OKLAHOMA SPACE ALLIANCE

OUTREACH -January 2022

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
McMurray residence at 2:00 p.m.
on January 8, details inside

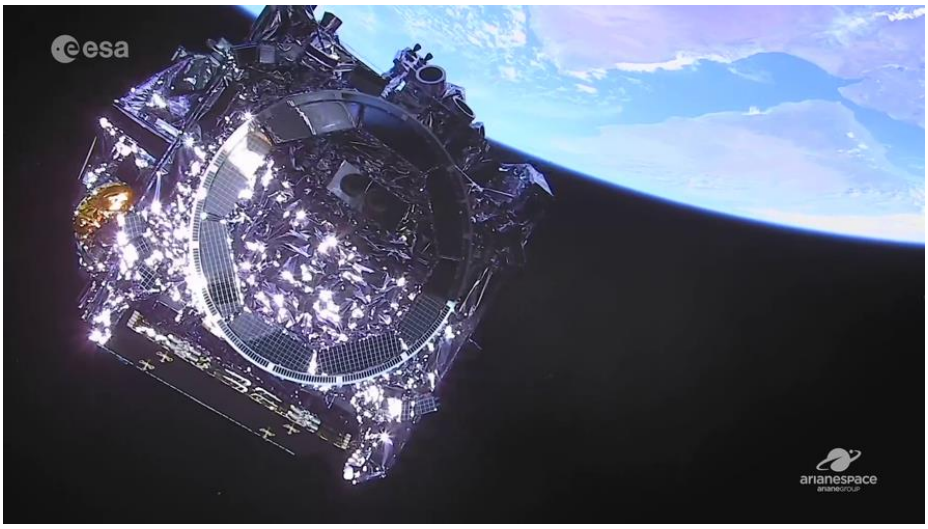

Figure 1 James Webb Space Telescope with Solar Panels extended after separation from Ariane 5

OKLAHOMA SPACE ALLIANCE OUTREACH
January 2022

January Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, January 8, 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/y2qtab28If for some reason the link doesn't work, call Clifford McMurray, Vice- President 405-329-4326 (H) 405-863-6173 (C) (e-mail cliffmcmurray at hotmail.com) , or Syd Henderson at 365-8983 (e-mail sydh at ou.edu) and we will send you updated information.

Saturday January 8, 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/Update2111.pdf for items to be discussed
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
   a. Review OSA treasurer's report
   b. Minutes of November meeting
   c. Chapters Assembly (Syd)
5. Video (to be announced)
6. Chat

Report on December 2021 Christmas Party and Meeting

Oklahoma Space Alliance had its annual Christmas Party on December 11 at the Koszorus. In attendance were Tom and Heidi Koszoru and their daughter Jenny (sorry Jenny, forgot your married name), an unidentified family friend of theirs, Adam Hemphill. Kip and Claire McMurray, Tim Scott, Dave Sheely and Syd Henderson. Kip and Claire, Syd and Dave renewed their membership while Russ Davoren renewed by mail. [Donald Whitney and family also renewed but I got their envelope late.] We held elections, with Clifford McMurray being elected President and Dave Sheely Vice-President, reversing their previous titles. Syd Henderson was re-elected Secretary and Tim Scott Treasurer. We also filled out nominating petitions for NSS Board elections.

After eating and discussion, we watched a tape of "Top 10 Reasons Not to Go to Space," posted online from the 2004 ISDC (the one we hosted in Oklahoma City.

Notes by OSA Secretary Syd Henderson

Minutes of November 2021 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met November 13 at the McMurray's house. Attending in person were Adam Hemphill, Tom and Heidi Koszoru, Claire McMurray. John Northcutt, Tim Scott, Dave Sheely, and Syd Henderson. We had no Zoom attendees and Clifford McMurray was unable to attend. OSA President Dave Sheely 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/Update2111.pdf so I'll cover the details that aren't covered there.

We watched a video on a Blue Origin/Sierra Space plan to build a space station that will be used for commercial marketing. We also watched a video on Starlab, a joint venture by Nanoracks and Lockheed Martin to build their own commercial space station. There are a number of such ventures being prepared for after the International Space Station is decommissioned.

We watched a video on a next-generation spacesuit being prepared by Collins Aerospace. NASA is turning to the private sector to produce new spacesuits for Gateway and the Artemis program. We watched a NASA video on the development of new Space Station space suits to be used on the ISS, Gateway and Artemis moon base. [It's not clear to me whether Collins has actually been commissioned by NASA or whether they are developing spacesuits for other projects. Clearly the astronauts on the new commercial space stations will need suppliers.]

