km, but the minimal potential distance is 1,015 km (this number has not changed a lot). The uncertainty depends mostly on the timing of closest approach. The uncertainty is now 76 minutes. As I have said before, the orbit of 2024 YR4 is known very well, with the greatest uncertainty being *where* it is in its orbit. The size of the asteroid has also been measured (it is slightly darker than previously thought). It is now estimated to be between 53 and 67 meters in diameter (174 to 220 ft).

https://earthsky.org/space/asteroid-2024-yr4-odds-hit-earth-torino-scale-2032



"The yellow dots represent the possible location of asteroid 2024 YR4 on December 22, 2032. The wide gray circle represents the moon's orbit. On June 3, 2025, new observations with the Webb Space Telescope pushed the chances of the asteroid crashing into the moon up to 4.3%, from its previous 3.8% in April. Image via NASA JPL/CNEOS."

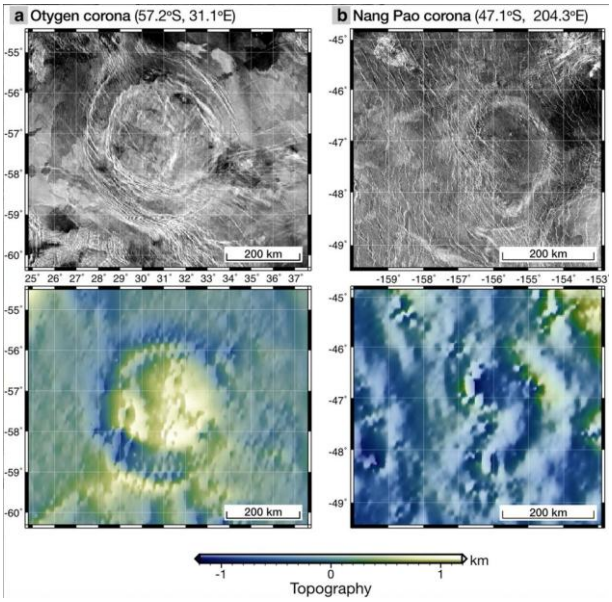
Planets:

Is Venus Geologically Active?:

The Magellan spacecraft was operational in orbit around Venus from 1990-1994. It used radar to map the surface of Venus below its thick clouds. There are about 1,600 large volcanic structures on Venus and more than 80,000 more, smaller volcanoes. It is not known if any of them are active. In this study, planetary geologists investigated and modeled "Coronae," large circular features on Venus that are thought to be related to past and possible present magmatic activity below the surface of Venus. The consensus is that the coronae are the surface expression of ancient mantle plumes. The scientists studied 75 coronae and found that more than fifty of them sit above buoyant mantle plumes.

https://earthsky.org/space/tectonics-on-venus-coronae-magellan-geology/

https://www.livescience.com/space/venus/venus-may-be-geologically-alive-after-all-reanalysis-of-30-year-old-nasa-data-reveals



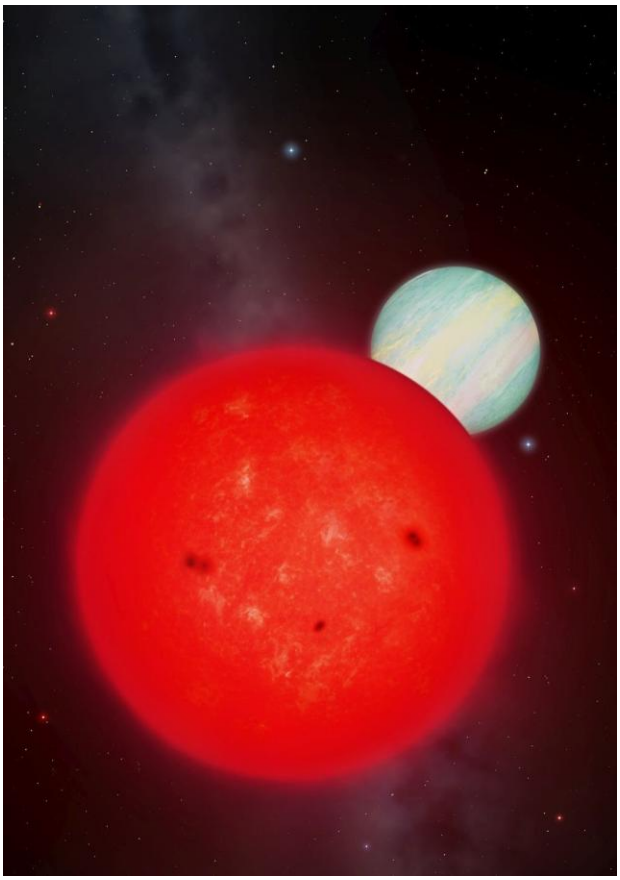
"'Coronae' are defined by a (partial) quasi-circular ring of closely spaced concentric fractures. They are hugely abundant on Venus' surface and considered key for Venus' tectonic and volcanic history"

