

OKLAHOMA SPACE ALLIANCE

OUTREACH – November 2023

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
at the room next to Norman Computer
at 2:00 p.m. on November 11, details inside



Image of asteroid Dinkinesh and its newly discovered moon, taken by Lucy space probe on its way to Jupiter's Trojan asteroids. (Photograph: NASA archives)

OKLAHOMA SPACE ALLIANCE OUTREACH November 2023

November Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, November 11, at the location next to Norman Computers on West Main. Prospective members are welcome.

The meeting room is in the Cyber Hall and Gaming Lounge at Norman Computers. Norman Computers is at 916 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 in a small mall.

We will have this meeting on Zoom for those who cannot attend in person: To join the meeting, go to <https://tinyurl.com/y2qtab28>. If the link doesn't work, call Clifford McMurray, President 405-329-4326 (H), 405-863-6173 (C) (e-mail cliffmcmurray@hotmail.com) or Syd Henderson at 405-365-8983 (C) (e-mail sydh@ou.edu) and we will send you updated information.

Saturday November 11, 2023, 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 October meeting
 - c. Officer Nominations
 - d. Christmas Party
 - e. Posters
 - f. Presentations from ISDC
5. Video (to be announced)
6. Chat

Minutes of October 14 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met October 14, 2023, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending in person were Clifford McMurray., Mark Deaver, Kevin?, Steve Marino, Dave Sheely, and Syd Henderson. OSA President Clifford (Kip) McMurray presided over the meeting He did an *Update* discussing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2310.pdf> so I'll cover the details that aren't covered there.

OSIRIS-REx returned more material from asteroid Bennu than expected. This was the third sample return mission to an asteroid after the two Japanese *Hayabusa* mission. *OSIRIS-REx*, under its new name *OSIRIS-APEX* is now off to the near-earth asteroid Apophis, which tends to come extremely close to Earth and may collide with us someday. However, although it will analyze it, it won't return samples because it only had the one container.

The recently returned astronauts were the sixth through eighth to spend a full year in space on one flight. All the first five were aboard Mir. The record stay in space is 437 days by Valery Polyakov. [Second longest is 379 days by Sergey Avdeev. Third are the 371 days just completed by Frank Rubio, Sergey Prokopyev and Dmitry Petelin, who are obviously in a three-way tie. Their achievement was enabled by a

coolant leak in the Soyuz spacecraft that was supposed to return them. The other two cosmonauts to spend a year in space (by a few hours) are Vladimit Titov and Musa Manarov.]

The Pakistani who flew aboard Virgin Galactic was also the first Pakistani to visit the North and South Poles.

The FAA has made a list of five possible methods of disposing of upper stages. These include controlled reentry, and insertion into solar orbit.

The asteroid 16 Psyche is 140 by 133 in its long directions, making it one of the larger asteroids. It is of interest as the largest mostly metallic asteroid. [Since it is dense as well, it has about 1% of the mass of the entire asteroid belt. Still, it is puny compared with Ceres, which has 40% of the mass of the asteroid belt.] We watched a video of the launch of the Psyche spacecraft and the landing of the boosters, and a video of the deployment of the spacecraft.

We watched the launch of SLIM to the Moon and XRISM, an X-ray telescope that will stay in Earth orbit. If SLIM is successful, it will make Japan the fifth nation to make a soft landing on the Moon.

New Glenn was going to use Cygnus to launch their own space station, but now are going to use it to supply a consolidate space station with Voyage Space.

The goal of Varda Space is to launch a capsule each month, but they are not being allowed to land by the FAA.

We viewed an article on how the SLS is not affordable.

Under current funding, the Mars Sample Return mission will cost 8 – 11 billion and not launch until after 2030. Kip commented that by then Starship will be launching to Mars and it could carry a vehicle that can directly return the samples.

We watched a video of Chinese astronauts lighting a candle aboard Tiangong as part of a demonstration for children on how fire burns differently in space due to hot air not being able to rise. [If I remember, a similar demonstration was done aboard Skylab back in the 1970s.]

We watched a video of an egg drop from the edge of space. The idea is to find a way to keep the egg from breaking when it lands.

This week @ NASA: Water and hydrocarbons were found in the OSIRIS-REx samples from Bennu.

The Psyche probe is the first time Hall effect thrusters have been used in space. This is a version of the ion drive and relies on a small thrust over a long period of time.

