

OKLAHOMA SPACE ALLIANCE

OUTREACH –March 2021

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
McMurray residence at 2:00 p.m.
on March 13 details inside



Figure 1 Vera Rubin with John Glenn (Wikipedia Commons)

OKLAHOMA SPACE ALLIANCE OUTREACH March 2021

March Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, March 13. at Claire and Clifford McMurray's house. Prospective members are also welcome. Their house is at 2715 Aspen Circle in Norman. An agenda is forthcoming.

This will be the first in-person meeting we've had for over a year, but since our most vulnerable members have been vaccinated, we feel it should be safe to resume meeting in person. If you've not been vaccinated and wish to attend, be sure to bring a mask and distance yourself from any other people who have not been vaccinated.

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. The turns at Poplar, Aspen Lane and Aspen Circle are the first you can take, 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://us04web.zoom.us/j/79444489279?pwd=R2hLS2R3RnVoUFVMcS9UaDRWMW9sUT09> If for some reason the link doesn't work, contact Dave Sheely at 821-9077 (email sheely at sbcglobal.net) or Syd Henderson at 365-8983 (e-mail sydh at ou.edu) and we will send you updated information.

Please note if you are on our e-mail list, the superlong URL is in the meeting announcement and you can click on it. I've also created a tinyurl version, <https://tinyurl.com/y2qtab28>, that you can click on and is much easier if you have to type it in.

Saturday March 9, 2021 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
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of February meeting
5. Video (to be announced)
6. Chat

Minutes of February 2021 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance chapter of National Space Society had its regularly scheduled meeting on January 9, 2021. However, due to the ongoing Covid-19 pandemic, we held the meeting online via Zoom. Attending were David Sheely, Clifford and Claire McMurray, Seth Potter, Robin Scott, Tim Scott, and Syd Henderson. OSA president David 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/Update2102.pdf>, so I'll cover the details that aren't covered there.

We watched a video on Elon Musk becoming the richest man on Earth (passing Jeff Bezos), We watched a video on the landing and explosion of the Starship 9 test vehicle. There was a question as to why SpaceX doesn't have at least three engines firing so that if one fails, there is sufficient backup. Seth commented that the engines can only be throttled to 60% so the spacecraft would be going too fast to land.

Dave attended a NSS meeting where the comment was made that SpaceX and Bezos are putting more money into innovation than NASA.

We watched a video of the January 13 Falcon 9 CRS 21 landing and recovery. They again had problems with boaters getting too close to the landing site in the Gulf of Mexico.

We watched a video of a proposed Spacebit lander on the Moon.

Jeff Lis sent out to NSS Directors about why Virgin Galactic went so long between tests was because of landing problems. White Knight is showing signs of age.

Eric Sundby of the Space Force Association used to attend OSA meetings.

We watched a video of the Space Force Anthem (this doesn't seem to be adapted; it's just entitled that). It sounds like a Russian army anthem.

Business meeting:

Dave sent money for OSA membership and a \$100 dollar donation to the Colombian chapter. [It actually had already arrived on the day of the meeting, so I mailed it to Tim.]

Claire: We are in the process of creating a category of NSS Outpost with one full member required. Others get a \$5 special fee.

NSS Chapters Assembly meets at 7:00 p.m. which is a bad time for people on the other side of the world. The German chapter suggested that we hold it at 7:00 a.m. on Saturday (Pacific Time).

Since many of us are getting vaccinated, we may try to go back to in-person meetings in March.

Annual Reports are due on February 15. Syd needs to send a PDF file to Tim.

We have \$714.21 in checking account and \$267 in Cash for a total of \$981.21. This includes \$75 for Colombian chapter but not Dave's donation.

We will attempt to have a potluck in April.

Seth Potter pointed out that some of the videos from our 2004 ISDC are on YouTube.

--Minutes by OSA Secretary Syd Henderson

Minutes of January 2021 Meeting

Oklahoma Space Alliance chapter of National Space Society had its regularly scheduled meeting on January 9, 2021. However, due to the ongoing Covid-19 pandemic, we held the meeting online via Zoom. Attending were David Sheely, Clifford and Claire McMurray, Seth Potter, Tim Scott, and Syd Henderson. OSA president David 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/Update2101.pdf>, so I'll cover the details that aren't covered there.