We watched a video on Russia's Soyuz return capsule rocket firing prematurely and changing the orientation of the ISS by 57 degrees. The correct orientation was restored within 30 minutes. This is not to be confused with an earlier module firing that turned the ISS earlier this year. This Soyuz was returning the film crew from the ISS and another astronaut.

We watched a video of the launch of Shenzhou-13 carrying three astronauts to the Chinese Space Station *Tiangong*.

We watched a video of Poland signing onto the Artemis accords.

We watched a video on Russian concerns that the Starlink network may be used to hijack cruise missiles used to carry nukes. Along those lines, we watched a video by George Friedman on space warfare. He notes that massing of troops for an invasion will not last very long if observed from space, and all ships can be seen. He thinks the computer age is creating opportunities for smaller nations and is for some reason obsessed with Poland becoming a future space power.

This was the meeting at which we nominated 2022 officers. Clifford McMurray is running for President, Dave Sheely for Vice-President (so they're switching again), Syd Henderson for Secretary, and Tim Scott for Treasurer.

Syd is to place Heinlein Award nominations in January *Outreach*. [Turns out the deadline has passed.]

We have $855.47 in checking account and $267 in cash for a total of $1122.47.

Minutes by OSA Secretary Syd Henderson

Space News

The James Webb Space Telescope was finally launched Christmas morning at 6:20 a.m. CST (9:20 a.m. local time, 12:20 a.m. GMT) by an ESA Ariane 5 from Kourou, French Guiana. Although there were a few postponements over the last couple of weeks (the last due to weather), the launch itself went off on time with no hitches and a few hours later the telescope was on its way to the Earth-Sun L2 point with some extra fuel since things went even more smoothly than expected. The solar panels were unfolded immediately after separation from the upper stage and the sunshield was unfolded on New Year's Eve. This sunshield had five layers, each as thin as a human hair, so this operation was extremely delicate. It is 46.5 by 69.5 feet and had to be folded twelve-fold in storage.

The next crucial stage is unfolding the telescope mirror itself, which is a grid of hexagons folded origami style. The mirror consists of eighteen hexagonal mirrors in rings of twelve and six, around an empty central hexagon which is where I assume are the instruments that will receive the data from the secondary (and tertiary!) mirrors. The telescope has 169 small motors to perform minute adjustments on the mirror. This is similar to the adaptive optics used by huge telescopes like the Keck but won't have to be done so often since there isn't wind or atmosphere to worry about. Although Webb doesn't have a tube like most earthly telescope, the sunshield does block about 40 of the sky from its view at any time. It's essential, though, because Webb is an infrared telescope, designed to detect low-temperature radiation from intergalactic sources and we don't have the sources drowned out by thermal radiation from the telescope itself.

On the other hand, unlike Hubble, the Earth will not block its view of its target for half of every ninety minutes. The scientists are really, really hoping the origami unfolds without problems.

The James Webb Space Telescope began development in 1996 with a planned launch in 2007 at a cost of $500 million. Due to many delays and cost overruns, the spacecraft wound up costing $8.8 billion (with another billion to support upcoming operations) I don't think this counts contributions by the ESA or Canadian Space Agency. (In comparison, the Hubble Space Telescope was supposed to cost $300 million, cost four times this much by launch. However, operational costs for the HST have been $9 billion or so once you include all the servicing missions and new equipment. Webb is famously designed not to be serviced so its instruments will have to last its lifetime, which is at least five years, probably ten, and perhaps more due to saving fuel during the launch.

Webb is not actually at L2 but in a halo orbit around it. This is a three-dimensional orbit allowed by the gravitational forces of the Earth-Moon and Sun, Coriolis forces and centripetal force. The particular halo orbit Webb will be in has a period of six months around L2. The orbital period of Webb around the Earth (and around the Sun), is, by the definition of L2, precisely one year.

Astronomy magazine has its top 10 space stories of 2022 in its February issue, and once again the Mars probes top the story. But next year, it may be the Moon that tops the list, with the arrival of the SLIM lander and maybe Hakuto R (Japanese), Luna 25 (Russia), Emirates Lunar Mission (United Arab Emirates), UNAM Lander (Mexico), Korea Pathfinder lunar orbiter (South Korea), Chandrayaan 3 (India), IM-1, PRIME-1, Peregrine 1, and the XL-1 lander (USA-NASA and commercial). We may still get *Artemis 1*, which will carry Lunar IceCube, Lunar Polar Hydrogen Mapper, and Lunar Flashlight lunar orbiters Lunar IceCube, Lunar Polar Hydrogen Mapper, and Lunar Flashlight lunar orbiter. (Also, USA, some by NASA, some not.) ALINA (PTScientists in Germany) is also expected to land near the Apollo 11 site. The number of actual flights will be smaller because many will be carrying multiple missions. Some of these may fall by the wayside, but even so, the Moon is going to be a busy and much more international place in 2022.

