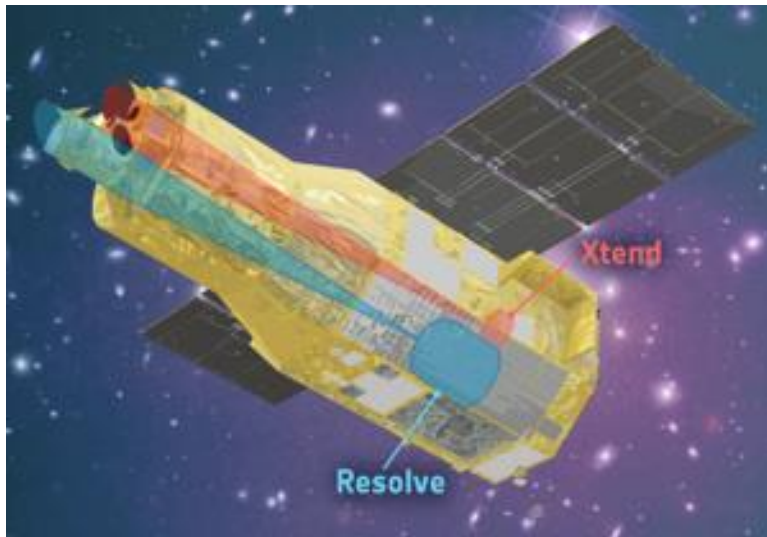


OKLAHOMA SPACE ALLIANCE

OUTREACH – November 2024

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
at Cyber Hall and Gaming Lounge next to Norman Computer
at 2:00 p.m. on November 9, details inside



XRISM X-Ray Observatory (ESA)

OKLAHOMA SPACE ALLIANCE OUTREACH November 2024

November Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, November 9, at the location next to Norman Computers on West Main in Norman. Prospective members are welcome.

The meeting room is in the Cyber Hall and Gaming Lounge next to Norman Computers. Please enter through the Cyber Hall door. The Cyber Hall is at 914 W Main St, opposite Norman High School. The phone number is (405) 292-9501. To get to the meeting space from points north, take the Highway 77 exit off I-35, and continue south until you reach Main Street. Norman Computers is about a block and a half west of this on the south (left) side of a small mall.

This is the meeting at which we nominate officers. If you wish to serve as an officer of Oklahoma Space Alliance, please let us know at the meeting or contact Syd by e-mail at sydh@ou.edu. Syd will be sending out election ballots around the beginning of December by both e-mail and snail mail. If you wish to be an officer, please contact him by December 1. Note that officers must be members of the National Space Society, though you can join at the Christmas party. Elections will be held at the Christmas Party, tentatively December 14 at the McMurrays'

Saturday, November 9, 2:00 p.m. (tentative)

1. Introductions and review of Space events this past month
2. What's Happening in Space, News, Pictures, and Videos approximately one hour. See <http://osa.nss.org> before the meeting for items to be discussed.
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report.
 - b. Minutes of September and October meetings
 - c. Posters
 - d. Membership Business
5. Video (to be announced)
6. Chat

Minutes of October 12 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met October 12, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending were Clifford and Claire McMurray, Dave Sheely and Syd Henderson. OSA President Adam Hemphill couldn't be at the meeting so OSA Vice-President Clifford McMurray presided over the meeting. He presented an update containing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2410.pdf> so I'll cover the details that aren't covered there.

Comet Tsuchinshan-ATLAS will be visible in the evening the next few days.

The astronauts returning from the International Space Station are the seventh and eighth to spend a continuous year on the ISS. (Since they went up and came back together, they are tied.) Eleven people are currently on the ISS but three are coming back.

We watched a video on the Chinese lunar space suits. The Feitian ("flying in the sky) space suits are named after a Buddhist goddess (?).

We watched a video of the launch of the United Launch Alliance's Vulcan Centaur test, showing the flare from a launch anomaly. Note that the flight was successful, carrying an inert payload in place of Dream Chaser, which will be launched next year. However, this flight was for achieving certification, and enough went wrong that that might be delayed.

The FCC does not really have the authority to establish deorbiting guidelines for spacecraft. They claim that space debris can affect radio transmissions meaning that they have this authority under the Federal Communications Act of 1934 [which, of course, was drafted well before spacecraft even existed. I wonder, though, whether they could do this for communications satellites, but even there, the FAA would have more say in it.--Syd]

Syd is going to look up Sanyuan Aerospace for information on their first launch, as in, can they actually do it this year as *Space News* speculated? [Apparently not: in a search through next June, I could find no mention of an upcoming launch.]

How many functioning orbiters are currently orbiting Mars? We came up with eight.

Syd suggested renaming the Janus probe if they are actually sending to Apophis. Since OSIRIS-APEX (formerly OSIRIS-REx) is going there, he thinks we should rename the Janus probe to something from ancient Egyptian mythology. Isis or Horus. [Actually naming it Isis might make people think it's sponsored by terrorists, so Horus. According to Wikipedia, Janus was cancelled, so this must have been a revival. The ESA is also sending a mission to Apophis and naming it *Ramses*. Thank you, ESA.]

ESA's 3D printer uses a 2200-degree Fahrenheit (1200° C) laser to melt the metal for printing.

The leak on the Russian module is currently losing between 2.4 and 2.7 pounds of air per day.

The amount of money in the checking account and cash box are unchanged.

--Minutes By OSA Secretary Syd Henderson

Minutes of September 14 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met September 14, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending were Adam Hemphill, Ian Clark, Kip and Claire McMurray, John Northcutt, Kevin Sampson, Tim Scott, and Syd Henderson OSA President Adam Hemphill presided over the meeting Adam presented an update containing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2409.pdf> so I'll cover the details that aren't covered there.