We watched a video on the Chang'e 5 Moon mission and sample return and the history of the Chinese space program.

Much of the "smoke" you saw during Shuttle launches was steam from the sound suppression system.

We went through an article on Kilopower, noting that this uses U235 (enhanced uranium, not weapons grade).

We watched a video on the Prometheus engine developed by Arianespace.

We watched a video about the Chinese gravitational wave satellite.

We watched the launch of the Turksat via SpaceX Falcon 9.

SpaceX is having their next test of Starship. We watched an animation of the launch.

Business:

Dave renewed his family membership.

We now have \$674.21 in the bank account and \$267 in cash, for a total of \$941.21.

Claire: There is a way to donate money to the NSS and have it go directly to chapters.

Post Meeting:

We watched a video on Kilopower reactors on Mars.

Bob Zubrin has a new book, *Ingenuity*, coming out.

We are still hoping to have a belated Holiday party as soon as enough people are vaccinated.

--Minutes by OSA Secretary Syd Henderson

Space News

Well, SpaceX is making progress with Starship, I guess. Starship SN10 didn't explode upon landing like Starships SN8 and SN 9 but eight minutes later. The cause appears to be a methane leak, but also three of the six landing legs failed to deploy properly and possibly destabilized the spacecraft. Prior to the explosion, the spacecraft maneuvered through a successful six-and-a-half-minute flight and achieved a soft landing. (Starships 8 and 9 landed two hard and exploded on impact.)

The numbering of the Starships is a bit odd. Starship SN 1, 3, and 4 were tests that didn't fly and 5 and 6 were single engine models. There don't seem to have been an SN2 or SN7 so maybe they weren't intended to undergo tests.

SpaceX had SN11 through 19 in various stages of production and will certainly have some remodeling to the landing gear (except for SN11, which is almost ready to go.)

All three of this year's Mars Probes appear to be successful, with *Hope* and *Tianwen-1* both achieving Mars Orbit and *Perseverance* landing at Jezero Crater, all within a ten-day period. *Tianwen-1* also has a lander, but it won't touch down until April 23.

Perseverance used the sky-crane landing method pioneered during the *Curiosity* landing for its February 18th landing inside Jezero crater. It sent back its first picture within minutes, while the television broadcast of the landing was still on. The picture was from one of the lower-resolution cameras, but photos from other cameras have arrived since. On March 5, it made its first drive on Mars.

On the same day, NASA announced that the landing site would be named Octavia E. Butler landing after the late Hugo and Nebula-winning author. I hadn't realized that NASA gives names to all the landing sites on Mars, and, though the names aren't official IAU names, they do make it easier to designate sites. Some earlier ones include:

Ray Bradbury Landing (*Curiosity*)

Carl Sagan Memorial Station (*Mars Pathfinder*)

Columbia Memorial Station (*Spirit*)

Challenger Memorial Station (*Opportunity*)

The Viking landing sites were named after Viking scientists, Thomas A. Mutch and Gerald Soffen, shortly after their deaths. [It's possible that all these sites are officially Memorial Stations since their namesakes died before they were named.]

See "Space-Related Articles" for more renamings.

Since the Lyrid Meteor Shower is coming up next month, it's neat that there appears to be a planet orbiting Vega (Alpha Lyrae) and it's a scorcher. According to an article published March 2 in the *Astronomical Journal* by a team led by Spencer A Hunt, a student at the University of Colorado Boulder, this planet, if confirmed, has a mass likely 20 times that of Jupiter and orbits Vega once every 2.43 days. There's some uncertainty in the orientation of the orbit, but since Vega polar axis points toward Earth, the planet's orbit is likely being seen flat on if it orbits in the plane of Vega's equator (which is likely due to tidal effects). Vega is not only the fifth-brightest star in the night sky, but also pretty hot: it's a type A0 star like Sirius. And since the planet orbits so fast, it must be close to Vega, which means its surface temperature would be almost 5400° F. This would make it the second hottest planet ever discovered.