Conspicuously absent from the countries launching Moon missions in 2022 are China, which doesn't launch Chang'e 6 and 7 until 2024 (I think they're concentrating on building their space station), and Israel, which may launch *Beresheet 2* in 2024. Turkey and the Netherlands will beat them in 2023.

Sky Viewing

We've been lucky enough to have Venus, Jupiter and Saturn in the evening sky for the last few months (and Mercury for the early part of January), but, alas, they are all about to fade into the sunset by early March.

Venus is already gone, being in inferior conjunction with the Sun on January 8. However, since this is an inferior conjunction, Venus will move rapidly into the morning sky and be easily visible late in the month for early risers. It will also brighten rapidly from magnitude -4.2 on January 10, when it will still be a challenge to observe, to magnitude -4.8 on January 29, when it will be impossible to miss. Venus is at greatest brightness of February 7, when it is magnitude -4.9. This is about .2 magnitudes than Venus normally gets, due to Venus being 40 million miles away at closest approach, when a typical approach brings it within 41 to 44 million miles. Note that the Earth is helping here: it was at perihelion on January 4. Venus is near perihelion itself, but its orbit is more circular than the Earth's, so it makes less difference. It's interesting to note that Venus does on rare occasions get a million or so miles closer and reach magnitude -5.0.

Mercury was at greatest eastern elongation on January 7 and reached magnitude -0.7. It should be visible about ten degrees above the horizon 45 minutes after sunset. Mercury will fade rapidly, reaching magnitude 0.0 by January 12 as it approaches inferior conjunction on January 23, after which it joins Venus and Mars in the increasingly crowded morning sky. By February 1, Mercury will be visible in the east about an hour before sunrise, but, at magnitude 1.1, will be a challenge, On February 15, Mercury will be at greatest elongation, 26° from the Sun, and magnitude 0.0. Unlike Venus, Mercury is brightest when it

is farther away from the Sun, but in this case only to magnitude -0.1 or so, since it is also at aphelion on February 28, so it is not only on the far side of the orbit (so we see most of the disk), it is farther away than usual, which makes it look less bright, and the two effects cancel out. The next evening apparition of Mercury is in April and it's the best of the year from the Northern Hemisphere.

Mars moved into the morning sky on October 8 and will be there for a while yet since it takes two years to complete an orbit as seen from the Earth. Since it is on the far side of its orbit, it is still dim, being magnitude 1.5. It is in Ophiuchus near the star Antares in Scorpius, but Antares is slightly brighter than Mars at magnitude 1.1. Both are conspicuously red (Antares means "rival of Mars.) However, both are low in the sky at dawn so may be hard to see. On January 20, Mars joins Venus in Sagittarius, but they won't be particularly close. Mercury is also in Sagittarius in the first half of February, and Pluto is there for decades, but they are well apart from each other. Even by the end of February, Mars will only be magnitude 1.4. It won't brighten much for a while: next opposition is December 7.

Jupiter is still conspicuous at magnitude -2.1 in the southwest for a several hours after sunset. (It's in Aquarius, by the by.) However, it's setting earlier each night now while the Sun is starting to set later, and by February 1, it will be only visible for an hour or so. In late February, Jupiter will be lost in twilight as it approaches conjunction with the Sun on March 5.

Saturn (magnitude 0.7) is about twenty degrees to the lower right of Jupiter, and sets about two hours after the Sun. On January 12-13 it will be 3.5° above and to the left of Mercury, which tells you that it will be getting hard to see. Saturn is lost completely at the end of the month as it nears its February 4 conjunction with the Sun. It will become visible in the morning sky at the end of February, when Mercury joins it in Capricornus.

Uranus is high in the south by southwest at sunset, and, at magnitude 5.7, is barely visible to the naked eye under very dark sky. It's located in Aries just north of the head of Cetus. To find it, see the star chart
https://skyandtelescope.org/astronomy-blogs/explore-night-bob-king/uranus-queues-up-for-opposition/.

Neptune is magnitude 7.9 in an inconspicuous region of Aquarius and requires a telescope. It's twenty degrees higher that Jupiter and sets an hour later. Sorry, don't have a map.

Pluto is in conjunction with the Sun on January 16, so is invisible even with telescopes.