We watched a video on “Is Starship Doomed to Repeat History?” which compared it with the Soviet Union’s N1 program. They’re similar in that they use a large number of engines (about 30 in both cases) and have a problem getting them all to light. The N1 was to launch cosmonauts to the Moon, so was basically their equivalent of the Saturn 5. It was abandoned about the time Apollo made it to the Moon. N1 had five stages, while Starship uses only two. SpaceX already uses up to 27 in its Falcon Heavy rockets, but they are configured differently than in Starship.

--Minutes by OSA Secretary Syd Henderson

Minutes of September 9 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met September 9, 2023, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending were Clifford McMurray, Adam Hemphill, Kevin Sampson, Tim Scott, Dave Sheely, and Syd Henderson. OSA President Clifford (Kip) McMurray presided over the meeting He did an Update discussing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2309.pdf> so I’ll cover the details that aren’t covered there.

SpaceX’s *Starship* is all ready to go subject to FAA approval.

Luna 25, the failed Russian return to the Moon, is actually part of the Chinese Lunar Program which Russia has signed onto. The Russian Space Program is seriously underfunded and has an entirely new generation from their old Lunar program. It’s been 46 – 47 years since their last Lunar mission. We watched a video of what should have been.

We watched a video of landing sites on the Moon.

We watched a video of China's upcoming mission.

We saw pictures of the *Luna 25* crash site.

We watched a video of Chandrayaan Mission Control watching the *Chandrayaan 3* Moon landing.

The Indian space mission used Earth as a substitute exoplanet to see what one would look like to their instruments.

We watched a video of India's Pragyan rover on the Lunar surface.

We watched the launch of India's *Aditya L-1*. It took a selfie with the Earth and Moon. This probe is headed toward the L-1 Lagrangian Point to study the corona heating problem. (That is: why is the Sun's corona so much hotter than its surface?)

We watched a video of China's *Yuti 2* (Jade Rabbit 2) which is still operational as is *Chang'e 4*. [These are on the far side of the Moon.]

Rocket Lab's Neutron rocket will be capable of launching 13,000 kg to low Earth orbit.

The rocket adaptor that was the target of Cleanspace-1 was hit by a meteor rather than an artificial object. We watched a video about Cleanspace, and a video about collisions in low Earth orbit.

We watched a video of the (night) launch of the Crew-7 launch to the ISS.

The Land_Now program was launched on *Ingenuity* mission 53 after the communication failure with *Perseverance*.

We watched a video of ISS astronauts' playing "space darts." They're actually using ping pong balls and aiming at rings.

The same security hiring restrictions that SpaceX is being sued over also apply to Boeing, Rocket Lab, Blue Dragon, etc., when they handle classified payloads.

New Horizons is taking up \$3 million of NASA's budget and they are planning to cut it?

Business: We have \$853.71 in the checking account and the perpetual \$267 in cash for a total of \$1120.71.

--Minutes by OSA Secretary Syd Henderson

Space News

NASA has updated its "Spot the Station" website, <https://spotthestation.nasa.gov/> and it can now download an app for Android and iOS. Unfortunately, it gives you maximum heights, and where it will appear and disappear, but doesn't give you a star map or time intervals, so www.heavens-above.com is much more useful to me.

The cover photo of this issue is from the first asteroid flyby for *Lucy*, the probe that is going to travel through both of Jupiter's Trojan Asteroid regions. 152830 Dinkinesh is not a Trojan asteroid but a main-belt asteroid. Dinkinesh is almost exactly a half-mile in diameter and is the smallest main belt asteroid yet visited by a spacecraft—or it would be, if *Lucy* hadn't discovered that Dinkinesh has a small satellite 720 feet in diameter. The satellite has not yet been named.

Outside of its location, Dinkinesh seems to resemble Didymos, whose satellite Dimorphos was the target of the DART mission. It also resembles Bennu so is probably a similar rubble pile.

Incidentally, *Lucy* is named for the fossilized hominid Lucy who in turn was named for the Beatles song "Lucy in the Sky with Diamonds." Dinkinesh is the Amharic name for the Lucy fossil—it means "you are wonderful." Lucy is also carrying a diamond-encrusted disk and its pentagonal mission badge is the shape of a cross-section of a diamond.