Early Jupiter Formation:
The authors of this research paper used Jupiter two small inner satellites, Amalthea and Thebe, along with Io, Jupiter's inner large satellite to model the early formation history of Jupiter. Since the satellites have slightly tilted orbits, the authors can use conservation of angular momentum to model the size (diameter) of early Jupiter. What they have found is that 3.8 million years after the Solar System's first solids formed (the start of planetary accretion), Jupiter was 2.0 to 2.5 times its present diameter and it magnetic field was 50 times stronger than it is today. I will point out that while the diameter was greater, the mass would be comparable to what we see now. At 3.8 million years, the accumulation of gas and dust would have stopped when the Sun went through it phase of strong solar winds that would have cleared out the remaining protoplanetary nebula. As I mentioned above, there are three different models for the formation of the gas giants, core accretion (planetesimals coming together and forming a rocky core that was large enough to accrete a gas atmosphere, pebble accretion as I mention in the first "Astronomy in the News" article, and disk instability. Here, the authors note that their formation model is consistent with the core accretion model. I am not an expert in planetary formation, so I will not try to explain the pros and cons of the various models.

https://www.space.com/astronomy/jupiter/jupiter-used-to-be-twice-as-big-as-it-is-now-it-could-have-held-2-000-earths

Exoplanet Update:
As of June 10, 2025, there are 7,494 confirmed extra-solar planets (22 more since May 11, my last update) orbiting 5,135 stars (13 more), with 1,046 star systems (6 more) having more than one exoplanet orbiting them. In addition, there are 2,437 candidate (unconfirmed) exoplanets (19 more) orbiting 2,137 stars (20 more), with 142 stars (1 less) having more than one exoplanet orbiting them. Most of these candidate exoplanets are likely to be real but need to be confirmed by more detailed ground-based observations or other techniques. There are 738 star systems with exoplanets orbiting one of the stars (9 more) and there are 31 star systems with 39 exoplanets orbiting both stars in the binary system (same). Three star systems have three exoplanets orbiting both stars.

Red Dwarf with Large Exoplanet:
The authors of this work previously published results for searches, using TESS transit data) for Saturn-sized to Jupiter-sized exoplanets orbiting low mass (less than 0.8 solar masses) stars. Formation models for such stars predict that they are too small to have protoplanetary disks massive enough to form such exoplanets. However, the authors found that about 0.2% of these stars do have large exoplanets orbiting them. For this new study, the authors made additional observations, including ground-based observations to study, in detail, one of the 15 stars they previously detected, TOI-6894, 240 light-years from us. TOI-6894 is only 0.2 times the mass of the Sun and is orbited by an exoplanet that is half the mass of Saturn, but slightly larger in diameter than Saturn (not "ginormous"). It therefore has a very low density of about 0.35 gm/cc (my estimate) which is less than half that of Saturn. It orbits the parent star at a distance of 0.025 AU with an orbital period of 3.3 days. Because the star is so cool, the estimated temperature of the exoplanet is only about 420 K. The authors state that neither core accretion nor disk instability (they do not mention pebble accretion) models can explain how such a large exoplanet could have formed. As is not unusual, our models do not always explain what we see, implying that our models need to be revised.



I should note that, in the original study, the authors looked at

91,000 red dwarfs. If 0.2% have large exoplanets, that is still nearly 200 exoplanets (they saw 15). This implies that they detected only 1/10 of all the large exoplanets and did not see the others due to the tilt of their orbits relative to us (no transits).