Viewing Opportunities for Satellites (January 8 – February 9, 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 1.0 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 can change its orbit. The next mission from America is that of Axiom 1 on February 28. There is also an unmanned Progress cargo launch from Baikonur om February 15, and an unmanned Antares Cygnus launch on February 19.

The Tiangong pace station's second crew was launched on October 15 and will return in April. I'm sure there will be some resupply missions before then, but I have no dates.

The information below is from Heavens Above.

HST 1/10/2022 mag. 2.5

Time	Position	Elevation
7:12 a.m.	210°	10°
7:15	173	29
7:19	113	10

HST 1/11/2022 mag. 2.3

Time	Position	Elevation
7:00 a.m.	238°	10°
7:04	176	31
7:07	114	10

HST 1/12/2022 mag. 2.2

Time	Position	Elevation
6:49 a.m.	241°	10°
6:53	178	31
6:56	115	10

Tiangong 1/12/2022 mag. 1.1

Time	Position	Elevation
7:09 a.m.	296°	10°
7:12	23	79
7:15	111	10

HST 1/13/2022 mag. 2.2

Time	Position	Elevation
6:38 a.m.	244°	10°
6:41	181	32
6:44	117	10

HST 1/14/2022 mag. 2.3

Time	Position	Elevation
6:27 a.m.	240°	14°
6:30	183	31
6:34	110	10

Tiangong 1/14/2022 mag. 1.4

Time	Position	Elevation
Appears from Earth's shadow		
6:47:57 a.m.	209°	16°
6:50:17	131	54
6:53	126	10

ISS 1/16/2022 mag. -3.5

Time	Position	Elevation
6:54 p.m.	210°	10°
6:57:06	134	48
6:58:04	84	35
Vanishes into Earth's shadow		

ISS 1/18/2022 mag. -3.0

Time	Position	Elevation
6:54 p.m.	246°	10°
6:56:56	321	47
6:58:46	26	22
Vanishes into Earth's shadow		

Tiangong 1/27/2022 mag. 1.5

Time	Position	Elevation
6:31 p.m.	227°	10°
6:34	151	51
6:36	76	13

HST 2/4/2022 mag. 2.0

Time	Position	Elevation
7:35 p.m.	246°	10°
7:38:12	183	31
7:39:12	155	27
Vanishes into Earth's shadow		

ISS 2/4/2022 mag. -2.6

Time	Position	Elevation
7:43 p.m.	297°	10°
7:46:22	227	39
7:46:59	197	35
Vanishes into Earth's shadow		

ISS 2/5/2022 mag. -3.7

Time	Position	Elevation
6:54 p.m.	310°	10°
6:58	224	81
7:01	136	10

HST 2/5/2022 mag. 2.2

Time	Position	Elevation
7:23 p.m.	247°	10°
7:26:52	186	30
7:28:41	143	21
Vanishes into Earth's shadow		

Tiangong 2/7 2022 mag. 1.1

Time	Position	Elevation
6:53 p.m.	293°	10°
6:56	205	82
6:59	119	13

Tiangong 2/9/2022 mag. 2.3

Time	Position	Elevation
6:30 p.m.	283°	10°
6:33	211	42
6:36	139	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 Tiangong Space Station at 6:50 a.m. on January 14, measure four-fist-widths south of due east then five and a half 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.

There don't seem to be any notable live broadcasts in January. I would think the *Axiom 1* launch and docking at the end of February will be covered.

Calendar of Events

First quarter of 2022: The first Nova-C mission will carry the IM-1 lander and Moon Mark and Spacebit lunar rovers to the Moon between Mare Serenitatis and Mare Crisium. To be launched by SpaceX.

January 7: Mercury is a greatest eastern elongation, 19.2 degrees from the Sun (hence can be seen after sunset).

January 8 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence

January 8: Venus is in inferior conjunction with the Sun.

January 13: SpaceX will launch a whole bunch of small satellites on one launch, including two Sherpa space tugs, two cubesat dispensers, and a bunch of Earth observation satellites.

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

January 31: Second launch attempt of *Firefly Alpha*.

February 4: Saturn is in conjunction with the Sun.

February 12 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence

February 16: Mercury is at greatest elongation, 26.3° west of the sun (hence can be seen before sunrise).

February 28: Launch of *Axiom Space Mission 1* which will carry a commercial crew of four to the ISS via SpaceX Crew Dragon. For more information, see https://en.wikipedia.org/wiki/Axiom_Mission_1.

March 5: Jupiter is in conjunction with the Sun.

March 12 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence

March 12: Earliest launch date for *Artemis 1* the first launch of the Space Launch System. On this 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.