Next encounter for *Lucy*, surprisingly, is Earth on December 13, 2024, for a gravity assist. After that is 52246 Donaldjohanson, a 2.5 mile in diameter main-belt asteroid, in April 2025. (Donald Johanson was the discoverer of fossil Lucy.) Finally, on August 12, 2027, *Lucy* will encounter 3548 Eurybates in the L4 (Greek) Trojan camp. After several other encounters with the members of the Greek camp, *Lucy* will

again fly past Earth in December 2030 on its way to meet 617 Patroclus-Menoetius in the Trojan camp (Patroclus is clearly a spy.) These are good sized asteroids, each 60 -70 miles in diameter, and make up a rather neat double asteroid.

Although I only see four Trojan flybys (counting Patroclus and Menoetius as one), Lucy will certainly find more targets when it actually nears the L4 and L5 camps.

The *New Horizons* Kuiper Belt mission has gotten a reprieve and will continue until it's actually out of the Kuiper Belt, which will in 2028 or 2029. (We're still a little uncertain about the outer boundary of the Kuiper Belt.) There is still hope for a third flyby, but no suitable object has been found yet.

Starting in 2025, *New Horizons* will start devoting itself more to heliophysics, which might be useful since it is still near the ecliptic, the plane of the Solar System. *Voyager 1* left the plane of the ecliptic when it went over Saturn's South Pole so it could fly by Titan. Similarly, *Voyager 2* flew over Neptune's North Pole so it could fly by Triton and exited the plane of the ecliptic in a totally different direction. Thus, *New Horizon* is in a unique position among our trans-Neptunian probes.

There is also a hypothesis that there may be a "Kuiper Belt II" which would possibly include Sedna, which doesn't come into the main Kuiper Belt. Note, though, that Sedna has an incredibly eccentric orbit that takes it more than thirty times the distance from the Sun to Neptune and goes far beyond the heliopause. This raises the question of what it is doing out there.

Astronaut Ken (T. K.) Mattingly, who died on October 31 at the age of 87, is best known for his association with two *Apollo* missions, as Command Module Pilot on *Apollo 16*, and would have had the same post on *Apollo 13* if he hadn't been exposed to German measles three days before launch and replaced by Jack Swigart. In a way, this was lucky since he was able to assist the crew remotely. I covered the Apollo 13 mission in the March 2020 *Outreach* and Apollo 16 in the March 2022 *Outreach*, both of which are online at <https://osa.nss.org/>. (March 2020 is on the page for "Earlier Issues of Newsletters.") March 2022 is still on the main page in that long list of newsletters that I need to trim.

Mattingly also trained for the backup crew of Apollo 11. He and John Young are the only people to fly to the Moon and also go to space on a Space Shuttle mission. He was played by Gary Sinise in the movie *Apollo 13* and by Željko Ivanek in the miniseries *From the Earth to the Moon*.

On November 1, the Netherlands became the 31st nation to sign the Artemis Accords, following Iceland in October. You can view the Artemis Accords and see the list of signatories at <https://www.nasa.gov/artemis-accords/>.

Now that the Netherlands and Luxembourg are both signatories, can Belgium be far behind?

The 2023 ozone hole over the Antarctic is one of the largest on record. Speculation is that this may be caused by the eruption of the Hunga Tonga-Hunga Ha'apai volcano early last year which sent large amounts of aerosols into the stratosphere. This included a lot of water vapor which formed stratospheric clouds, which give CFCs a template where they can deplete in ozone. However, CFCs were banned in 1987 and the ozone layer is expected to be normal by 2050.

Note, this is speculation since insertion of large amounts of water vapor into the stratosphere is a rare event. It would also take a long time to reach the Antarctic, so it may happen for a few more years.

The *Euclid* Space Telescope has released its first preliminary images, which indicate that the Telescope is in good health in its new position at the Earth-Sun L2 point. *Euclid*'s job is to map all the galaxies out to 10 billion light years provided their light is not blocked by dust. Thus, it is not looking for them in the galactic plane or the plane of the ecliptic. However, in the regions where it is designed to look at, it's giving very sharp images already. It also has a pretty good field of view, about 7.5 arcminutes squared. That's the size of a square whose sides are a quarter the apparent width of the Moon. That means that it will take a long time to complete its survey, but there will be a huge number of galaxies to view,

and we will catch them in all stages of their lifetime. Since it can also detect red shifts into the infrared, we will get a three-dimensional view of the distribution of the galaxies it can see.

These are test commissioning images, which means they are pretty raw. It will be well into next year before Euclid begins its true survey.

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.

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 not be a factor, 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.