Presumably such a planet would be unable to host life, but Vega may well have other planets. Being hot, it also has a short lifetime compared to the Sun. Vega is about half a billion years old, which means it's halfway through its lifetime, and would be a short time for life to develop in planets further out. Vega also has a rotational period of 12.6 hours, about 50 times that of the Sun, which makes it markedly ellipsoidal. Since the poles are so much closer to its center than the equator, Vega's temperature at its north pole is well over three thousand degree higher than that on its equator. It's not clear to me how this rapid rotation might affect the formation of planet. Perhaps it shed a lot of mass when it was young and produced a lot more. This might also have caused some of its planets to spiral inward and fall into Vega,

Space-Related Articles

"Trailblazing Astronomers and their Groundbreaking Observatories," by Randall Hyman, *Astronomy*, April 2021, pp 24 -31. Two upcoming great telescopes have received new names honoring pioneering women astronomers who made discoveries that made the renaming appropriate. The Large Synoptic Survey Telescope (LSST) in Chile will be the Vera C. Rubin Observatory and the Wide-Field Infrared Survey Telescope (WFIRST) will be the Nancy Grace Roman Space Telescope (usually called the Roman Space Telescope).

Vera Rubin was the astronomer who discovered the stars in the outer regions of the spiral galaxies move much faster than would be expected from the distribution of visible matter in the galaxies, and that means that there must be lots of "dark matter" present in these galaxies. In fact, the velocity of the outer stars increases, so the dark matter cannot be concentrated in the core of the galaxies.

Note that she wasn't the first to postulate dark matter: Fritz Zwicky came up with the idea in 1933 when he observed that the galaxies in the Coma Cluster are not massive enough to keep the Cluster together and therefore there must be large amounts of unseen matter in the Cluster. His observations were controversial.

Incidentally, when it came time to present her paper, she was pregnant and about due, so her department chair volunteered to present it under his own name, Rubin didn't go for that, presented the paper herself and blew astronomers minds, and incidentally became famous,

The Rubin Observatory will continue Rubin's legacy. (She died in 2016.) It will study twenty billion galaxies and discover millions of asteroids, comets, and supernovae in the process. It will map the entire southern sky eight hundred times while flooding astronomers with petabytes (probably exabytes) of data.¹ In the process, it will search for evidence of gravitational lensing, which will indicate the true mass of the object doing the lensing. The Rubin Observatory should come online in 2022 with full operations beginning in 2023.

Nancy Grace Roman came to prominence in 1950 when she published a paper on the materials making stars in the Milky Way. In particular, the oldest stars would have less material other than hydrogen and helium because they formed before the generations of supernovae produced the heavier elements. In other words, early-generation stars are "metal poor." (To an astronomer, any element other than hydrogen or helium is a "metal." We need to talk to them about this.) Rubin discovered that these older, reddish stars are in elliptical orbits that tend to be inclined to the galactic center.

Roman got to attend the opening of an observatory in Armenia (then part of the Soviet Union) in 1956, one year before *Sputnik*. She joined NASA as a science administrator, leading the development of many space observatories. She may be most famous for her lobbying and leadership which led to the creation of the Hubble Space Telescope, for which reason she was nicknamed the "Mother of Hubble."

The Roman Space Telescope, as its former name implies, has a much larger field of view than the Hubble Space Telescope, 0.28 square degrees. (The area of the Full Moon is 0.19 square degrees.) This makes it suitable for star surveys. It also contains a coronagraph to block the light of stars, enabling it detect planets more than 20 million times dimmer than the star they orbit, and in extreme cases, a billion times dimmer, the only limitation being that the planets must be more than 0.15 arcseconds from the star, which I assume is the radius of the coronagraph. Note that the planets will be directly images, and we will a lot fewer "hot Jupiters" and "hot Neptunes." The Roman Space Telescope will be doing this from the L2 Sun-Earth Lagrangian point, the one on the far side of the Earth from the Sun. Incidentally, the Roman Space Telescope will transmit about 1.3 terabytes of data a day, which means its output over its lifetime will be measured in petabytes rather than exabytes, but still sufficient to swamp astronomers.



Figure 2 Model of Roman Space Telescope (Wikipedia)

"The Galaxy's Marvelous Rogues and Misfits," by Randall Hyman, *Astronomy*, April pp. 16 – 23. (Yes, the same author.) This is an article on planets than are wandering the galaxy without stars, stars wandering outside of galaxies and objects which visit the Solar System from interstellar space. According to some estimates there may be more rogue planets than visible stars. And moons can go rogue too if perturbations move them out of orbit. Such objects are called ploonets, which is too cute for words.