"The discovery of a giant planet orbiting a small red dwarf is challenging the core accretion theory of planet formation. Image Credit: University of Warwick/Mark Garlick"

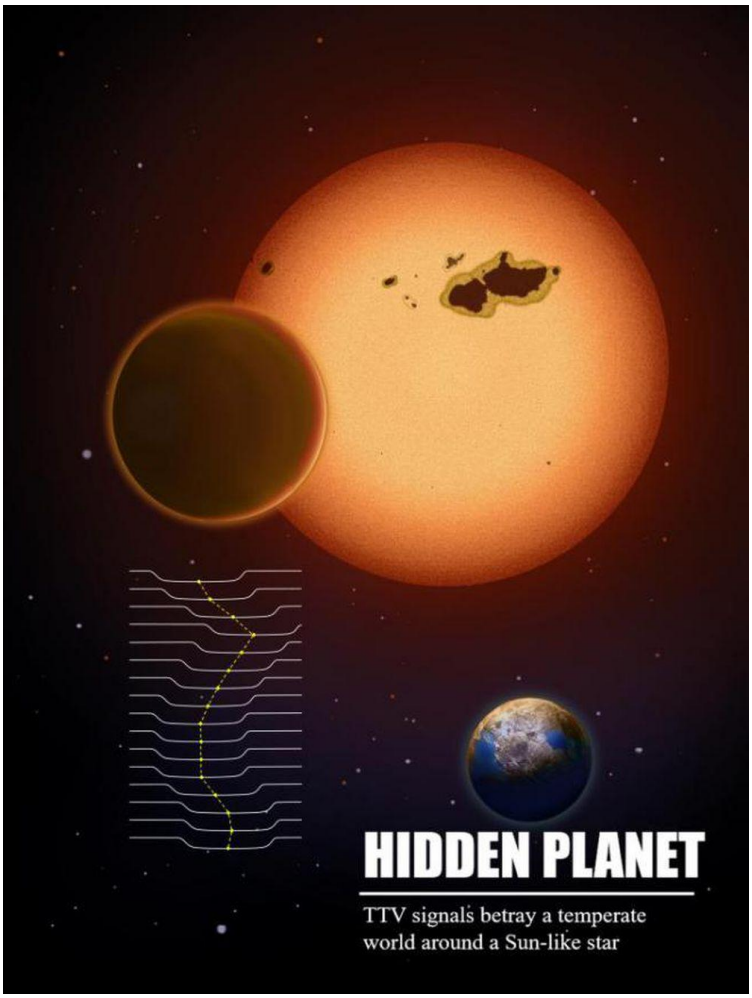
https://www.livescience.com/space/exoplanets/ginormous-planet-discovered-around-tiny-red-star-challenges-our-understanding-of-solar-systems

https://www.universetoday.com/articles/this-massive-gas-giant-orbiting-a-tiny-red-dwarf-tests-our-planet-formation-theories

Hidden Exoplanet:

TOI-6894b was detected by the transit method and ground-based radial velocity methods were used to determine its mass. Another method for detecting exoplanets is called the Transit Timing Variation (TTV) method. To see a transit, an exoplanet has to be pass in front of its host star, it has to be in our line of sight. However, in a system with transiting exoplanets, there may be other exoplanets with slightly tilted orbits or too far from the star to transit it (from our perspective). This was how the authors of this research paper discovered an exoplanet Kepler-725b. Kepler-725 is a solar-type star that is slightly smaller, slightly less massive, and slightly cooler than the Sun. It is 2,500 light-years from us. In 2021, the Kepler spacecraft discovered Kepler-725b, slightly smaller than Jupiter and orbiting once every 40 days, a hot Jupiter. However, as reported in this research, the orbital period varied (see the illustration on the right). This could be explained by the gravitational tug of an unseen exoplanet. By modeling the changing orbital period of Kepler-725b, they demonstrate the existence of another exoplanet, Kepler-725c, with an orbital period of 208 days at a distance of 0.67 AU and with a mass of about 10 times that of the Earth, a super-Earth. The authors note that this puts Kepler-725c in the star's habitable zone.

https://www.universetoday.com/articles/astronomers-find-a-hidden-planet-partly-in-the-habitable-zone-of-its-star