The **Geminid Meteor Shower** is active from December 4 through 17, peaking on the morning of December 14. This year viewing conditions are ideal, with the Moon being new only two days before the peak. The Geminids are one of the more prolific and dependable meteor showers of the year with 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 2025 Japan will be launching the DESTINY+ mission to 3200 Phaethon, the parent asteroid of the Geminids, to arrive in 2029. 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, and this year has to contend with a nearly Full Moon. 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 **Quadrantid Meteor Shower** is always the first major shower of the year and this year peak on the night of January 3-4. Since they happen before the January 2024 *Outreach*, I'm including them here. 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. However, our luck in major meteors runs out because the last-quarter Moon rises just after midnight. On the other hand, the radiant of the meteor shower is pretty far north and you should be able to see quite a few of them flying to the north and west.

Interestingly, this appears to be a fossil meteor shower whose parent was a great comet that broke up thousands of years ago, leaving several other comets that don't come near us. Another candidate is the great comet of 1490 that was thrown out of its orbit by Jupiter and hasn't been seen since.

Mercury is currently lost in evening twilight but will gradually become more visible through November until it reaches greatest elongation on December 4. Still, it's a challenge since it is setting only an hour after the Sun and is only seven degrees above the horizon a half hour after sunset. Mercury will be magnitude -0.4 then, but it will fade rapidly the rest of the month as it reaches inferior conjunction on December 22.

Venus, on the other hand, dominates the sky before sunrise as it rises more than two hours before the Sun. It is currently magnitude -4.4, a little below its peak, as it is now in the far side of its orbit. It is currently under the red end of Leo and will pass through Virgo and Libra and by the end of December will be about to enter Scorpius. Venus will be easy to see into March, at which time it will be easily visible.

Mars is in conjunction with the Sun on November 17 and will not be visible until sometime in January.

The asteroid **4 Vesta** is at opposition on December 19. Vesta is the only asteroid that is regularly visible to the naked eye getting up to magnitude 5.1, which is half a magnitude brighter than Uranus ever gets. This year it only gets up to magnitude 6.4, so it's a binocular object. On the other hand, it's also in northern Orion.

Jupiter, on the other hand, was in opposition on November 3, and is up in the sky all night. I've been seeing it in the East soon after sunset and the west a short while after sunrise. It is magnitude -2.9, which is about the brightest it ever gets. Currently, it is in the rather dim constellation Aries, and actually will be there through December as it's in retrograde motion across the sky. It won't dim appreciably and will be higher in the eastern sky after sunset.

Saturn is magnitude 0.7 in Aquarius. It lies to the south at sunset and is up pretty much all evening. There are no bright stars in this region except Fomalhaut in Piscis Austrinus. Fomalhaut is about twenty degrees south-southeast of Saturn and peaks at about 7:30 p.m. and is about half a magnitude dimmer. As for Saturn, its rings are at a tilt of about ten degrees, which makes it less bright than usual. The tilt is shrinking, and in 2025 we will be viewing them edge-on. Saturn will gradually grow dimmer in November and December as it moves away from us, but at the end of December it will still not set until 9:00 p.m. and will be magnitude 0.9. All this time, it will be in Aquarius, as it will be through all of 2024.

Uranus is joined in Aries by Jupiter. This is a rather dim region of the sky, and Uranus is magnitude 5.6, so it may be difficult to locate (though it is at least as bright as stars close to it in the sky). Uranus is at opposition on November 13, so it is a tiny bit brighter than usual. It's about eleven degrees east of Jupiter but only visible under the darkest of skies. To search for Uranus, try <https://lovethenightsky.com/see-uranus-through-a-telescope/>

Neptune is magnitude 7.8 and rising around midnight. It's located just on the Pisces side of the border with Aquarius. It is located south of the Circlet asterism in Pisces. To search for Neptune, try <https://lovethenightsky.com/see-neptune-through-a-telescope/>.

Viewing Opportunities for Satellites (November 11 – December 16 , 2023)

You can get sighting information at www.heavens-above.com, which gives you a constellation map showing the trajectory of the satellite. The Sky & Telescope web site carries ISS observation times for the next few nights at skyandtelescope.com/observing/almanac. 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, although magnitude -2 to -3 is more likely. 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 – 2.5 is more likely. *Tiangong* is the Chinese Space Station. It currently gets up to magnitude -2.3 after the addition of the Wentian module last July and will do so on November 20.