¹ Tera = trillion, peta quadrillion, and exa quintillion, so an exabyte is a million terabytes, or a billion gigabytes, In other words, astronomers will be drowned in data.

Sky Viewing

The **Lyrid Meteor Shower** lasts from April 14 through 30 with a peak on April 22. This shower produces about eighteen meteors an hour at its peak. The radiant is easy to locate: it's not far from Vega, which is the fifth brightest star in the night sky, and the third brightest visible from Oklahoma (after Sirius and Arcturus; the other two are Canopus and Alpha Centauri, which are not visible from here).

Mercury, Jupiter, and Saturn are all low in the eastern sky before Sunrise. Saturn at magnitude 0.6 is the highest of the three, followed by Jupiter at magnitude -2.0 and Mercury at magnitude 0.3. Mercury is pretty low, so you will need a clear horizon to see it, but Jupiter and Saturn should be easy to spot. In fact, on March 14 Saturn is rising about an hour before Jupiter and Mercury maybe twenty minutes after Jupiter. Mercury is moving away from the other two as it approaches superior conjunction on April 18. In fact, it had a close conjunction with Jupiter on March 5 and a more distant conjunction with Saturn on February 23. A gibbous Moon will be in the west during much of the night while Lyra will be in the east,

Once Mercury passes superior conjunction, it will be in the evening sky and close to Venus (which will be very low). Mercury will also be low, but if it's possible to see Venus, it should be possible to see Mercury a few degrees above it. I assume this means Mercury and Venus are having a conjunction in Mid-April when we can't see them.

As for **Venus**, it is approaching superior conjunction on March 26 and is invisible until late April, when it will begin eight months as the evening star, gradually brightening into November.

At the moment, the only easily seen planet in the evening sky is **Mars**, which is slowly approaching its October superior conjunction with the Sun. At the moment, it is about ten degrees (a fist-width) to the right of Aldebaran, the bright star in Taurus and a similar distance to the left of the Pleiades. Note that Aldebaran and Mars are almost exactly the same brightness (magnitude 0.8 and 0.9), so it appears that Taurus has twin stars. Mars won't get particularly close to Aldebaran this pass, moving above of the Hyades star cluster in late March and April and fading to magnitude 1.6 by the end of April.

In contrast, **Jupiter** is becoming more visible, and by the end of April will be rising several hours before the Sun and increasing its brightness to magnitude -2.2.

On April 1, **Saturn** will already be ten degrees above the horizon at the beginning of morning twilight, and by the end of the month, it will be 20 degrees above the horizon. Since Jupiter and Saturn are about ten degrees apart and slowly separating, this means Jupiter will be ten degrees above the horizon. Saturn will be magnitude 0.6 from now to the end of April.

Uranus is up around 30 degrees in the western sky at the end of evening twilight and is magnitude 5.9, so you would need binoculars or a small telescope to see it. It's lower by about five degrees a week until it finally reaches conjunction with the Sun on April 30.

Neptune was in conjunction with the Sun on March 10 and won't be visible until nearly the end of April. Even then, since it's magnitude 7.8, it requires a telescope.

You can find sky charts for Uranus and Neptune at https://in-the-sky.org/findercharts/09uranus_2020_2.png and https://in-the-sky.org/findercharts/10neptune_2020_2.png, and at https://skyandtelescope.org/wp-content/uploads/UranusNeptune2020_BW_WebFinder.pdf.

Viewing Opportunities for Satellites (March 13 – April 13, 2021)

You can get sighting information at www.heavens-above.com, which allows you to get satellite-viewing data for 10-day periods and 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 -3.8 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.

Missions to and from the International Space Station can change its orbit. The only mission to the ISS during this time intervals is the Soyuz launch on April 10, which is after all these passes. SpaceX's next mission to the ISS is scheduled to launch on April 22. Also, in late April, three American astronauts will return from the ISS.

China will be launching the core module for their Space Station sometime in April, so I'll try to include observation times for that when they become available.