The Cyber Hall address is 914 West Main, and we will be using that as the meeting address, so people know which door to go to. This was Ian's first meeting, and we got his contact information.

We had a discussion on radar detection of possible UFOs which appear to experience g-forces not survivable by humans.

Astronauts aboard the ISS photographed red spirit lightning going into the extreme upper atmosphere. Pictures were shown on the cover of the September *Update*.

Starliner returned crewless. The thrusters that were of such concern that Butch Wilmore and Suni Williams are staying on the ISS, were not actually part of the return capsule, separated from the capsule and burned up on reentry. [Meanwhile, Suni Williams has taken command of the ISS.]

We may need to establish a common standard for spacesuits so all types will be compatible with interfaces. (The space suits Wilmore and Williams wore are incompatible with SpaceX Dragon Capsule.)

The ISS has LIDAR for active docking support.

We watched a video of spacewalks on the *Polaris Dawn* mission. These were the first spacewalks on a private mission, but the astronauts did not completely leave the spacecraft but held on to a ladder that projected out. The suits they were testing are not capable of operating separately from spacecraft so are not Moon capable. [I think SpaceX is working on Bo suits that are.] The two astronauts who spacewalked did not do so at the same time. We watched a video of the launch of *Polaris Dawn*. Astronaut Sarah Gillis

and earth-bound musicians participated in a concert of music from Star Wars. Participants included singers and musicians for Haiti, Sweden, Brazil, Uganda, the United States, Venezuela, and more.

Boeing is currently valued at \$96.60 billion in marketing capitalization, which is comparable with companies such as Lockheed Martin and Northrop Grumman.

The crawler that carries rockets to the launch pad gets six feet per gallon.

Boeing now has a much younger workforce because they are not paying competitive salaries, especially for Seattle.

Chang'e 5 landed 43.1°N 51.8°W on the Moon but still found water-rich material.

Syd is going to check on Heavens Above to see if they give viewing information for the ACS3 Solar Sail satellite. NASA has an app so you can track it.

We now have \$775.38 in the checking account and \$267 in cash for a total of \$1042.38.

Tim will not be at the October meeting. Syd will give the financial information.

--Minutes by OSA Secretary Syd Henderson

Space News

Betelgeuse (Alpha Orionis) has long been a target for close observation—sometimes too close, as any brightening or dimming of this variable star sparks stories of its impending doom. Really, its likelihood of exploding in 2025 is probably no greater than it exploding in 3025, or even 10025. I hope it doesn't because it is essential for the shape of the constellation.

It seems to me a lonely situation for a major star to have people hoping that it will blow up, but maybe not so lonely now that a couple of papers are in preprint that argue that Betelgeuse has an as-yet unobserved stellar companion that is responsible for its longest cycle which lasts 2170 days. This is an odd cycle that indicates that Betelgeuse is either twice as large as we think, or that it has a companion that either periodically blocks some of its light or causes the longest pulsation. The companion star would have an orbital period of, naturally, 2170 days or 5.9 years. The distance from it to the center of Betelgeuse would be about that between the Sun and Saturn, or, to put it another way, it would on average be as far away from the surface of Betelgeuse, as that surface is from the center of the giant star. One study actually claims to have detected the gravitational wobble produced by the companion, which seems to me to be really difficult, but they have lots and lots of observations to search for a pattern.

Another less lonely star is Gliese 229, or more precisely, its companion, which was the first brown dwarf to be confirmed. A brown dwarf is a star-like body that is too small to fuse hydrogen, although it may be able to fuse deuterium and lithium, both of which are far less abundant, though we use them to make hydrogen bombs. It now seems that Gliese 229B is actually two brown dwarfs. So instead of having 70 times the mass of Jupiter, the twins have masses 38 and 34 times that of Jupiter. This explains a bit of mystery: why the brown dwarf was so cold. Smaller brown dwarfs cool off more rapidly, and these may not have had much in the way of lithium-deuterium fusion at all.

Interestingly, Gliese 229A itself has two planets orbiting it. Sounds like a busy place.

Finally, after decades of false claims of planets orbiting Barnard's Star, it appears that it really does have a planet, though, since it's smaller than Earth, the planet could not have been responsible for the wobbles Peter van de Kamp thought he detected in 1963, or another supposed detection in 2018. However, Jonay González Hernández's team's observations use the high-resolution spectroscope (ESPRESSO [!]) at the Very Large Telescope in Chile, and that should be able to detect spectral line shifts produced by the planet orbiting the star. The planet would orbit only about two million miles from Barnard's Star, but that star is so dim that the planet is in the habitable zone. It would have an orbital period of only three days. The team also saw signs of other tiny planets, all with periods of less than a week. This planet has a surface temperature of 260 degrees Celsius, which makes me wonder why it's being described as being in the habitable zone.

The Chandra X-Ray Observatory, which was scheduled to be decommissioned in December, has received a reprieve due to a grassroots campaign by space enthusiasts under the hashtag #SaveChandra to save one of the Great Observatories. The US Senate has committed \$72 million, and the House has passed an authorization bill that told NASA to take no action to reduce or decommission the spacecraft over the next year, which is when Chandra undergoes a three-year review. The 72 million dollars are full funding for another year of operations. It also means that the forty percent of Chandra's staff facing termination at the end of this month can keep their jobs.