The “mag.” beside the date indicates the brightest magnitude the satellite gets during the pass. All the ISS passes get between -3 and -4, 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. There is a Progress cargo flight to the ISS on December 1. There will be none to Hubble in the near 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. The Hubble Space Telescope passes usually repeat five or six times with similar trajectories and 10 – 15 minutes earlier each day, to about 30 degrees above the horizon. I quit on November 28 because it will be too much in twilight, but it may still be visible on November 29. It doesn't get above 28° this month until it peaks before sunset.

ISS 11/15/23 mag. -3.9		
Time	Position	Elevation
6:49 p.m.	228°	10°
6:52:27	317	86
6:53:03	42	57

Vanishes into Earth's shadow.

ISS 11/16/23 mag. -3.3		
Time	Position	Elevation
6:00 p.m.	208°	10°
6:04	134	46
6:07	61	12

ISS 11/18/23 mag. -3.1		
Time	Position	Elevation
6:59 p.m.	243°	10°
7:02	321	51
7:06	38	10

Tiangong 11/20/23 mag. -2.3		
Time	Position	Elevation
6:45 p.m.	247°	10°
6:48:13	334	85
6:48:37	54	65

Vanishes into Earth's shadow.

Tiangong 11/21/23 mag. -1.7		
Time	Position	Elevation
5:44 p.m.	227°	10°
5:47	151	50
5:50	74	10*

*Passes just above Jupiter

Tiangong 11/22/23 mag. -1.7		
Time	Position	Elevation
6:19 p.m.	262°	10°
6:22:32	340	51
6:24:13	49	23

Vanishes into Earth's shadow.

HST 11/27/23 mag. 2.3		
Time	Position	Elevation
6:01 p.m.	230°	10°
6:04	172	27
6:07	113	10

HST 11/28/23 mag. -2.3		
Time	Position	Elevation
5:44 p.m.	234°	10°
5:48	173	28
5:52	100	10

Tiangong 12/1/23 mag. -2.0		
Time	Position	Elevation
6:45 p.m.	290°	10°
6:48:00	208	66
6:48:39	148	48

Vanishes into Earth's shadow.

Tiangong 12/2/23 mag. -2.2		
Time	Position	Elevation
5:43 p.m.	299°	10°
5:46	22	65
5:49	105	10

ISS 12/5/23 mag. -3.3		
Time	Position	Elevation
6:35 p.m.	306°	10°
6:39	225	52
6:42	145	13

ISS 12/6/23 mag. -3.8		
Time	Position	Elevation
5:46 p.m.	318°	10°
5:49	40	64
5:52	120	10

ISS 12/16/23 mag. -3.6		
Time	Position	Elevation
7:00 p.m.	232°	10°
7:03	136	76
7:06	51	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 6:22:32 p.m. on November 22, measure two fist-widths west of due north, then five fist-widths above the horizon.

Programming Notice: NASA TV on the Web

Watch NASA TV (Public, Media and Education Channels) on your computer using Flash, Windows or QuickTime at <http://www.nasa.gov/multimedia/nasatv/index.html>.

NASA TV Schedules are available at <http://www.nasa.gov/multimedia/nasatv/schedule.html>.

November 9, 7:00 p.m.: Launch coverage of SpaceX CRS 29 cargo craft to the ISS. The actual launch is 7:28 p.m.

November 11, 2:45 a.m.: Coverage of docking of SpaceX CRS 29 cargo craft with the ISS.

There should also be live coverage of the Peregrine launch to the Moon on December 24.

Calendar of Events

Sometime in 2023: Launch of ADRAS-J, a space debris removal demonstration by Aeroscale Japan.

Fourth Quarter of 2023: Launch of *Eris*, the first Australian rocket to launch an Australian payload, and the first launch from Bowen Orbital Spaceport in Queensland, Australia. *Eris* is the launch vehicle for Gilmour Space. For more information, visit en.wikipedia.org/wiki/Gilmour_Space_Technologies#Eris.

November: Second orbital test flight of SpaceX's *Starship* spacecraft.

November: Third launch attempt of North Korea's orbital launch craft *Chöllima 1*.

November 10: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See www.okcastroclub.com for details.

November 11: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at <http://osa.nss.org>.

November 11 – 12: Peak of Northern Taurid meteor shower.

November 13: Uranus is in opposition.

November 17: Mars is in conjunction with the Sun.

November 17 – 18: Peak of Leonid meteor shower.

December: Launch of the Chinese Academy of Sciences *Einstein Probe* which is dedicated to X-ray Astronomy

December 4: Mercury is at greatest eastern elongation, 21.3 degrees from the Sun (so can be seen after sunset).

December 8: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See www.okcastroclub.com for details.