The NASA website that I was using for sightings information has been retired as of February 25, 2021. The information below is from Heavens Above. Note that their maps show the location of the ISS at one-minute intervals but doesn't give the position or altitude. Also note that on March 16 and April 3, the ISS disappears on the way up as it enters Earth's shadow.

ISS 16 March 2021

Time	Position	Elevation
9:07:57 p.m.	222°	10°
9:11:09	166	74

Vanishes into Earth's shadow
 Passes through southeastern corner of Orion

ISS 19 March 2021

Time	Position	Elevation
8:22:12 p.m.	240°	10°
8:25:29	320	59
8:28:48	40	10

ISS 3 April 2021

Time	Position	Elevation
9:27:30 p.m.	316°	10°
9:30:44	23	69

Vanishes into Earth's shadow

ISS 6 April 2021

Time	Position	Elevation
8:40:03 p.m.	327°	10°
8:43:13	37	38*
8:45:21	99	18

Vanishes into Earth's shadow
 *Passes through handle of Big Dipper

ISS 5 April 2021

Time	Position	Elevation
9:29:20 p.m.	292°	10°
9:32:20	229	31
9:33:02	203	28

Vanishes into Earth's shadow.
 The ISS path is along Orion's belt and gets very close to Sirius on this pass.

HST 6 April 2021

Time	Position	Elevation
Appears from Earth's Shadow		
5:53:00 a.m.	175°	24°
5:54:27	175	30
5:58:04	113	10

Passes very close to Jupiter and Saturn near the end of this pass

ISS 6 April 2021

Time	Position	Elevation
8:41:31 p.m.	305°	10°
8:44:49	225	60
8:47:51	145	12

Vanishes into Earth's shadow
 The ISS passes very close to Mars and Procyon on this pass.

HST 7 April 2021

Time	Position	Elevation
Appears from Earth's shadow		
5:42:39 a.m.	201°	28°
5:43:29	177	31
5:47:09	114	10

Again passes very close to Jupiter and Saturn

HST 8 April 2021

Time	Position	Elevation
Appears from Earth's shadow		
5:32:18 a.m.	187°	31°
5:32:32	180	32
5:36:13	116	10

And again passes very close to Jupiter and Saturn

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 5:54:27 a.m. on April 6, you'd measure a half-fist-width east 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>.

Highlights (times are Central Standard Time):

Very little this month. On March 18, the Soyuz module currently attached to the Rassvet module will be moved to the Poisk module, which will involve three cosmonauts. Coverage begins at 11:15 a.m., with undocking at 11:38 a.m. and redocking at 12:07 p.m.

I assume there will be a lot of coverage in April with two manned spacecraft going to the ISS and one returning,

NASA also has a weekly podcast, This Week @ NASA, which you can watch online at

<https://www.youtube.com/playlist?list=PL1D946ACB21752C0E>

. You can also get the most recent episodes at NASA.gov.

Calendar of Events

Sometime in 2021 [Moved from 2020].: ALINA, the Autonomous Landing and Navigation Module will be launched aboard an Ariane rocket, and land near the Apollo 17 landing site in the Taurus-Littrow valley. It will carry two Audi lunar rovers which will try to locate Apollo 17's Lunar Rover. For more information, see <https://ptscientists.com/products/alina>.

First Quarter of 2021: First flight of India's Small Satellite Launch Vehicle (or SSLV).

First Quarter of 2021: First commercial launch of the South Korean *Blue Whale 1* from Australia.

March 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence.

March 20: Launch of many minisatellites from many countries via a Soyuz 2.1 from Baikonur. This includes Tunisia's first satellite, as well as satellites from Argentina, Hungary, Thailand, Saudi Arabia, and more usual suspects such as the US, Russia, Canada, and Japan.

March 26: Venus is at superior conjunction with the Sun.

Sometime in 2021: China launches the first module of their space station. Sometime in April: Launch on *Tianhe*, the first element of the Chinese space station.

April 8: [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

April 10: Launch of three cosmonauts by Soyuz from Baikonur to the ISS.

April 17: Mars is 0.1 degrees north of Moon. This is an occultation in India, Indochina, and western Indonesia.

April 18: Mercury is at superior conjunction with the Sun.

April 22: Peak of Lyrid meteor shower.

April 22 (moved from March): SpaceX's Dragon Crew-2 mission to the ISS.

