

OKLAHOMA SPACE ALLIANCE

OUTREACH -May 2022

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the McMurray residence at 2:00 p.m. on May 14, details inside



Figure 1 New NSS LOGO



Figure 2 And the ISDC is back in person!

OKLAHOMA SPACE ALLIANCE OUTREACH May 2022

May Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, May 14, at the McMurray's house. Prospective members are welcome. Their house is at 2715 Aspen Circle in Norman. To get to the meeting either: (1) Take the Lindsey Street east exit from I-35, turn right at Berry, and proceed to Imhoff Road. Turn right at Imhoff, right at Poplar Lane, left at Aspen Lane, and right at Aspen Circle. or (2) Take the Highway 9 east off I-35, turn left at Imhoff Road, left at Poplar, left at Aspen Lane, and right at Aspen Circle.

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

Saturday May 14, 2022, 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. (The impact of the Russian invasion of Ukraine on space will undoubtedly be part of it.)
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of April meeting
 - c. Chapters Assembly (Syd)
5. Video (to be announced)
6. Chat

Minutes of April 2022 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met April 9, 2022, at the McMurray's house in Norman, Oklahoma. Attending in person were Clifford and Claire McMurray. Tom and Heidi Koszoru, John Northcutt, Tim Scott, Dave Sheely, Steve Swift and Syd Henderson. Robin Scott attended by Zoom. OSA President Clifford McMurray presided over the meeting. He did an Update discussing links to material covered in the meeting and this is online at <http://osa.nss.org/Update2204.pdf> so I'll cover the details that aren't covered there.

Pyotr Dubrov of the cosmonauts who came back with Mark Vande Hei, also went up with him, so he also spent 355 days on a single mission, [Vande Hei's is an American record, but the Russian record is held by Valeri Vladimirovich Polyakov who spent 437 days in space in one stay aboard *Mir*.]

Blue Origin's six-person flight didn't include *Saturday Night Live* comedian Pete Davidson because the flight was rescheduled, and Davidson had a conflict. We watched a video with the crew after the flight.

Poland's neighbors are interested in Poland's launch capability. [I'd think the countries down-range would be very interested, especially Russia. A good article on this is at <https://spacenews.com/poland-virgin-orbit-partner-on-eastern-europe-launch-initiative>]

Virgin Orbit has gone public. [Poland's working with them.]

We read an article on lunar mining. The Missouri School of Science and Technology at Rolla will process materials.

A Chinese company is going to start suborbital tourist flights in 2024. Their spacecraft looks a lot like Blue Origin's and SpaceX's.

This Week at NASA included the launch of the NOAA satellite, GOES-18 which is going to the GOES West position. [In case you are getting a feeling of déjà vu, I often hear the satellite itself called GOES west. GOES East is a position 75.2° West Longitude in geostationary orbit and GOES-West is 136° West Longitude.]

We watched a video on the Webb Space Telescope alignment.

NASA has extended *Ingenuity*'s mission.

We have now confirmed 5,000 exoplanets.

After the meeting we had a cookout with hamburgers and hot dogs. The plan was to also watch a movie, but people cleared out after feeding. We'll show the movie around the *Apollo 17* anniversary.

Minutes by OSA Secretary Syd Henderson

Minutes of March 2022 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met on March 12, 2022, at the McMurray's house in Norman, Oklahoma. Attending in person were Clifford and Claire McMurray. Adam Hemphill, Dave Sheely, and Syd Henderson. Russ Davoren attended by Zoom. OSA President Clifford McMurray presided over the meeting. He did an Update discussing links to material covered in the meeting and this is online at <http://osa.nss.org/Update2203.pdf> so I'll cover the details that aren't covered there.

This meeting occurred a few days after Russia invaded the Ukraine, so this was our special Ukraine War meeting.

Adam is involved in flying medical supplies by drone to clinics in remote regions of Honduras This means some negotiation with a small airport nearby, but they are not near the Honduran capital, Tegucigalpa, so air traffic isn't large. Adam showed us a video of a test flight.

Chang'e's upper stage would weigh 1000 lb. so should cause a substantial crater. [This was the stage that crashed into the far side of the Moon—we think.]