"Astronomers from China and Germany used the Transit Timing Variation method to detect a super-Earth orbiting the Sun-like star Kepler 725. Image Credit: GU Shenghong"

Stars and Nebula:

Historic Solar Storm:

Scientists (dendrochronologists) can study tree rings to look for solar storms that cause spikes in carbon-14. Cosmic rays, high energy particles, in the upper atmosphere create carbon-14 which is then absorbed in tree rings. Solar storms disrupt the Earth's magnetic field and create a spike in these high energy particles and carbon-14. These events can be dated very accurately. Increases in carbon-14, associated with strong solar storms have been seen five times in the last 10,000 years. The scientists, in this research, report on a carbon-14 spike that occurred 13,500 years ago. For context, the Carrington Event in 1859 knocked out telegraph lines in the US and Europe and created aurora as far south as Hawaii. It has been estimated to have been 10 times stronger than two recent solar storms in 2003 and 2024. The event 13,500 years ago (dated by tree rings, not carbon dating), in this research, is estimated to be 50 times as powerful as the Carrington Event!

Notes: First, I am not sure how one can distinguish a carbon-14 spike due to a solar storm vs. a supernova event. This is not addressed in the article. I could be wrong about this concern. Also, as a side note, radioactive dating using carbon-14 cannot be for dating anything after (more recent than) 1950 thanks to nuclear bomb testing.

https://www.space.com/astronomy/sun/14-000-years-ago-the-most-powerful-solar-storm-ever-recorded-hit-earth-this-event-establishes-a-new-worst-case-scenario

Solar Corona "Rain":

Solar astronomers have a new tool for studying the Sun's outermost atmosphere, the solar corona. Cona is a coronal adaptive optics system installed on a solar telescope in California (Big Bear Solar Observatory). The images on the right show the Sun's corona in H-alpha light (like the solar telescopes at Astronomy Camp). Both links below contain videos of the "rain" of plasma in the corona.

https://www.space.com/astronomy/sun/scientists-capture-never-before-seen-plasma-streams-and-bizarre-raindrops-in-sharpest-ever-view-of-suns-outer-atmosphere-video

https://earthsky.org/sun/clearest-view-of-the-suns-corona-adaptive-optics/

"Using a newly developed adaptive optics system called Cona, scientists peered through Earth's turbulent air to reveal the sun's corona in astonishing clarity. (Image credit: Schmidt et al./NJIT/NSO/AURA/NSF)"

Unusual Stellar Pulses:

ASKAP J1832 is one of 10 known Long Period Transients (LPTs), radio sources that have periods of minutes to hours, unlike pulsars and other short period radio sources. ASKAP (Australian Square Kilometre Array Pathfinder) is a wide field survey telescope, so finding the source of LPTs is difficult to pinpoint. In this case, astronomers were lucky that the Chandra Space Telescope was looking in the same area of the sky and was able to pinpoint X-ray signals from the same source. It is unclear what causes this object to emit at radio and X-ray wavelengths for two minutes and then repeat at 44-minute intervals. This is unlike any pulsar, magnetar, or binary star system. One of their goals is to find other radio and X-ray pairs, but that is difficult because of the wide field of ASKAP.

https://www.livescience.com/space/unlike-anything-we-have-seen-before-astronomers-discover-mysterious-object-firing-strange-signals-at-earth-every-44-minutes

"A telescope image of the region of sky surrounding ASKAP J1832-0911. (Image credit: Ziteng (Andy) Wang, ICRAR)"

Supernovae, Neutron Stars, and Black Holes:

Hidden Supermassive Black Hole:

A Tidal Disruption Event (TDE) occurs when a star gets to close to a black hole. Astronomers using Hubble Space Telescope have seen such an event, AT2024tvd. This object was also seen at radio and X-ray wavelengths. What is interesting about this event is that the one million solar mass black hole is offset from the center of the galaxy (and its central, more massive, 100 million solar mass black hole) by about 2,600 light-years. The smaller black hole implies that a smaller galaxy has merged or is passing through the larger galaxy and, at some point in the future the two black holes will merge.