The Chandra X-Ray Telescope was launched in 1999, so this year is its 25th anniversary, and like its older optical sibling, the Hubble Space Telescope, is still producing great science. It named after Subrahmanyan Chandrasekhar, the Indian (later American) astrophysics who, among many things, worked out Chandrasekhar's limit, which is the maximum mass of a white dwarf, about 1.4 times the mass of the Sun. Stellar remnants above that limit must be a neutron star, or if above the Tolman-Oppenheimer-Volkoff (TOV) limit, must be a black hole. The latter is somewhere between 2.2 and 2.9 solar masses. In the former case, and sometimes the latter, you also get a supernova explosion.

Chandra got a new companion X-Ray Telescope last year: XRISM (pronounced 'Kriz-em' The X has a sound like the Greek letter chi, to trap the unwary. XRISM = X-Ray Imaging and Spectroscopy Mission, which, among other things, uses the heat produced by impacting X-rays to analyze the spectrum of X-ray emitting objects in great detail, the energy of a X-ray photon being inversely proportional to its wavelength. This allows it, for example, to analyze the spectrum of the supernova remnant N132D (in the Large Magellanic Cloud) which includes iron heated to 10 *billion* degrees Celsius. [This cannot be a conventional spectrum but a nuclear spectrum. I think.] Interestingly, the plasma comprising N132D was emitted in the shape of a torus rather than a sphere. I'm guessing the supernova that produced it must have been spinning very rapidly.

XRISM has also been looking at the supermassive black hole at the center of the spiral galaxy NGC 4151. (I think this makes the black hole NGC 4151*.) This black hole weighs 30,000,000 times as much as the Sun and is about 16 -20 million parsecs (52 - 62 million light years) from Earth. The black hole has a very large accretion disk. Once again, XRISM can map this accretion disk using superheated iron, and has discovered that it is more of an accretion torus.

I look forward to XRISM discovering many more doughnuts in space.

Sky Viewing

In November and December, we have no fewer than four meteor showers, including one major one and one sometimes major one, and three of them have excellent viewing conditions. In addition, I'm including the Quadrantids, which peak on January 4 and are a major shower, but which come before the next issue of *Outreach*.

The **Northern Taurid Meteor Shower** peaks on the night of November 12 -13. This is a very minor shower, peaking at about ten meteors per hour, but the Moon will set early, and the radiant is south of the Pleiades, which makes it easy to locate. (There is a Southern Taurid meteor shower, but it has just passed.)

The **Leonid Meteor Shower** peaks on November 18 and the Moon sets early in the evening and will not interfere. Although there will be only 10 – 15 meteors per hour on the 18th, the shower lasts from November 14 through 21, and is unusually clumpy. Sometimes one of these clumps will produce a lot more meteors, with about 50 meteors per hour. Since Leonids often produce bright fireballs, it may be worth getting up to see them. The best time is in the morning, since Leo rises about midnight. The radiant is right in the middle of the curve made by the blade of the Sickle asterism in Leo. The Sickle is easy to find since the first-magnitude star Regulus is in its handle. Unfortunately, the Moon will be three days past full at the time of this and that will interfere with meteor viewing.

The **Geminid Meteor Shower** is active from December 4 through 17, peaking on the morning of December 14. Unfortunately, this is fairly close to the Full Moon. The Geminids are one of the more

prolific and dependable meteor showers of the year with a peak rate of 100 meteors per hour being usual. The radiant is, of course, in Gemini, just above Castor. Since Gemini is north and a bit east of Orion, Castor and Pollux are easy to locate. Pollux is noticeably the brighter of the two, but Castor is a bright second-magnitude star.

In 2028 Japan will be launching the DESTINY+ mission to 3200 Phaethon, the parent asteroid of the Geminids, which will arrive there in 2030. Phaethon gets its name because it comes closer to the Sun than any other named asteroid: In Greek mythology, Helios let Phaethon drive the Sun chariot one day, and Phaethon lost control and nearly fried the Earth until Zeus killed him. Icarus also gets its name from a solar disaster.

The **Ursid Meteor Shower** is less impressive, peaking at about ten meteors/hour on December, but this is a week after the Full Moon, so it may be worth checking them out. The Ursids do occasionally produce minor outbursts, but none is expected this year: the last was in 2014, and the one before that in 1986. The constellation that gives them their name is Ursa Minor, and radiant is very close to Kochab, the second brightest star in the constellation, which is actually not that much dimmer than Polaris.

The **Quadrantid Meteor Shower** is always the first major shower of the year and this year's peak is on the night of January 3-4. This shower reaches up to 120 meteors per hour, making it comparable to the more famous Perseids and Geminids. Radiant is in the northern point of the constellation Boötes near the end of the handle of the Big Dipper. It's actually closer to that than to Arcturus. The meteor shower is named after the obsolete constellation Quadrans (or Quadrans Muralis) which would have made a nice companion to Sextans and Octans to make a trio of astronomical instruments but a very dim constellation. Alas the IAU disagreed when it made the official list of 88 constellations, but the shower gets to keep its name and it is much more impressive than the Ursids or Boötids, so there.

Although the Quadrantids can be seen for a week or two before and after the peak, the peak of this one is sharp, so you are much better off looking for them at their peak. This is only four days after the New Moon, so the sky will be dark, and the shower should be much better than the Geminids this time.

Mercury is currently low in the western sky immediately after sunset, and, though it is technically visible for quite a while, it is still no more than four degrees above the horizon for the first two weeks of November. This is because the ecliptic is still at a fairly low angle to the horizon, though not as bad as it was at the autumnal equinox. On November 16, it will set an hour after sunset, which is your best day to see it.

Mercury will be in inferior conjunction with the Sun on December 5, after which it will have a much better apparition in the morning. By December 28, it will be eleven degrees above the horizon a half-hour before sunrise and will shine at magnitude -0.4.