The European Space Agency Exosat Mission could find another launcher but there is no alternative for the Kazachok platform that would have been supplied by Russia.

Adam thinks China may go by itself (on its space program.)

Russia is now attacking Dnipro, which is the center of Ukraine's Space Industry. This complex has 50,000 employees--nearly as large as NASA.

SS navigation is within the Russian module.

The ESA's Euclid mission is one of the launches affected by the Soyuz shutdown.

Since Dragon does not have an airlock, all four astronauts on *Polaris Dawn* will have to wear space-suits during the first *Polaris Dawn* spacewalk.

We read the bios and saw the pictures of the first four *Polaris Dawn* astronauts. Syd asked if Jared Isaacman will be on all *Polaris* flights. We don't know yet, but Kip thinks Isaacson will be on at least the first and third flights.

Elon Musk thinks Starship could launch quickly after FAA Approval.

Mars helicopter *Ingenuity* has now flown 4.5 kilometers.

We watched spectacular videos of Juno's flybys of Ganymede and Jupiter.

We watched several episodes of *This Week at NASA*, which included approval of the first *Axiom* crew.

The *Parker Space Probe* captured the first visual image of the surface of Venus.

We watched a video of the *Antares* spacecraft being transported.

We saw the first images for IXPE the Imaging X-ray Polarimetry Explorer.

Syd asked if we are doing anything for Yuri's night. Kip proposed a cookout at the McMurray's.

Minutes by OSA Secretary Syd Henderson

Space News

The Russian invasion of Ukraine and the world's reaction to it are forcing some major changes for missions in which Russia collaborated or used Western launch sites such as Kourou, French Guiana. For example, the *Euclid Space Telescope* was supposed to launch on a Russian rocket, but that's clearly out, so it's now going to be launched on an Ariane 62. I haven't a more precise date than "sometime in 2023."

Most drastically affected is the ESA's *ExoMars* mission. The mission depended on a Russian launch platform, and since that is no longer available, a new platform has to be developed and the projected launch date for the mission has moved six years until 2028. This will be the launch that carries the *Rosalind Franklin* Mars rover.

Note that the *ExoMars* mission involves several different spacecraft, one of which, the *ExoMars Trace Gas Orbiter* launched in 2016 and has been in Mars orbit since October 2016. The lander part of the mission has been delayed several times, first due to parachute problems which forced the lander to be postponed until 2022, and now the Russo-Ukrainian War. There was a lander associated with the TGO, the Schiaparelli demo lander, but it apparently failed and crashed into the Martian surface.

The European Space Agency announced April 13 that they would halt cooperation with Russia on upcoming missions, namely a camera on this year's Lunar 25 Moon lander. Also affected are the Lunar 26 Moon lander and Lunar 26 Moon rover. The navigation equipment and the drill for the last were to be supplied by the ESA.

Last issue I mentioned the confirmation of a second trojan asteroid with respect to the Earth, and both trojans will be gone in a few thousand years. Given the difficulty of finding such asteroids, there are at most a hundred of them. Why so few? A new hypothesis (see arxiv.org/pdf/2204.10316.pdf) is that with all the large objects impacting the inner planets 4 – 45 billion years ago, including Theia, the planet which collided with Earth to form the Moon, any Earth Trojans would have been expelled from around L4 and L5. Changes to the Earth's orbit would have destabilized the orbits of the Trojans. With the inner solar system getting cleaned up, there were not enough asteroids left to replenish the L4 and L5 points, so mostly we get transitory visitors. [Trojans very close to L4 and L5 might well stay much longer, but they have to get there first.]

I suspect this is too neat and the same perturbations that affect the planets' orbits also destabilize the orbits of asteroids L4 and L5. Mars, which is much closer to the asteroid belt, still doesn't have many Trojans (14 known so far). Jupiter, of course, is both enormous and near the asteroid belt, so it collects thousands of Trojans. Saturn apparently has none, but I bet it also has transitory ones. Uranus has two transitory ones.