December 9 [Tentative]: Oklahoma Space Alliance Christmas Party, location to be determined at November Meeting.

December 13 – 14: Peak of the Geminid meteor shower. Often the best shower, the Geminids will be even better since the Moon is practically New.

December 21 – 22: Peak of the Ursid meteor shower.

December 24: Launch of the *Peregrine* lunar lander by ULA's Vulcan Centaur for Astrobotic Technology. This is the maiden flight for Vulcan Centaur. Also aboard are the *Iris* Cube Rover and the Mexican lunar rover *Colmena x5*. *Colmena* is Mexico's first Moon mission.

Sometime in 2024: Launch of *Hakuto-R* mission 2, lunar lander and iSpace lunar rover. The Lander is Japanese and the rover apparently from Luxembourg. For more information, see en.wikipedia.org/wiki/Hakuto.

Sometime in 2024: First launch of Firefly's *Blue Ghost* lunar lander delivering payloads to Mare Crisium. For more information, see https://en.wikipedia.org/wiki/Firefly_Aerospace#Blue_Ghost_lunar_lander.

Sometime in 2024: India launches Mars Orbiter Mission 2 (MOM 2). For information, see https://en.wikipedia.org/wiki/Mars_Orbiter_Mission_2.

Sometime in 2024 (moved from 2023): First flight of Blue Origin's *New Glenn* orbital rocket.

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

Sometime in 2024 (postponed from 2023): UK Pathfinder Launch, from SaxaVord Spaceport on Unst in the Shetland Islands to low Earth orbit. This, amazingly, will be the first orbital launch from the ground in the history of the United Kingdom.

First Quarter of 2024 [Moved from 2023]: Launch of *Polaris Dawn* flight carrying Jared Isaacman and four other civilians into space. https://en.wikipedia.org/wiki/Polaris_Dawn

First quarter of 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.

First quarter of 2024: First (uncrewed) *Gaganyaan* flight test. For more information, see https://en.wikipedia.org/wiki/Gaganyaan_1

First half of 2024: Maiden flight of Ariane 6. More precisely, Ariane 64. An Ariane 62 launch will also occur in 2024.

January 2024 [moved from November 2023]: Launch of *Axiom-3 (Ax-3)* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts. For more information, see https://en.wikipedia.org/wiki/Axiom_Space.

January 4, 2024: Peak of the Quadrantid meteor shower.

January 12, 2024: [moved from November]: Launch via Falcon 9 of the *Nova-C* lander and other cargos to the Lunar South Pole. For more on *Nova-C*, see <https://en.wikipedia.org/wiki/Nova-C>

January 12, 2024: Mercury is at greatest western elongation, 23.5° west of the Sun (hence can be seen before sunrise).

February 2024: Crew-8 launches to the ISS via Falcon 9.

February 25, 2024: Mercury is in superior conjunction with the Sun.

February 28, 2024: Saturn is in conjunction with the Sun.

March 2024: Launch of China's Queqiao-2, the relay satellite for the *Chang'e-6* mission to the far side of the Moon.

March 1, 2024: Final launch of the Delta IV Heavy rocket, and the final launch of a Delta rocket, period. This ends nearly 64 years of flights of the Delta Rocket family.

March 17, 2024: Neptune is in conjunction with the Sun.

March 24, 2024: Mercury is at greatest eastern elongation, 18.7 ° east of the Sun (hence can be seen after sunset).

April 2024: First ISS Cargo Resupply mission for Dream Chaser.

April 11, 2024: Mercury is at inferior conjunction.

Mid-April 2024 [Moved from 2023]: First crewed test launch of *Boeing Starliner-1* to the ISS. For more information, see https://en.wikipedia.org/wiki/Boeing_Starliner.

Second quarter of 2024: A SpaceX Nova-C mission to the moon takes Intuitive Machines' IM-3 lander, NASA's Lunar Vertex rover, Lunar Outpost's M2 MAPP rover, and several NASA Cadre rovers.

Second quarter of 2024: Second uncrewed *Gaganyaan* test flight.

April 6, 2024: 3:20 a.m.: conjunction of the Moon and Saturn. This will be an occultation from some locations.]

April 8, 2024: Next total eclipse of the Sun visible in the United States. This one will be visible on a path through northern Mexico (making landfall opposite the tip of Baja California), passes through Texas (including Dallas, Arlington, and Waco), touches the southeastern corner of Oklahoma, then

crosses Arkansas, eastern Missouri, Illinois, western Kentucky, Indiana, Ohio (including Cleveland), Erie in Pennsylvania, upper New York (including Buffalo and Niagara Falls), Burlington in Vermont, New Hampshire, and Maine, then into Canada.