Venus is now easily visible in the southwestern sky during late twilight and doesn't set until a half-hour after the end of twilight. Venus will soon be getting easier to see as it continues to rise higher each night, aided by the increasing angle of the ecliptic to the horizon, but also because it's returning from the far side of the Sun. At the moment, it is magnitude -4.0 but it will be near -4.7 by the end of the year.

Mars is now about ten weeks from opposition and has gotten up to magnitude 0.0. It is currently rising about 10 p.m. CST and is in Gemini, not far south of Castor and Pollux. It will brighten to magnitude -0.5 by the end of the month and will move from Gemini to the dim constellation Cancer. However, on December 7, this places it only two degrees above the Beehive, a famous star cluster that should appear in the same binocular field. This is the same night Mars is stationary as it begins its retrograde motion among the stars which will last until February 24, with opposition with respect to the Sun on January 16.

Also on December 7, **Jupiter** reaches opposition with respect to the Sun, which means it is now visible for most of the night and is at its brightest at magnitude -2.7. It will be nestled between the horns of Taurus the Bull for the rest of the year. Currently it is near the tips of the horns, the northern of which is El Nath, or Beta Tauri, a star that falls just short of first magnitude. Jupiter will gradually descend toward the head of the Bull, formed by the Hyades star cluster and Aldebaran (which is located in the southern horn)/

Saturn was on opposition in early September and is still visible in the south at sunset. Saturn is only magnitude 0.8, partly because the rings are nearly edge-on, and is Aquarius. If you look twenty degrees south (two fist-widths), you'll see Fomalhaut almost as bright. Fomalhaut is Alpha Piscis Austrini, and is not only the only really bright star in that constellation, but the only first-magnitude star that's at its best in the fall. It has a planet named Dagon, either after the Mesopotamian deity or the Lovecraftian monster.

Uranus is almost exactly on the border of Taurus and Aries, in a particularly dim part of the sky. It is about seven degrees southeast of the Pleiades. Don't expect it to move much against the stars over the rest of the year. Since it is magnitude 5.8, it is theoretically visible to the naked eye in really dark skies, but you would probably need binoculars or a small telescope. To search for Uranus, try <https://lovethehightsky.com/see-uranus-through-a-telescope/>

Neptune, at magnitude 7.9, definitely requires a strong pair of binoculars or a telescope. It's also in an inconspicuous part of Pisces below the Cirlet asterism about fifteen degrees to the left of Saturn. It's a difficult object to search for, but <https://lovethehightsky.com/see-neptune-through-a-telescope/> should be a help. Neptune has the advantage that if you find it at all, it will be in about the same place for the next year or two.

Viewing Opportunities for Satellites (November 9 – December 9, 2024)

You can get sighting information at www.heavens-above.com, which gives you a constellation map showing the trajectory of the satellite. You can also get data at <https://spotthestation.nasa.gov/sightings/>.

With the addition of the solar panels, the International Space Station can be as bright as magnitude -4.0 making it brighter than all the stars other than the Sun and all the planets other than Venus. The Hubble Space Telescope can get up to magnitude 1.5, which is brighter than the stars in the Big Dipper, but magnitude 2.0 is more likely. *Tiangong* is the Chinese Space Station. It currently gets up to magnitude -2.2 after the addition of the Wentian module last July and will do so several times below.

The "mag." beside the date indicates the brightest magnitude the satellite gets during the pass. All the ISS passes get between -2.9 and -3.9, which is brighter than Jupiter ever gets, but not quite as bright as Venus.

Missions to and from the International Space Station and *Tiangong* can change their orbits. A Cargo Dragon was to be launched by SpaceX on November 5, just as this is going to press. *Shenzhou 19* launched on October 29, carrying two male taikonauts and one female taikonaut on a six-month mission. There will also be a resupply mission to *Tiangong* on November 15. There will be no launches to Hubble in the foreseeable future. Also note that the ISS (and presumably *Tiangong*) sometimes have to alter orbits to avoid space debris. Hubble is high enough that this is less of a concern.

The information below is from Heavens Above.

Tiangong 11/9 mag. -2.3			Tiangong 11/11 mag. -1.6		
Time	Position	Elevation	Time	Position	Elevation
6:58 p.m.	248°	10°	6:34 p.m.	264°	10°
7:00:45	334	81	6:36:56	341	49
7:00:47	348	81	6:38:11	40	29
Vanishes into Earth's shadow.			Vanishes into Earth's shadow.		
Tiangong 11/10 mag. -1.8			HST 11/13 mag. 2.3		
Time	Position	Elevation	Time	Position	Elevation
5:57 p.m.	229°	10°*	6:33 a.m.	237°	10°
6:00	151	53	6:36	176	29
6:03	74	1	6:39	115	10

*Passes just above Venus

HST 11/14 mag. 2.2		
Time	Position	Elevation
6:10 a.m.	239°	10°
6:13	177	30
6:16	116	10

ISS 12/3 mag. -3.1		
Time	Position	Elevation
6:30 p.m.	304°	10°
6:33	225	55
6:36	147	10

ISS 11/14 mag. -3.7		
Time	Position	Elevation
6:23 p.m.	233°	10°
6:26:32	318	73
6:28:42	41	20

Vanishes into Earth's shadow.

Tiangong 12/5 mag. -2.2		
Time	Position	Elevation
6:45 a.m.	243°	10°
6:48	156	85
6:51	66	10

HST 11/15 mag. 2.3		
Time	Position	Elevation
6:49 a.m.	230°	17°
6:51	178	30
6:54	115	10

HST 12/6 mag. 2.2		
Time	Position	Elevation
6:08 p.m.	233°	10°
6:11	174	28
6:14	114	10

Tiangong 11/19 mag. -1.9		
Time	Position	Elevation
6:31 p.m.	302°	10°
6:34:29	19	50
6:35:00	69	37

Vanishes into Earth's shadow.