The decadal survey (which is led by the National Academy of Sciences) recommends a new mission to Uranus, this time with an orbiter and atmospheric probe. The mission would cost an estimated \$4.2 billion (in 2022 dollars). Uranus has strange seasons since its poles are tilted almost in the plane of its orbit (actually farther than the ecliptic, so it technically rotates retrograde compared with all the other planets—except Venus, which is upside down compared to the other planets). Seasons on Uranus last 21 years, and Voyager 2 went by in southern summer (when the south pole points toward the Sun), so the hope is to arrive before southern spring. I would think the spring equinox would be the best time so we could image pretty much the entire planet. (We didn't see much of the northern hemisphere the first time.)

Of course, we would also be looking at Uranus's moons, of which there are 27 known, five of which were known before Voyager. Compared with Jupiter's Galilean satellites, Saturn's Titan, Neptune's Triton, and our Moon, Uranus's satellites are small although the four largest are about the size of Saturn's second through fifth largest, and the two largest, Titania and Oberon, are more than 25% larger in diameter than Charon. The fifth largest, Miranda, is the one that looks like it was broken apart and put back together. Uranus also has a set of thirteen (and counting) rings, two of which are substantial and very dark compared to Saturn's rings. So, there is a lot to study.

If this mission is approved, it won't reach Uranus before the 2040s. They absolutely want to get it there before 2045, which is the equinox. Possible names are Caelus (the Roman god corresponding to Uranus), Shakespeare and probe Pope (the sources of the major satellite names). My opinion is that we should continue the naming tradition of *Galileo* and *Cassini* and name it after William Herschel, the discoverer of Uranus, Titania and Oberon, and the probe after William Lassell, the discoverer of Ariel and Umbriel.

I was curious why Uranus was chosen before Neptune, which has its giant moon Triton (in a retrograde orbit, no less), its own set of rings, very strange heat signature and the periodic Great Blue Spot. It all comes down to planetary mechanics: if the mission is launched in 2031, it can use a Jupiter assist to get to Uranus around 2044 or 2045—and get into orbit, which is a real trick. Conditions aren't as favorable for a Neptune flyby.

Sky Viewing

There will be a **Total Eclipse of the Moon** on the evening of May 15, and nearly all of it is visible from Oklahoma. The Moon will be entering the partial phase of the eclipse at 9:28 p.m. CDT, just after it rises, and grow progressively redder as it ascends and slowly disappears. Totality begins at 10:29 p.m. and lasts until 12:54 a.m. The partial phase ends at 12:56 p.m.

We are about to have an unusual situation in the night sky. **Mercury** is in inferior conjunction with the Sun on May 21, after which it becomes a morning star until July 16. (It's only visible in the middle of that period). During that time, there will be no planets in the evening sky at all. In fact, even **Pluto** is currently rising just after midnight. In late June, the planets and the Moon will be strung in a long line in the morning sky, in the order Mercury, Venus, Uranus, Moon, Mars, Jupiter, Neptune and Saturn (and Pluto, too), and all but Uranus, Neptune and Pluto will be at least magnitude 0.5. It might be rewarding to check the sky for the next couple of months and watch this develop.

We had an alignment similar to this in 1982, at which time we were supposed to get major earthquakes according to John Gribbin's *The Jupiter Effect*. They didn't happen. Gravitational effects from other planets are too small to do that, although they do change orbits over millions of years.

In the meantime, **Mercury** is currently lost in twilight at sunset, and will be lost in twilight before sunrise after conjunction until the second week in June, when it becomes visible at magnitude 0.8 due south of the Pleiades and eleven degrees east of Venus. Mercury is at greatest elongation on June 15 but will actually get brighter for a week or so afterward, reaching magnitude 0.1. On June 22, Mercury will be three degrees northwest of Aldebaran, the brightest star in Taurus.

Venus and **Jupiter** are the two brightest planets in the morning sky. Venus is the brighter at magnitude -4.0, while Jupiter is magnitude -2.1 and higher in the sky. They'll be separated by thirteen degrees on May 14, but it will widen quite a bit through the rest of the month and through June. **Mars** is about ten degrees west of Jupiter and is magnitude 0.8. Jupiter is closing in each day, and on May 29, it will catch it, with a separation of 35 arc-minutes, a little more than the width of the Moon. From then on, Mars will be between Venus and Jupiter, but much closer to Jupiter. It will also brighten slightly, to magnitude 0.5. Jupiter also will brighten a bit to magnitude -2.4.