"The tidal disruption event AT2024tvd is the bright dot offset from the center of the galaxy, which is shown in gold. (NASA, ESA, STScI, Yuhan Yao/UC Berkeley)"

https://www.stsci.edu/contents/news-releases/2025/news-2025-015.html

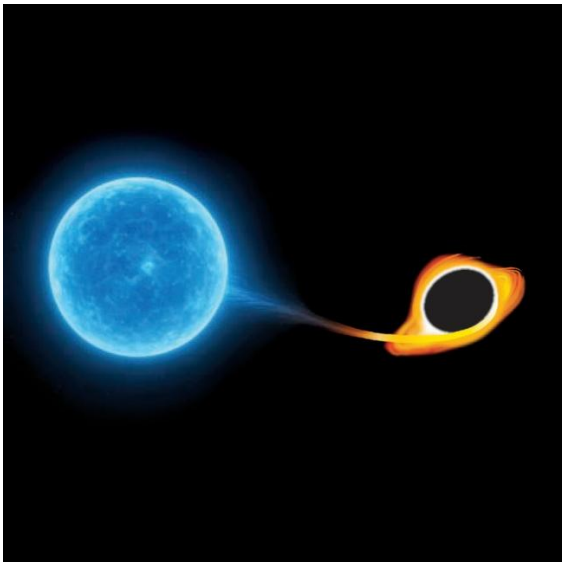
https://www.sciencealert.com/a-hidden-supermassive-black-hole-has-just-revealed-itself-in-deep-space

Largest Explosion in Space:

We started with LPTs, then talked about TDEs. When you have a very large TDE, you get an ENT, an Extreme Nuclear Transient (ENT). Are you keeping up? When a massive star (at least three to ten times the mass of the Sun) gets too close to a supermassive black hole (image on the right), you get the largest explosions since the Big Bang. Astronomers have recently seen three of these. The largest of these, Gaia18cdj (so discovered by the Gaia spacecraft), released 25 as much energy as the largest supernovae, ten times greater than a typical TDE. While TDEs last for a few months, ENTs will be visible for several years. In a year, it put out 100 times as much energy as the Sun will put out in its lifetime (I take the word of the authors). The image on the right is the first of a series of illustrations from IfA (sorry, Institute for Astronomy at the University of Hawaii). The series of images are in the second link below.

https://www.space.com/astronomy/astronomers-discover-most-powerful-cosmic-explosions-since-the-big-bang

https://earthsky.org/space/largest-explosions-since-the-big-bang-ents-extreme-nuclear-transients

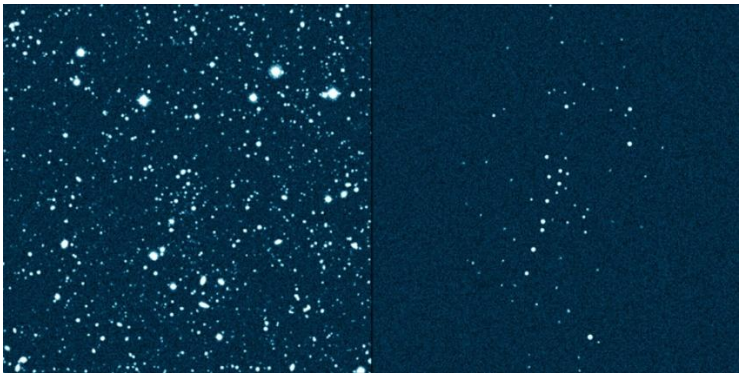


"An unlucky massive star approaches a supermassive black hole. Image via University of Hawaii at Manoa."

Galaxies:

Star Cluster or Galaxy:

Ursa Major III / UNIONS 1 (UMa III / U1) is a group of about 60 stars. It is only 20 light-years across and is 33,000 light-years away. The article discusses whether it is the smallest known dwarf galaxy (Ursa Major III) or the oldest star cluster (UNIONS 1). For comparison, the Pleiades star cluster contains about 1,000 stars and has about the same diameter. If it is a dwarf galaxy, the majority of its mass would be in the form of dark matter. The article implies that the evidence leans toward UMa III / U1 being a star cluster, but that more investigation is needed.



"Uma3/U1 (right) is a bound group of stars hidden within a deep sky image (left). Credit: CFHT / S. Gwyn / S. Smith"

https://www.universetoday.com/articles/its-either-the-milky-ways-farthest-known-star-cluster-or-the-smallest-known-galaxy