Tiangong 12/7 mag. -2.2		
Time	Position	Elevation
Appears from Earth's shadow.		
6:16:32 a.m.	207°	28°
6:17:55	339	60
6:21	60	10

Tiangong 11/21 mag. -2.2		
Time	Position	Elevation
6:05 p.m.	296°	10°
6:08	22	81
6:11	112	11

HST 12/7 mag. 2.3		
Time	Position	Elevation
5:44 p.m.	235°	10°
5:48	174	28
5:51	114	10

ISS 12/1 mag. -3.6		
Time	Position	Elevation
6:34 p.m.	323°	10°
6:38:34	39	47
6:39:41	67	43

Vanishes into Earth's shadow.

ISS 12/13 mag. -2.9		
Time	Position	Elevation
6:36 a.m.	211°	10°
6:39	134	51
6:42	57	10

Key: Position is measured in degrees clockwise from north. That is, 0° is due north, 90° is due east, 180° is due south, and 270° is due west. Your fist held at arm's length spans about ten degrees. "Elevation" is elevation above the horizon in degrees. So, to view the Tiangong Space Station at 6:21 a.m. on December 7, measure three fist-widths north of due east, then one fist-width above the horizon.

Programming Notice: NASA+ on the Web

NASA-TV has become NASA+ <https://plus.nasa.gov/>

NASA+ live event schedules are available at <https://www.nasa.gov/live/> or <https://plus.nasa.gov/scheduled-events/>.

The current schedule only goes up to September 16. However, there will be coverage of the September 24 Crew-9 launch to the ISS. There should also be coverage of the *Europa Clipper* launch on October 10.

Calendar of Events

Sometime in 2024: Maiden flight of the Aurora rocket. This will be the first orbital launch from Spaceport Nova Scotia in Canso, Nova Scotia in Canada.

Sometime in 2024: First flight of *Eris*, from Bowen Spaceport at Abbot Point in Queensland, Australia. If successful, this will give Australia the ability to launch its own satellites.

Fourth Quarter of 2024: Sixth *Starship* orbital test flight.

November: Maiden flight of *Pallas-1* launch vehicle by Galactic Energy in China. For information, see en.wikipedia.org/wiki/Pallas-1.

November: Maiden flight of *New Glenn*. This is the *National Security Space Launch* demonstration flight.

November: First flight of Firefly's *Blue Ghost* lunar lander delivering payload to Mare Crisium. For more information, see https://en.wikipedia.org/wiki/Firefly_Aerospace_Blue_Ghost.

November 16: Uranus is at opposition.

November 16: Mercury is at greatest eastern elongation, 22.5° from the Sun (hence can be seen after sunset).

December 5: Mercury is at inferior conjunction with the Sun.

December 7: Jupiter is at opposition.

December 13: Peak of Geminid meteor shower.

December 22: Peak of Ursid meteor shower.

December 24: Mercury is at greatest western elongation, 22.0° from the Sun (hence can be seen before sunrise).

December 24: *Parker Solar Probe* makes its first pass through the outer corona of the Sun. For more information, see <http://parkersolarprobe.jhuapl.edu>.

December 30: Launch of the *Venus Life Finder Probe and Photon* relay satellite to Venus by RocketLab's Electron Booster. For more information, visit https://en.wikipedia.org/wiki/Venus_Life_Finder

Late December: *Hakuto R Mission 2* carrying iSpace's Resilience lunar lander and a Luxembourg (!) iSpace Europe lunar mini-rover. [*Hakuto R* mission 1 was the one that crash landed with a UAE rover aboard.]

Sometime in 2025 (most likely September): End of *JUNO* mission to Jupiter.

Sometime in 2025: Israel launches its *Beresheet 2* landers (two of them) and orbiter to the Moon. For more information, see en.wikipedia.org/wiki/Beresheet_2.

Sometimes in 2025: Launch of Skynet 6A by Airbus and the UK Ministry of Defense, which will catapult us into the Terminator universe.

Sometime in 2025: Uncrewed *Starship* lunar landing demonstration.

Sometime in 2025 [Moved from fall 2024]: Second (uncrewed) *Gaganyaan* flight test. This one will carry the Vyommitra humanoid robot. For more information on the *Gaganyaan* program, see <https://en.wikipedia.org/wiki/Gaganyaan>.

Sometime in 2025: Third (uncrewed) *Gaganyaan* flight test. This one will carry the Vyommitra humanoid robot. For more information on the *Gaganyaan* program, see <https://en.wikipedia.org/wiki/Gaganyaan>.

Sometime in 2025 [maybe]: India launches its first crewed orbital flight *Gaganyaan 4*. For more information, en.wikipedia.org/wiki/Gaganyaan.

Sometime in 2025: First flight test of ESA's uncrewed Space Plane *Vega-C*.

First half of 2025: In flight fuel transfer from *Starship* to a target.

First half of 2025: Commercial Lunar Payload Services (CLPS) delivers lunar lander to the Gruithuisen Domes and the western edge of Mare Imbrium.

First quarter of 2025: Launch of the *Mission Robotic Vehicle* (MRV) which carries the RSGS (Robotic Servicing of Geosynchronous Satellites) to attach jet packs to remove dying satellites from orbit. For more information, see https://en.wikipedia.org/wiki/Mission_Extension_Vehicle.

January 2025 [Moved from December 2024]: Launch of the *IM-2 South Pole Mission*, including the Polar Resources Ice Mining Experiment 1 (PRIME-1), the IM-2 Lunar Lander, the Lunar Trailblazer orbiter, the Micronova Lunar Hopper, and the M1-MAPP demo lunar rover. The last is a joint US/Finnish mission. Also on this flight is Tanker-002, an in-space refueling satellite from Orbit Fab. This is the second NOVA-C mission.