Saturn is much higher in the sky than the other planets, about 25 degrees west of Mars and thirty-five degrees west of Jupiter. It's also getting brighter. It's magnitude 0.8 now and will be 0.5 by the end of June. In other words, Saturn and Mars are the same brightness right now and brightening in tandem. Saturn is currently rising about 2:00 a.m., will rise around 1:00 a.m. at the beginning of June and around midnight at the end. Jupiter and Mars are rising about 90 minutes after Saturn and Venus about 45 minutes after them.

For the record **Neptune** is about a third the angular distance from Jupiter to Saturn, and **Uranus** is lost in the sunrise. However, Venus is well past greatest elongation (the point where it looks farthest from the Sun), and Uranus is rising earlier each night. They will pass each other on June 11, at which point

Uranus will be 1.6° north of Venus. However, Uranus is just visible to the naked eye for people with excellent vision and very dark skies, so you need binoculars and Venus to locate it.

The most notable meteor shower from now to July is the **Arietid meteor shower** that peaks on June 7, but it also peaks too close to sunrise to be easily visible. The next readily visible meteor shower is the Southern Delta Aquariids, which peak at the end of July, followed by the famous Perseids in mid-August.

Viewing Opportunities for Satellites (May 14 – June 14, 2022)

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 0.9 (as on March 27) but will get brighter as more modules are added. 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. The Boeing Orbital Test Flight 2 will be launched on the evening of May 19. An unmanned Progress cargo flight is on the morning of June 3. SpaceX launches a resupply flight on June 7

The Tiangong Space Station’s third crew flight is on June 5.

The information below is from Heavens Above.

ISS 5/13/22 mag. -3.9			
Time	Position	Elevation	
5:46 a.m.	310°	10°	
5:49	224	79	
5:52	237	10	

ISS 5/13/22 mag. -2.4			
Time	Position	Elevation	
10:26 p.m.	250°	10° *	
10:30	322	40	
10:33	34	10	

*Passes just east of Procyon, Castor and Pollux

ISS 5/14/22 mag. -3.7			
Time	Position	Elevation	
9:38 p.m.	231°	10°	
9:41	318	77	
9:44	45	10	

Tiangong 5/14/22 mag. -1.8			
Time	Position	Elevation	
9:44 p.m.	302°	10° *	
9:47:19	18	48	
9:48:43	79	27	

*Passes very close to Capella

ISS 5/16/22 mag. -3.5			
Time	Position	Elevation	
Appears from Earth’s shadow			
4:59:24 a.m.	278°	28°	
5:00:40	227	42	
5:04	154	10	

Tiangong 5/16/22 mag. 1.1			
Time	Position	Elevation	
9:22 p.m.	216°	10°	
9:24:41	25	80	
9:26:02	110	18*	

Vanishes into Earth’s Shadow
*Passes just below Arcturus

Tiangong 5/18/22 mag. 1.5			
Time	Position	Elevation	
8:59 p.m.	287°	10°	
9:02	209	54	
9:05	131	10	

ISS 6/1/22 mag. -3.6		
Time	Position	Elevation
9:40 p.m.	314°	10°*
9:42:43	40	62
9:44:57	118	20

Vanishes into Earth's shadow
*Passes very close to Capella

5:27	183	31
5:31	120	21

HST 6/8/22 mag. 1.7		
Time	Position	Elevation
5:36 a.m.	244°	10°
5:39	180	32
5:43	117	10

HST 6/10/22 mag. 1.0		
Time	Position	Elevation
5:13 a.m.	237°	17°
5:15	185	30
5:19	123	10

Tiangong 6/9/22 mag. 1.0		
Time	Position	Elevation
5:20 a.m.	239°	16°
5:22	155	77
5:25	68	10

Tiangong 6/11/22 mag. 1.4		
Time	Position	Elevation
Appears from Earth's shadow		
4:56:29 a.m.	264°	24°
4:58:12	338	62
5:01	61	10

HST 6/9/22 mag. 1.4		
Time	Position	Elevation
5:24 a.m.	242°	13°

HST 6/10/22 mag. 1.0		
Time	Position	Elevation
5:13 a.m.	237°	17°
5:15	185	30
5:19	123	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 is about ten degrees wide. "Elevation" is elevation above the horizon in degrees. Thus, to find the Hubble Space Telescope at 5:15 a.m. on June 10, measure half a fist-width west of due south then three 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>.