April 23: Landing of China's *Tianwen-1* on Mars.

April 30: Uranus is in conjunction with the Sun.

Sometime in May (moved from March): Second uncrewed orbital test flight of Boeing's CST-100 *Starliner*.

May 4: Peak of the Eta Aquariid meteor shower.

May 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

May 17: Mercury is at greatest elongation, 22 degrees east of the Sun (hence is visible after sunset).

May 26: Total eclipse of the Moon, visible from all the Pacific Ocean and lands on its rim. In Oklahoma, totality will be occurring just before moonset

June 10: Annular eclipse of the Sun. The eclipse passes through the Arctic from Russia just north of Kamchatka, almost to the North Pole, back through northwestern Greenland, Baffin Island, and Hudson Bay. Until terminating in central Ontario north of Lake Superior. In other words, few people will be able to see the annular eclipse, though a partial eclipse will be visible in the northeastern United States, and eastern and central Canada.

June 10: Mercury is in inferior conjunction with the Sun.

June 10 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 4: Mercury is at greatest elongation, 21.6 degrees west of the Sun (hence can be seen before sunrise).

July 8 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 13: Conjunction of Mars and Venus. Venus will be half a degree north of Mars, the diameter of a Full Moon.

July 17: Pluto is at opposition.

July 26 – August 7: 50th Anniversary of Apollo 15.

July 27: Peak of Delta Aquariid meteor shower.

July 30: *Juno* ends its mission to Jupiter with a fiery death in Jupiter's atmosphere.

August 1: Mercury is in superior conjunction with the Sun.

August 1: Saturn is at opposition.

August 12: Peak of Perseid Meteor shower.

August 19: Jupiter is at opposition.

September: SpaceX's Dragon Crew 3 to the ISS.

September: First crewed flight of Boeing's *Starliner* space craft on a voyage to the Space Station.

September 13: Mercury is at greatest elongation, 26.8 degrees east of the Sun (hence can be seen after sunset).

September 14: Neptune is at opposition.

Fourth quarter of 2021 [Moved from July]: 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_\(rocket\)](https://en.wikipedia.org/wiki/Vulcan_(rocket)) and https://en.wikipedia.org/wiki/Astrobotic_Technology#Peregrine_lander.

Fourth quarter of 2021: Launch of *Axiom Space Mission 1* which will carry a commercial crew of four to the ISS via SpaceX Crew Dragon.

Fourth quarter of 2021: SpaceX launches of *Space Adventures Crew Dragon* which will carry up to four tourists to orbit. For more information, see https://en.wikipedia.org/wiki/Space_Adventures_Crew_Dragon_mission.

October [Moved from February]: Maiden flight of KSLV-II (aka Nuri), the first South Korean indigenous orbital launch vehicle.

October 1: 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>.

October 7: Mars is in conjunction with the Sun.

October 9: Mercury is in inferior conjunction with the Sun.

October 11: The first Nova-C mission will carry the IM-1 lander and Moon Mark lunar rover to the Moon. To be launched by SpaceX.

October 16: Launch of Lucy, a mission to explore Jupiter's Trojan Asteroids. See [https://en.wikipedia.org/wiki/Lucy_\(spacecraft\)](https://en.wikipedia.org/wiki/Lucy_(spacecraft)) for details.

October 21: Peak of Orionid meteor shower.

October 24: Mercury is at greatest western elongation, 18 degrees west of the Sun (hence is visible before sunrise).

October 29: Venus is in greatest eastern elongation 47 degrees from the Sun (hence is visible after sunset.)

October 31: [Postponed from April] Launch of the James Webb Space Telescope. For more information, see https://en.wikipedia.org/wiki/James_Webb_Space_Telescope

Late 2021 or early 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.

November: [Moved from 2020] Launch of 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 NearEarth Asteroid Scout cubesat (https://en.wikipedia.org/wiki/Near-Earth_Asteroid_Scout) and a bunch of other satellites.

November [Moved from September]: Launch of the IXPE X-Ray Telescope by Falcon 9. For more information, see <https://en.wikipedia.org/wiki/IXPE>.

November 4: Uranus is at opposition.

November 5: Peak of South Taurid meteor shower.

November 12: Peak of North Taurid meteor shower.