March 13: Neptune is in conjunction with the Sun.

March18: Launch of Expedition 67/68 to the ISS

March 20: Venus is at greatest western elongation, 46.6 degrees from the Sun (hence can be seen before sunrise).

Mid 2022: [Moved several times]: Maiden flight of the Vulcan Centaur, ULA's new heavy launch vehicle. which will carry the Peregrine lunar lander. For more information, visit https://en.wikipedia.org/wiki/Vulcan_(rocket) and https://en.wikipedia.org/wiki/Astrobotic_Technology#Peregrine_lander.

April 2: Mercury is at superior conjunction with the Sun.

April 4: Mars is 0.3° south of Saturn.

April 9 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence

April 12: Neptune is 0.1 degrees below Jupiter.

April 15: Launch of SpaceX Crew-4 mission to the ISS.

April 16 – 27: 50th anniversary of Apollo 16.

` April 22: Peak of Lyrid meteor shower.

April 29: Mercury is at greatest eastern elongation 20.6°from the Sun (so can be seen after sunset).

April 30: Partial eclipse of the Sun, visible from the southern tip of South America, parts of Antarctica, and lots of ocean.

April 30: Venus is only 0.2° south of Jupiter.

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

May: Orbital test launch 2 of Boeing Starliner.

May 5: Uranus is in conjunction with the Sun.

May 5: Peak of the Eta Aquariid meteor shower.

May 14 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence

May 15: Total lunar eclipse, visible from all of South America and Antarctica and the eastern half of North America. It looks like Oklahoma gets most of this.

May 19: Second flight of South Korea's *Nuri*, and the first with a commercial payload.

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

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 29: Mars is 0.6° south of Jupiter.

June: First uncrewed test flight of *Gaganyaan*, which will eventually become India's first manned spacecraft. For more information, see https://en.wikipedia.org/wiki/Gaganyaan.

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

June 11 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence.

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

Second half of 2022: Launch of *ALINA* (the Autonomous Landing and Navigation Module) near the *Apollo 17* landing site. This will land two rovers which will search for Apollo 17's lunar rover.

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.

Third quarter of 2022 [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.

Third Quarter of 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

Third Quarter of 2022: Maiden flight of Ariane 6.

July: Launch of the Luna 25 lunar lander, the first mission of Russia's Luna-Glob lunar exploration mission. For more information, visit en.wikipedia.org/wiki/Luna_25 and en.wikipedia.org/wiki/Luna-Glob.

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

July 28: Peak of the Delta Aquariid meteor shower.

August: Launch of *Psyche*, which will orbit a large metallic asteroid also named Psyche. For more information, visit https://en.wikipedia.org/wiki/Psyche_(spacecraft).

August: Launch of *Mengtian*, the second laboratory module to the *Tiangong* space station.

August 1 (postponed from December 2020]: 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 14: Saturn is at opposition.

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.

September 20 [postponed from 2020]: 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.

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

September 26: Jupiter is at opposition.

Fourth quarter of 2022: First flight of Blue Origin's *New Glenn* orbital rocket. For more information, see https://en.wikipedia.org/wiki/New_Glenn.

Fourth quarter of 2022 [Moved from 2020.] 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.

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

Fourth quarter of 2022: Launch of *Axiom-2* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts.

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 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.

October 25: Fifth Crew Dragon mission to the ISS.

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

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 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 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: India launches its first crewed orbital flight *Gaganyaan-3*.

Sometime in 2023 (Really tentative): 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.

First quarter of 2023: First Dream Chaser cargo mission.

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.

April – July 2023: The *ExoMars* Mars landers land on Mars. This includes the Russian Kazachok surface platform and the ESA's Rosalind Franklin Mars rover.

Mid 2023: First launch of Firefly's *Blue Ghost* lunar lander.

June 2023 [approximate, moved from 2022]: First crewed launch of an Orion space capsule.

August 2023: [Moved from August 2022] Launch of *JUICE*, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is https://sci.esa.int/web/juice .

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.

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.

November 2023: Launch of *Maste*n 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).

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

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: 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).

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: (Tentative): 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 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 [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: 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.

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).

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 CC_{21}.

October 2026: Launch of the ESA's Earth *Return Orbite*r to Mars. This is the vehicle that will bring the *Perseverance* Mars samples to Earth.

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: 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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A Chapter of the National Space Society
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To join the Mars Society, visit www.marssociety.org. One-year memberships are $50.00; student and senior memberships are $25, and Family memberships are $100.00. Their address is Mars Society, 11111 W. 8th Ave, Unit A, Lakewood, CO 80215.

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