May 15, 10:00 p.m.: Live coverage of the total lunar eclipse

NASA's schedule only goes up to May 18, but I'm sure there will be something about the Boeing flight on May 19.

Calendar of Events

May: Third crew to the Chinese Space Station. Also launch of Wentian, the first lab module to the station.

May 13: 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.

May 14: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

May 15: Total lunar eclipse, visible from all of South America and Antarctica and the eastern half of North America. Oklahoma gets all the partial and total phases but misses most of the penumbral phase (which doesn't look like much anyway).

May 19, 5:54 p.m.: (Unmanned) Orbital test launch 2 of Boeing Starliner.

May 21: Mercury is at inferior conjunction with the Sun.

May 25: SpaceX launches a slew of microsats and cubesats including a couple of Sherpas.

May 26: Venus is 0.2° north of the Moon as seen from Oklahoma. This is an occultation from some parts of the Earth.

May 27: Launch of CAPSTONE, a lunar orbiter that will test the stability of the proposed orbit for Lunar Gateway.

May 27- 29: International Space Development Conference, Hyatt Regency Crystal City, Arlington, Virginia. For more information or to register, visit <https://isdc2022.nss.org>.

May 29: Mars is 0.6° south of Jupiter.

June: Launch of *Firefly Alpha* carrying the Elana 43 mission.

June: Launch of Virgin Orbit's *LauncherOne* from Spaceport Cornwall in England.

June 5: Third crew launched to the Chinese Space Station.

June 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.

June 11 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

June 15 [Postponed from May/]: Second flight of South Korea's *Nuri*, and the first with a commercial payload.

June 16: Mercury is 23.2° west of the sun so can be seen before sunrise.

June 24 – 26: Soonercon 30, Embassy Suites Norman Hotel and Conference Drive, Norman OK 73069. For more information or to preregister, visit <https://soonercon.com>.

Second half of 2022: Launch of SLIM, the Smart Lander for Investigating Moon, a Japanese lunar lander. Another JAXA spacecraft, *XRISM*, the X-Ray Imaging Spectroscopy Mission (pronounced “krism”) launches on the same flight. For more information, see https://en.wikipedia.org/wiki/Smart_Lander_for_Investigating_Moon and https://en.wikipedia.org/wiki/X-Ray_Imaging_and_Spectroscopy_Mission.

Second half of: Launch of *Eris*, the first Australian rocket to launch an Australian payload. *Eris* is the launch vehicle for Gilmour Space.

Third quarter of 2022: Maiden flight of Ariane 6.

Third quarter of 2022: Maiden flight of Taiwan's Hapith V.

Third quarter of 2022: First commercial smallsat mission to Mars, launched by Virgin Orbit from Mojave

July 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.

July 9 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

July 16: Mercury is in superior conjunction with the Sun.

July 24: Launch of Wentian, the first laboratory module of the *Tiangong* space station.

July 28: Peak of the Delta Aquariid meteor shower.

August: Earliest launch date for *Artemis 1* the first launch of the Space Launch System. On this uncrewed launch NASA launches the Lunar IceCube, Lunar Polar Hydrogen Mapper, and Lunar Flashlight lunar orbiters, in addition to Japan's OMOTENASHI cubesat lunar lander. For more information, see https://en.wikipedia.org/wiki/Lunar_IceCube, the Near-earth Asteroid Scout cubesat (https://en.wikipedia.org/wiki/Near-Earth_Asteroid_Scout) and a bunch of other satellites.

August 2022: India launches Chandrayaan-3, which will include a lander and a long-lived rover which will explore craters around the Moon's South Pole in search of ice. See <https://en.wikipedia.org/wiki/Chandrayaan-3>

August 1: Launch of *Psyche*, which will orbit a large metallic asteroid also named Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)). On this same launch are the twin Janus Asteroid probes each of which will visit a binary asteroid pair. Janus A visits 1991 VH and Janus-B 1996 FG3.