January 3, 2025: Peak of Quadrantid meteor shower.

January 9, 2025: Venus is at its greatest eastern elongation, 47.2 degrees east of the Sun (so can be seen after sunset).

January 15, 2025: Mars is at opposition, 60 million miles from Earth. In other words, this is a poor opposition.

February 2025 [Moved from December 2024]: First (uncrewed) *Gaganyaan* flight test. For more information, see https://en.wikipedia.org/wiki/Gaganyaan_1

February 2025: SpaceX launches SpaceX Crew-10 to the ISS. This is the mission that will allow the *Boeing Crew Flight Test* crew to finally come home (aboard Crew-9, which has been serving as a lifeboat).

March 2025 [Moved from December 2024: *Fram2*, a four-passenger civilian flight by Crew Dragon. This will be the first crewed flight ever launched into polar orbit. For more information, visit <https://en.wikipedia.org/wiki/Fram2>.

March 2025: Launch of Russia's Bion -M No. 2, to observe the effects of the Van Allen radiation belts on mice over a period of 30 days.

March 2025: *New Glenn* will carry a prototype Blue Moon lunar lander to the Moon. This is known as Pathfinder Mission 1.

March 2025: Launch of South Korea's Hanbit-Nano from Alcântara Space Center in Brazil. This is the first private launch from Alcântara.

March 7, 2025: Mercury is at its greatest eastern elongation, 18.2 degrees east of the Sun (so can be seen after sunset).

March 11, 2025: Saturn is in conjunction with the Sun.

March 14, 2025: Total eclipse of the Moon, visible throughout the Americas.

March 22, 2025: Venus is in inferior conjunction with the Sun.

Second quarter of 2025 [moved from September 2024]: *ESCAPADE Blue* and *Gold* Mars Orbiters launch by New Glenn. For more information, see <en.wikipedia.org/wiki/EscaPADE>.

Second quarter of 2025: Launch of *Axiom-4 (Ax-4)* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts, including the winner of the *Space Hero* reality show. For more information, see https://en.wikipedia.org/wiki/Axiom_Space.

April 2025: Launch of *IMAP* heliophysics probe and *Solar Cruiser* to the Earth-Sun L1 Lagrangian point (the one between us and the Sun). For more information, visit https://en.wikipedia.org/wiki/Interstellar_Mapping_and_Acceleration_Probe and https://en.wikipedia.org/wiki/Space_Weather_Follow_On-Lagrange_1

April 20, 2025: *Lucy* flies by asteroid 52246 Donaldjohanson.

May 2025 [Moved from March 2025]: First Dream Chaser cargo mission via Vulcan Centaur. This is the mission that was supposed to go up in July 2024.

May 2025: Launch of *Tianwen-2* (formerly *Zheng He*), China's asteroid sample return mission and comet orbiter, which will visit Earth's co-orbital asteroid Kamo'oalewa and comet 311P/PANSTARRS,. For more information, see <https://en.wikipedia.org/wiki/Tianwen-2>.

June 2025: Maiden flight of LandSpace's *Zhuque-3* orbital launch vehicle.

Second half of 2025 (not in July!): first crewed mission to Vast's *Haven-1* space station. For more information, <https://en.wikipedia.org/wiki/Haven-1>.

August of 2025: First operational crewed mission of *Starliner 1* to the ISS. This now seems doubtful, with SpaceX's Crew-11 taking this spot. For more information, visit https://en.wikipedia.org/wiki/Boeing_Starliner-1.

August 2025: launch of Vast's *Haven-1* space station. For more information, <https://en.wikipedia.org/wiki/Haven-1>.

September 2025: Astrobiotic's *Griffin Mission 1*, including lunar lander and CubeRover. They leave Earth on a Falcon Heavy. This was originally going to carry *VIPER*, which has been cancelled.

September 2025: *Artemis 2*, the first crewed test flight of SLS and Orion. This will be a free-return mission: that is, it will loop around the Moon without landing. For more information, visit https://en.wikipedia.org/wiki/Artemis_2.

Fourth quarter of 2025: *Mission Possible*, a demonstration flight of the Nyx reusable spacecraft by the Exploration Company a French-German enterprise.

Second quarter of 2025: *Axiom-5*, a four-person fourteen-day mission to the ISS.

Fourth quarter of 2025: Launch of CLPS mission to the Lunar South Pole, including PROSPECT. CLPS=Commercial Lunar Payload Services.

October 2025 [moved from first quarter of 2025]: A SpaceX Nova-C mission to the Moon takes Intuitive Machines' IM-3 lander, NASA's Lunar Vertex rover, and several NASA Cadre rovers.

Sometime in 2026: Launch of ispace's Mission 3. First flight of ispace's APEX 1.0 lunar lander.

Sometime in 2026: Launch of Japan's *Martian Moons Exploration* (MMX) which includes a Phobos lander and sample return. For information, see [en.wikipedia.org/wiki/Martian_Moons_exploration_\(MMX\)](https://en.wikipedia.org/wiki/Martian_Moons_exploration_(MMX)).

Sometime in 2026 [moved from 2024]: India launches *Mars Orbiter Mission 2* (MOM 2 or *Mangalyaan 2*). For information, see https://en.wikipedia.org/wiki/Mars_Orbiter_Mission_2.

Sometime in 2026: Maiden flight of Terran R mission to Mars from Impulse Space. For more information, en.wikipedia.org/wiki/Terran_R.

Sometime in 2026: Launch of MIT's Venus Habitability Mission.