November 17: Peak of Leonid meteor shower (unfortunately coinciding with the Full Moon).

November 19: Partial lunar eclipse, 3:02 a.m. peak, visible from Oklahoma. Since the moon is 97% covered, this is not far from being a total lunar eclipse.

November 28: Mercury is in superior conjunction with the Sun.

December: First operational *Starliner* mission to the ISS.

December 4: Total eclipse of the Sun. Unfortunately, this one is only visible from West Antarctica and the ocean around it.

December 8: Soyuz crew mission to the ISS from Baikonur.

December 14: Peak of the Geminid meteor shower.

December 22: Peak of Ursid meteor shower.

Sometime in 2022 [tentative]: India launches its first manned orbital flight Gaganyaan-3.

Sometime in 2022: SpaceX plans to launch a human crew around the Moon. [This is speculative, reflected by this mission being postponed from 2018.]

Sometime in 2022: Launch of several crews to the Chinese Space Station and the addition of the second lab module.

Sometime in 2022 [Moved from October 2021]: 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>.

January 2022: [Moved from 2020]: 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>.

February 4, 2022: Fourth Crew Dragon mission to the ISS.

March 2022: Launch of *Eris*, the first Australian rocket to launch an Australian payload. *Eris* is the launch vehicle for Gilmour Space.

April 16 – 27, 2022: 50th anniversary of Apollo 16.

May 2022: Second flight of South Korea's *Nuri*, and the first with a commercial payload.

May 22 - June 10, 2022: Launch window for JUICE, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <https://sci.esa.int/web/juice>.

June 2022 [approximate]: First crewed launch of an Orion space capsule.

July to December 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>.

August 2022: 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)).

August 1, 2022 (postponed from December 2020): Launch of the Korea Pathfinder Lunar Orbiter (KPLLO) and lunar impactor from Naro Space Center in South Korea. For more information, see https://en.wikipedia.org/wiki/Korea_Pathfinder_Lunar_Orbiter.

September 20, 2022 [postponed from 2020]: ESA launches the ExoMars Mars Rover, which has been christened Rosalind Franklin, and the Exomars 2020 surface platform. For more information, visit <https://en.wikipedia.org/wiki/ExoMars>.

Fourth quarter of 2022: [Tentative] Launch of the Israeli Lunar Surface Access Service (LSAS). Tentative because they are looking for a launch to hitch a ride on.

December 2022: Launch via Falcon 9 of Masten Mission 1, a Commercial Lunar Payload Services mission to the lunar South Pole.

December 21, 2022: Launch of the *Nova-C* lander to the Lunar South Pole.

December 7 – 19, 2022: 50th anniversary of Apollo 17. This, to date, is the last manned mission to the Moon.

Sometime in 2023: OSIRIS-REx returns samples from Asteroid Bennu.

Sometime in 2023 (tentative): 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.

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

Sometime in 2023: (Tentative): Launch of the first module of the Lunar Orbiter Platform- Gateway.

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

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.

November 2023: Launch of NASA's VIPER lunar rover, which will hunt for ice near the Moon's South Pole.

Sometime in 2024: India launches its Mangalayaan-2 Mars mission, which includes an orbiter, lander, and rover.

Sometime in 2024: Planned date of Artemis 3, which will land astronauts 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.

September 2024: Launch of Japan's Martian Moons Exploration, which includes a Phobos lander.

December 19, 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: First crewed flight of Russia's Orel (formerly called Federatsiya).

Sometime in 2025: Launch of the Nancy Grace Roman Space Telescope [formerly known as WFIRST].

December 2025: BepiColombo arrives at Mercury orbit.

April 2026: Launch of Dragonfly to Titan.

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)).

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 phone is 202-424-2899 (new as of May 2019). 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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National Space Society has a special \$20 introductory rate for new members. Regular membership rates are \$52, Student memberships are \$36, Senior \$42. Part of the cost is for the magazine, *Ad Astra*. If you choose to receive the magazine digitally, memberships are \$40 for regular, \$24 for students and \$30 for seniors. Mail to: National Space Society, PO Box 98106, Washington, DC 20090, or join at www.nss.org/membership. (Brochures are at the bottom with the special rate.) Be sure to ask them to credit your membership to Oklahoma Space Alliance.

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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