August 1: Launch of the *Korea Pathfinder Lunar Orbiter* (KPLO) and lunar impactor from Naro Space Center in South Korea. For more information, see https://en.wikipedia.org/wiki/Korea_Pathfinder_Lunar_Orbiter.

August 12: Peak of the Perseid meteor shower.

August 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

August 14: Saturn is at opposition.

August 22: Launch of the Luna 25 lunar lander, the first mission of Russia's Luna-Glob lunar exploration mission. This will land near Boguslawsky Crater about 77 degrees South on the Moon. For more information, visit en.wikipedia.org/wiki/Luna_25 and en.wikipedia.org/wiki/Luna-Glob.

August 27: Mercury is at greatest eastern elongation, 27.3° from the sun (so it can be seen before sunset.)

September: First *UK Pathfinder* launch from SaxaVord Spaceport in the Shetland Islands (probably). Amazingly, this appears to be the first orbital launch from the United Kingdom. (**CORRECTION:** Virgin Orbit will be if it launches in June—and it actually launches from Cornwall.)

September [moved from January]: India launches Aditya-L1 to the Earth-Sun L1 point, on a mission to study the Sun's corona. For more information, visit <https://en.wikipedia.org/wiki/Aditya-L1>.

September 1: Fifth Crew Dragon mission to the ISS.

September 10: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

September 23: Mercury is in inferior conjunction with the Sun.

September 26: Jupiter is at opposition.

Fourth quarter of 2022: Launch of the *Einstein* X-ray astronomy probe by China.

October: Launch of *Hakuto-R* mission 1, Japan's lunar lander. (Hakuto is Japan's Moon rabbit, so is equivalent to China's Jade Rabbit). For more information, see <https://en.wikipedia.org/wiki/Hakuto>. The same Falcon rocket will launch the *Rashid* lunar rover for the United Arab Emirates.

October: [Moved from August]: Launch of *Mengtian*, the second laboratory module to the *Tiangong* space station.

October 8: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

October 8: Mercury is at greatest western elongation, 18.0° from the Sun (so can be seen before sunrise).

October 21: Peak of the Orionid meteor shower.

October 22: Venus is at superior conjunction with the Sun.

October 25: Partial eclipse of the Sun visible from Europe, western Asia (including India) and northeastern Africa.

November: Launch of *Polaris Dawn* flight carrying four civilians into space, led by Jared Isaacman.

November 5: Peak of the South Taurid meteor shower.

November 8: Total lunar eclipse over all of the Pacific Ocean. Oklahoma will get most of this eclipse.

November 8: Mercury is in superior conjunction with the Sun.

November 9: Uranus is at opposition.

November 12: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

November 17: Peak of Leonid meteor shower.

December: Launch via Falcon 9 of the *Nova-C* lander and other cargos to the Lunar South Pole.

December: Launch of fourth crew to the *Tiangong* space station.

December 7: Mars is at opposition.

December 7 – 19: 50th anniversary of Apollo 17. This, to date, is the last manned mission to the Moon.

December 14: Peak of Geminid meteor shower.

December 21: Mercury is at greatest eastern elongation, 20.1° from the sun (hence can be seen after sunset.)

December 22: Peak of Ursid meteor shower.

Sometime in 2023: launch of *#dearMoon*, which will carry six to eight artists on a lunar free-return mission.

Sometime in 2023: Rocket Lab launches an atmospheric probe and flyby to Venus.

Sometime in 2023: Launch of the European Space Agency's *Euclid* space telescope. This will map the distribution of dark matter and search for evidence of dark energy. The Euclid website is <https://sci.esa.int/web/euclid>. This is one of the missions that had to find a new ride after the Russian invasion of Ukraine.

Sometime in 2023: First flight of Blue Origin's *New Glenn* orbital rocket. For more information, see https://en.wikipedia.org/wiki/New_Glenn.

First quarter of 2023: First Dream Chaser cargo mission.

First quarter of 2023: Launch of *Axiom-2* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts.

March 2023: First crewed launch of *Boeing Starliner-1* to the ISS. Note: I had this down for April 2022, but due to recurring valve problems with the Starliner test vehicle, it keeps getting pushed.