April 8, 2024: Peak of Lyrid meteor shower. Note that this is happening at the same time as the eclipse.

May 2024: Launch of *Chang'e 6*, China's second lunar sample return mission, this time to the Apollo Basin on the far side of the Moon. For more information, see https://en.wikipedia.org/wiki/Chang%27e_6

May 3, 2024: Peak of Eta Aquariid meteor shower.

May 9, 2024: Mercury is at greatest western elongation, 26.4° from the Sun (hence can be seen before sunrise).

May 13, 2024: Uranus is in conjunction with the Sun.

May 18, 2024: Jupiter is in conjunction with the Sun.

May 23 – 26, 2024: International Space Development Conference 2024 in Los Angeles, California.

June 4, 2024: Venus is in superior conjunction with the Sun.

June 14, 2024: Mercury is in superior conjunction with the Sun.

Summer 2024 (maybe): First operational flight of Boeing's Starliner 1 to the ISS.

July 22, 2024: Mercury is at greatest eastern elongation, 26.9 from the Sun (hence can be seen before sunset).

July 23, 2024: Pluto is at opposition.

July 27, 2024: Peak of Delta Aquariid meteor shower.

August 6 – 15, 2024: *ESCAPADE Blue* and *Gold Mars Orbiters* launch by New Glenn. For more information, see en.wikipedia.org/wiki/EscaPADE.

August 12, 2024: Peak of the Perseid meteor shower.

August 18, 2024: Mercury is at inferior conjunction with the Sun.

September 2024: 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)).

September 4, 2024: Mercury is at greatest western elongation, 18.1° from the Sun (hence can be seen before sunrise).

September 7, 2024: Saturn is at opposition.

September 20, 2024: Neptune is at opposition.

September 30, 2024: Mercury is in superior conjunction with the Sun.

Fourth quarter of 2024: China launches its *Xuntian* space telescope, which will orbit close to orbit close to *Tiangong* for easy servicing.

Fourth quarter of 2024: launch of *#DearMoon*, which will carry Japanese billionaire, Yusaku Maezawa, two crew members, and eight artists on a lunar free-return mission. For more information, visit https://en.wikipedia.org/wiki/DearMoon_project.

October 2024: 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.

October 2024: Launch of the *Hera* asteroid orbiter by the ESA, which contains the *Juventas* and *Milani* asteroid probes. Destination is the binary asteroid Didymos/Dimorphos to evaluate the results of the DART asteroid impact mission. For more information, visit [https://en.wikipedia.org/wiki/Hera_\(space_mission\)](https://en.wikipedia.org/wiki/Hera_(space_mission)).

October 2024: Launch of *Europa Clipper* orbiter to Jupiter's moon Europa. For more information, https://en.wikipedia.org/wiki/Europa_Clipper,

October 2, 2024: annular eclipse of the Sun. This one is almost entirely over the South Pacific Ocean, touching land in Easter Island and southern tips of mainland Chile and Argentina. It will be partial in Hawaii, southern South America, and a bunch of small South Pacific islands as well as Western Antarctica.

October 21, 2024: Peak of the Orionid meteor shower.

November 2024 (moved from May): *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.

November 2024: Launch of NASA's *VIPER* lunar rover, which will hunt for ice near the Nobile Crater at Moon's South Pole. *VIPER* is landing aboard Astrobotic's *Griffin* lunar lander. They leave Earth on a Falcon 9. For information, see [en.wikipedia.org/wiki/VIPER_\(rover\)](https://en.wikipedia.org/wiki/VIPER_(rover))

November 16, 2024: Uranus is at opposition.

November 16, 2024: Mercury is at greatest eastern elongation, 22.5° from the Sun (hence can be seen after sunset).

December 2024: Launch of India's *Shukrayaan-1* Venus orbiter. For more information, see <https://en.wikipedia.org/wiki/Shukrayaan-1>.

December 5, 2024: Mercury is at inferior conjunction with the Sun.

December 7, 2024: Jupiter is at opposition.

December 13, 2024: Peak of Geminid meteor shower.

December 22, 2024: Peak of Ursid meteor shower.

December 24, 2024: Mercury is at greatest western elongation, 22.0° from the Sun (hence can be seen before sunrise).