Sometime in 2026: second *Blue Ghost* mission, carrying Lunar Pathfinder to the far side of the Moon. (Lunar Pathfinder is not to be confused with UK Pathfinder which failed launch in 2024, Intuitive Machines GEO Pathfinder, which is a variant of SHERPA, or Pathfinder Mission 1, which is part of the Blue Moon program.)

Sometime in 2026: *Gaganyaan-5*, India's second crewed spaceflight.

Sometime in 2026: *Gaganyaan-6*, India's first resupply mission to the ISS.

Sometime in 2026: Maiden flight of *Volans*, the first orbital launch vehicle developed in Singapore.

Sometime in 2026: Launch of Canadensys lunar rover, the first for Canada.

First quarter of 2026: Launch of *Daytona 1*, carrying the first pair of satellites for Tropical Weather Analytics' Hurricane Hunter Satellite Constellation. Daytona is a series of launchers for the Phantom Space Corporation, en.wikipedia.org/wiki/Phantom_Space_Corporation#Daytona

May 2026: The *Psyche* probe flies by Mars.

Second half of 2026: ClearSpace-1 will capture PROBA-1 and deorbit it.

July 2026: *Hayabusa 2* flies by 98943 Torifune.

September 2026: Launch of *Artemis 3*, which will be the first crewed lunar landing since 1972. For information, see en.wikipedia.org/wiki/Artemis_3.

Fourth quarter of 2026: China launches the lunar mission *Chang'e 7*, which includes an orbiter, a lander and a hopping probe. For more information, see https://en.wikipedia.org/wiki/Chang%27e_7.

Fourth quarter of 2026: China launches its *Xuntian* space telescope, which will orbit close to orbit close to *Tiangong* for easy servicing. For more information, visit <https://en.wikipedia.org/wiki/Xuntian>

October 2026: Launch of the *Nancy Grace Roman Space Telescope* [formerly known as WFIRST] to the Earth-Sun L2 point. For more information, see https://en.wikipedia.org/wiki/Nancy_Grace_Roman_Space_Telescope.

November 2026 [postponed from December 2025 due to a thruster problem]: *BepiColombo* arrives at Mercury orbit.

Sometime in 2027: Launch of the first two modules of the Lunar Orbiter Platform Gateway by SpaceX's Falcon Heavy. These were originally going to be launched on separate spacecraft but are now bunked together.

Sometime in 2027: First flight of Long March 10, which will be China's vehicle for crewed Moon missions.

Sometime in 2027: Launch of NEM-1, the core module of the Russian Orbital Service Station, or ROSS. For more information, see https://en.wikipedia.org/wiki/Russian_Orbital_Service_Station.

Sometime in 2027: Launch of the ESA's *Earth Return Orbiter* to Mars. This vehicle will bring the *Perseverance* Mars samples to Earth.

Sometime in 2027: Launch of *Luna 26*, the Luna-Resurs-Orbiter. This mission is in tandem with next year's *Luna 27* lander. For more information, see https://en.wikipedia.org/wiki/Luna_26.

Sometime in 2027: USSF's *DRACO* demonstration of a nuclear thermal rocket in low-Earth orbit. For more information, see en.wikipedia.org/wiki/Demonstration_Rocket_for_Agile_Cislunar_Operations.

August 12; 2027: *Lucy* flies by asteroid 3548 Eurybates in its first encounter with a Trojan asteroid. It will fly by at least 3 more Trojans in 2027 and 2028.

September 2027[moved up from 2028!]: Launch of the *NEO Surveyor* which will be able to detect more than 90% of near-earth objects greater than 460 feet in diameter. For more information, see https://en.wikipedia.org/wiki/NEO_Surveyor.

September 15, 2027: *Lucy* flies by Trojan asteroid 15094 Polymele.

Sometime in 2028 [moved from 2025]: JAXA launches *DESTINY+*, an asteroid flyby mission to Phaethon, the parent of the Geminid meteor shower. It will arrive there in 2029. For information, see en.wikipedia.org/wiki/DESTINY%2B.

Sometime in 2028 [moved from 2026]: Launch and landing of Japan/India *LUPEX* (Lunar Polar Exploration) lander. For more information, see https://en.wikipedia.org/wiki/Lunar_Polar_Exploration_Mission.

Sometime in 2028: Launch of *Luna 27*, the Luna-Resurs Lander which will land in the South Pole-Aitkin Basin on the far side of the Moon. This mission is in tandem with 2027's *Luna 26* orbiter. For more information, see https://en.wikipedia.org/wiki/Luna_27#Science_payload.

Sometime in 2028: Launch of *Chang'e 8*, which will include a lander, rover and a 3D printing experiment using lunar resources. This will be the last *Chang'e* mission before China sends a human crew to the Moon.

Sometime in 2028: Launch of the *Sample Retrieval Lander* to Mars. This is part of a joint NASA/ESA mission and will include Ingenuity class helicopters. [There's a very good chance that this will be delayed for up to a decade.]

Sometime in 2028: first uncrewed test launch of *Orel*, Russia's new crewed spacecraft, with first crewed launch later in the year. For information, [https://en.wikipedia.org/wiki/Orel_\(spacecraft\)](https://en.wikipedia.org/wiki/Orel_(spacecraft)).

Sometime in 2028: Launch of the first module of India's *Bharatiya Antariksha* space station. For more information, see https://en.wikipedia.org/wiki/Bharatiya_Antariksha_Station.

First quarter of 2028: Launch of the *Emirates Asteroid Mission* to the asteroid belt, where it will make at least seven flybys of asteroids, the largest of which are Chimaera and Justitia. [See May 2035.]