March 2023: SpaceX's Sixth Crew Dragon mission to ISS

April 5, 2023: Launch of *JUICE*, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <https://sci.esa.int/web/juice>.

May 2023: Launch of Venus Life Finder probe as well as the *Photon* relay satellite.

September 24, 2023: *OSIRIS-REx* returns samples from Asteroid Bennu.

Fourth quarter of 2023: Launch of *Hakuto-R* mission 2, Japan's lunar lander and rover. For more information, see <https://en.wikipedia.org/wiki/Hakuto>.

October 14, 2023: Annular eclipse of the Sun. The path where it is annular extends from the coast of Oregon, northern Nevada, Utah, central New Mexico, and southwestern Texas (including Austin and San Antonio), thence lengthwise through Yucatan and Central America, then Colombia and northern Brazil. This will be partial from Oklahoma with 80% of the Sun covered. This makes a good prelude to the total eclipse the following April.

November 2023: Launch of NASA's *VIPER* lunar rover, which will hunt for ice near the at Nobile Crater at Moon's South Pole. VIPER is landing aboard Astrobotic's *Griffin* lunar lander. They leave Earth aboard a Falcon 9.

November 2023: Launch of *Masten Mission One* lander and MoonRanger rover on the Moon via Falcon 9.

December 15, 2023: uncrewed test launch of *Orel*, Russia's new crewed spacecraft. For information, [https://en.wikipedia.org/wiki/Orel_\(spacecraft\)](https://en.wikipedia.org/wiki/Orel_(spacecraft)).

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

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

Sometime in 2024: Launch of the ispace Lunar Lander (Japanese company)

Sometime in 2024: India launches its first crewed orbital flight *Gaganyaan-3*

Sometime in 2024: India launches Mars Orbiter Mission 2.

First half of 2024: Israel launches its *Beresheet 2* lander and orbiter on the Moon.

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.

May 2024: [Moved from September 2023] 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.

May 2024: Commercial Lunar Payload Services mission delivers a lunar lander in Schrödinger Basin,

September 2024: Launch of Japan's *Martian Moons Exploration* (MMX) which includes a Phobos lander and sample return. For more information, see [https://en.wikipedia.org/wiki/Martian_Moons_exploration_\(MMX\)](https://en.wikipedia.org/wiki/Martian_Moons_exploration_(MMX)).

September 2024: Launch of the first Axiom Hub Module.

October 2024: Planned date of *Artemis 3*, which will land astronauts on the Moon for the first time since 1972.

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

November 2024: 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 2024: Launch of the Space Entertainment Enterprise's SEE-1 inflatable space habitat docked to the Axiom segment of the ISS.

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

Sometime in 2025: Launch of *Artemis 3*, which will be the first crewed lunar landing since 1972.

Sometime in 2025 [moved from 2024]: India launches its *Mangalayaan-2* Mars mission, which includes an orbiter, lander, and rover.

Sometime in 2025: 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.

September 2025: First crewed flight of Russia's Orel (formerly called Federatsiya).

December 2025: *BepiColombo* arrives at Mercury orbit.

January 31, 2026: The *Psyche* asteroid probe arrives at the asteroid 16 Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

July 2026: Launch of the *Sample Retrieval Lander* to Mars. This is the lander which will bring take the samples taken by *Perseverance* to orbit.

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

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

May 2027 [Moved from December 2025]: 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.

June 2027: Launch of *Dragonfly*, the Titan helicopter mission.

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: [postponed from 2022]: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*, and the Russian Kazachok surface platform. 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 *VERITAS* to Venus.

First quarter of 2028: Launch of the *Emirates Asteroid Mission*.

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

Fourth quarter of 2029: Launch of *DAVINCI+* to Venus.

October 2029: *JUICE* achieves Jupiter orbit. [See 2022.]

Sometime in 2033: *JUICE* achieves Ganymede orbit. [See 2022.]

December 2034: *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 Mars Society, Box 273, Indian Hills CO 80454. 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, PO Box 98106, Washington DC 20090-1600 Web page is space.nss.org.

The Planetary Society phone 626-793-5100. The address is 65 North Catalina, Avenue, Pasadena, California, 91106-2301 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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