December 24, 2024: Parker Solar Probe (makes its first pass through the outer corona of the Sun. For more information, see <http://parkersolarprobe.jhuapl.edu>).

December 30, 2024: Launch of the Venus Life Finder Probe and Photon relay satellite to Venus by RocketLab.

Sometime in 2025: India launches its first crewed orbital flight *Gaganyaan-3*. For more information, en.wikipedia.org/wiki/Gaganyaan.

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

Sometime in 2025: Israel launches its *Beresheet 2* lander and orbiter to the Moon. For more information, see en.wikipedia.org/wiki/Beresheet_2.

Sometime in 2025: 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 2025: first crewed mission to Vast's *Haven-1* space station. For more information, <https://en.wikipedia.org/wiki/Haven-1>.

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: Launch and landing of Japan/India LUPEX (Lunar Polar Exploration) lander. For more information, see https://en.wikipedia.org/wiki/Lunar_Polar_Exploration_Mission.

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: OSAM-1 will rendezvous with Landsat 7 and refuel it. For more information, see <https://en.wikipedia.org/wiki/OSAM-1>

February 1, 2025: Launch of IMAP heliophysics probe and Solar Cruiser to the Earth-Sun Lagrangian point (the one between us and the Sun).

April 2025 [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.

May 2025: Launch of Tianwen-2 (formerly Zheng He), China's asteroid sample return mission and comet orbiter. For more information, see <https://en.wikipedia.org/wiki/Tianwen-2>.

Fourth quarter of 2025: Launch of the Space Entertainment Enterprise's SEE-1 inflatable space habitat docked to the Axiom segment of the ISS. If all else goes well, this will be launched on New Glenn.

November 2025: Launch of the first two modules of the Lunar Orbiter Platform- Gateway. These were originally going to be launched on separate spacecraft but are now bunked together.

December 2025: Launch of *Artemis 3*, which will be the first crewed lunar landing since 1972. For information, see en.wikipedia.org/wiki/Artemis_3. (This will likely be postponed to 2026.)

December 2025: *BepiColombo* arrives at Mercury orbit.

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

Mid 2026: Launch of Starship HLS Lunar lander and Astrolab's FLEX Lunar rover to the South Pole of the Moon.

July 2026: *Hayabusa 2* flies by asteroid 2001 CC₂₁.

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

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

Sometime in 2027: Launch of NEM-1, the core module of the Russian Orbital Service Station. 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.

June 2027: Launch of *Dragonfly*, the Titan helicopter mission. For information, see [en.wikipedia.org/wiki/Dragonfly_\(spacecraft\)](https://en.wikipedia.org/wiki/Dragonfly_(spacecraft)).

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.

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: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*. For more information, visit <https://en.wikipedia.org/wiki/ExoMars>. Note: this is the mission most affected by Russia's invasion of Ukraine, since they were supposed to supply the landing platform.

Sometime in 2028: Launch of *Chang'e 8*, which will include a lander, rover and a 3D printing experiment using lunar resources.

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.

First half of 2028 (postponed from 2026): 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.

March 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.]

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

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

November 2028: Launch of China's *Tianwen-3* Mars sample return mission.

Sometime in 2029: DESTINY+ flies by asteroid 3200 Phaethon, the parent body of the Geminid meteor shower.

Sometime in 2029: Launch of the *ARIEL Space Telescope* and the *ESA/JAXA Comet Interceptor* mission via Ariane 62.

Sometime in 2029 (moved from 2028): Launch of *VERITAS* orbiter and Venus Atmosphere Sample Return Mission to Venus.

Sometime in 2029: The *Psyche* asteroid probe arrives at asteroid 16 Psyche. [This is assuming a 2023 launch.] For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

April 21, 2029: *OSIRIS-APEX* rendezvous with the asteroid Apophis. Note: *OSIRIS-APEX* is the same spacecraft as *OSIRIS-REx*; it gets 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>

September 2029: Launch of Artemis 5 to the Moon.

October 2029: *Juice* achieves Jupiter orbit.

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

Sometime in 2030: Launch of *Tianwen-4*, which includes a Jupiter orbiter and a mission to Uranus.

For more information, see <https://en.wikipedia.org/wiki/Tianwen-4>.

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

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

Sometime in 2032 [tentative]: 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 *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.

December 2034: *Juice* achieves Ganymede orbit.

Sometime in 2035: Launch of India’s first space station.

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 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.

Write to any U. S. Senator or Representative at [name]/ Washington DC, 20510 (Senate) or 20515 [House]

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