March 29, 2028: Launch of India's *Shukrayaan-1* Venus orbiter. For more information, see <https://en.wikipedia.org/wiki/Shukrayaan-1>.

April 2028: Launch of ESA's *Ramses* spacecraft, which will fly by Apophis.

April 18, 2028: *Lucy* encounters asteroid 11351 Leucus.

July 2028: Launch of *Dragonfly*, the Titan helicopter mission. For information, see [en.wikipedia.org/wiki/Dragonfly_\(spacecraft\)](https://en.wikipedia.org/wiki/Dragonfly_(spacecraft)).

September 2028: Launch of *Artemis 4*, a Lunar Gateway expedition which will also land four astronauts on the Moon.

October 2028: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*. For more information, visit <https://en.wikipedia.org/wiki/ExoMars>.

November 11, 2028: *Lucy* flies by Trojan asteroid 21900 Orus.

Sometime in 2029: Launch of the *ARIEL Space Telescope* and the *ESA/JAXA Comet Interceptor* mission via Ariane 62 to the Sun-Earth L₂ point, where the Interceptor will wait for a long-period comet to come by.

Sometime in 2029: Launch of *VERITAS* orbiter and Venus Atmosphere Sample Return Mission to Venus. For more information, see [https://en.wikipedia.org/wiki/VERITAS_\(spacecraft\)](https://en.wikipedia.org/wiki/VERITAS_(spacecraft)).

April 21, 2029: *OSIRIS-APEX* rendezvous with the asteroid Apophis. Note: *OSIRIS-APEX* is the same spacecraft as *OSIRIS-REx*; it is renamed “Apophis Explorer” for this part of its mission.

June 2029: Launch of *DAVINCI+* to Venus. For more information, see <https://en.wikipedia.org/wiki/DAVINCI>

August 2029: The *Psyche* asteroid probe arrives at asteroid 16 Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

September 2029: Launch of Artemis 5 to the Moon. This mission carries the ESPRIT Refueling Module to the Lunar Gateway, and a crew and the crewed Lunar Terrain Rover.

September 2029: Launch of *Tianwen 4* which will carry a Jupiter orbiter and a mission to Uranus. The Uranus spacecraft will eventually leave the solar system, something that only the US has achieved.

Sometime in 2030: *DESTINY+* flies by asteroid 3200 Phaethon, the parent body of the Geminid meteor shower.

Sometime in 2030 [Moved from November 2028]: Launch of China’s *Tianwen-3* Mars sample return mission.

Sometime in 2030: China will land a crewed mission on the Moon.

Sometime in 2030: Launch of the ESA’s *NEOMIR* (Near-Earth Object Mission in the Infrared).

Sometime in 2030: Launch of Russia’s *Luna 28* sample return mission.

Sometime in 2030: Launch of ESA’s *EnVision* Venus orbiter.

April 2030: *Europa Clipper* arrives at Jupiter.

September 2030: Launch of *Artemis 6* to the Moon.

Spring 2031: *Europa Clipper*’s first flyby of Europa.

July 2031: Hayabusa 2 arrives at asteroid 1998 KY26.

July 2031: *JUICE* flies by Ganymede then is inserted into Jupiter orbit.

September 2031: Launch of *Artemis 7* to the Moon. This will include the crewed Lunar Cruiser rover build in Japan.

Sometime in 2032: Launch of the *Yenisei* lunar flyby mission. This will be the first Russian manned mission to the Moon (though it’s not a landing).

Sometime in 2032: Launch of first South Korean lunar lander.

Sometime in 2032: Launch of *Artemis 8* to the Moon, which includes the first component of the Artemis Base Camp.

Sometime in 2033: First flight of the Long March 9 super-heavy launch vehicle. This looks like it will be able to carry 53,000 kg to the Moon and 44,000 kg to Mars and will probably carry Chinese astronauts to the Moon.

March 2, 2033: *Lucy* flies by the double Trojan asteroid 617 Patroclus-Menotius. I believe these are the largest asteroids it will encounter.

December 2034: *Juice* achieves Ganymede orbit.

Sometime in 2035: Launch of LISA gravitational wave observatory.

May 2035: The *Emirates Asteroid Mission* touches down on Justitia.

Sometime in 2036: *Dragonfly* arrives at Titan.

August 12, 2045: The next total solar eclipse is visible in Oklahoma City. This one is also visible in Salt Lake City, Denver, Little Rock (again), Tampa Bay and New Orleans.

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Other Information

Oklahoma Space Industrial Development Authority (OSIDA), 401 Sooner Drive/PO Box 689, Burns Flat, OK 73624, 580-562-3500. Website is <http://airspaceportok.com/#home>,

Science Museum Oklahoma (former Omniplex) website is www.sciencemuseumok.org. Main number is 602-6664.

Tulsa Air and Space Museum, 7130 E. Apache, Tulsa, OK 74115.

Web Site is www.tulsaairandspacemuseum.com. Phone (918) 834-9900.

The Mars Society address is The Mars Society, 11111 West 8th Avenue, Unit A, Lakewood, CO 80215. Phone: (303) 980-0890 Their web address is www.marsociety.org.

The National Space Society's Headquarters Executive Director e-mail nsshq@nss.org. The Chapters Coordinator is Bennett Rutledge 720-641-7987, rutledges@chapters.nss.org. The address is: National Space Society, 1300 I Street NW, Suite 400E, Washington, DC 20005. Phone (321)452-2448. Web page is space.nss.org.

The Planetary Society phone 626-793-5100. The address is 60 South Los Robles Avenue, Pasadena, California, 91101, and the website is www.planetary.org. E-mail is tps@planetary.org.

NASA Spacelink BBS 205-895-0028. Or try www.nasa.gov .

Congressional Switchboard 202/224-3121.

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