

OKLAHOMA SPACE ALLIANCE

OUTREACH –January 2020

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at Clifford and Claire McMurray's house 2715 Aspen Circle in Norman 2:00 p.m. on January 11, 2019 Directions are inside.



Figure 1: Simulation of orbit of TOI 1338 b, the first planet detected as circumorbiting a double star system (see page 5)

Photograph from NASA website.

OKLAHOMA SPACE ALLIANCE OUTREACH January 2020 January Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, January 11. 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.

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.

Saturday January 11, 2020 2:00 p.m.

Place: McMurray Residence Tentative

agenda

1. Introductions and review of Space events this past month
 - a. What's Happening in Space, News, Pictures, and Videos approximately one hour. 2.

Break

- . Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of November and December Meetings
 - c. Annual Reports
3. Video (to be announced)
4. Chat

Minutes of November Meeting

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on November 9, 2019. In attendance were Clifford and Claire McMurray, Adam Hemphill, Mike Hopkins, John Northcutt, Tim Scott, Dave Sheely, Bryan Swift, Steve and Karen Swift. and Syd Henderson. OSA President Clifford McMurray presided over the meeting. He also did an Update with links to the videos he presented. This can be found at <http://osa.nss.org/Update1911.pdf> so I'll cover the highlights.

OSA members Adam Hemphill, Clifford McMurray, Dave Sheely, Steve Swift and Don Whitney met with US Representative Kendra Horn and brought pictures to the meeting.

VIPER (the Volatiles Investigating Polar Exploration Rover), which will fly to Lunar South Pole as early as December 2022, will carry a drill capable of penetrating Lunar soil to a depth of a meter.

New Glenn will have twice the payload volume of anything currently flying. We watched a video of Bezos presenting *Blue Moon*, a moon lander and cargo carrier that could be launched by *New Glenn* or several other heavy launchers. *Blue Moon* will be capable of landing four rovers simultaneously on the Moon. It will use liquid hydrogen, which has the advantage that it can refuel using lunar ice.

We also watched a video presentation of the BE-7 engine and one of *Blue Moon* releasing small satellites and landing on the Moon.

China will launch two test flights of Long March V and a Mars mission before the lunar sample return mission *Chang'e 5* in December 2020.

We watched a video of the Next Generation Space Station.

There has never been a robotic orbital rendezvous outside LEO.

The first Virgin Orbit test flight may be before the end of 2019. [Didn't happen. It's now projected for 2020. The spacecraft is named LauncherOne.]

We watched a short video on Virgin Galactic going public on the New York Stock Exchange. We watched a video on working on the space station.

We watched a video of epigenetic studies in orbit. These are important as epigenetic regulation, which works by turning off specific genes, is a major method the genome uses to adapt to the environment, and function may not always be restored to the genes when astronauts return to Earth.

We nominated officers for 2020. We renominated Cliff McMurray for President, Dave Sheely for Vice-President, Tim Scott for Treasurer, and Syd Henderson for Secretary.

We watched several episodes of *This Week at NASA*.

The Van Allen Belt mission ended after seven years.

We watched a video from the ISDC by Doug Plata on Earth Independence. You can find related videos at Doug Space, <https://www.youtube.com/channel/UC0xYcRHOpAcBkMMTgF75MQg>.

Kendra Horn used to work for the Space Frontier Foundation and used to share office space with the National Space Society. She is a graduate of the International Space University.

Minutes of December Meeting and Christmas Party

The Oklahoma Space Alliance Christmas Party was at Claire and Clifford McMurray's on December 14. Only Clifford and Claire, Dave Sheely, Tim Scott and Syd Henderson attended. We re-elected our officers with the assistance of three ballots by Syd's phone from the Swifts and a mail-in by Russ Davoren. Claire is resigning as our person in charge of communications.

Space News

Betelgeuse has been creating a bit of a fuss lately as its brightness has diminished quickly to a historic low, dropping from magnitude 0.5 (tenth brightest star other than the Sun) to magnitude 1.5, slightly brighter than Bellatrix, which is a second magnitude star. In fact, it is the brightness of Adhara, or epsilon Canis Majoris, which is at the border of being first magnitude.

This is creating speculation that Betelgeuse is about to explode, which it certainly could, and it is expected to do so within the next hundred thousand years. Betelgeuse is a variable star and during the 20th century got to magnitude 0.2 (almost as bright as Rigel) and down to magnitude 1.3. It has been speculated that the reason Betelgeuse was designated alpha Orionis is that it was brighter than Rigel when Johann Bayer was assigning Greek letters to stars. However, Bayer wasn't consistent about this, and often assigned letters according to geometry as he did in the Big Dipper and Orion's belt. A more likely explanation than an imminent supernova explosion is that Betelgeuse's variability has several component cycles, with lengths of 5.9 years, 425 days and one that varies from 100 to 180 days, and these can reinforce each other, producing unusually high maxima and minima. The 5.9 year and 425-day cycles are now both at minima, and although this is unusually deep, it's not that much deeper than previous minima.

Betelgeuse would be spectacular if it did explode, shining as bright as the full Moon, though you'd have to be careful not to stare at it because all that brightness would appear to come from a point. On the other hand, when it faded, it would ruin the distinctive outline of Orion, so I would prefer the next supernova to be another star. I'm looking at you, Antares.

One of the great mysteries of the universe is why there is so little antimatter—indeed, why there aren't equal amounts of matter and antimatter. Results from the T2K (Tokai to Kamioka) experiment in Japan may have a clue. Generally, it is expected that particles and antiparticles should have identical properties, but the experiment found a difference among neutrinos. It's known that neutrinos come in three types, electron neutrinos, muon neutrinos and tau neutrinos (muons and tauons are heavier analogues of electrons and are unstable—I don't know why the third isn't called the tauon neutrino), and a given neutrino oscillates between the three types. Antineutrinos have a corresponding oscillation. However, it now appears that antineutrinos oscillate less often than neutrinos. This suggests that there may be asymmetries in how fundamental particles decayed in the first moments after the Big Bang. [Science News, December 21, 2019, page 12. The original abstract was <https://arxiv.org/abs/1910.03887>.]

On January 6, astronomers at LIGO reported the detection of the second known collision of neutron star. Unlike the first detection in 2017, this April 25, 2019 event was only detected by LIGO, (which may have been why it took more than eight months to report it). It is also why the distance was estimated to be within 290 and 744 million lightyears, of between twice and five times the distance to the first event. There is a chance that the more massive black hole may have a mass of 2.5 solar masses, which would put it near black-hole range, in which case this is the first observed collision of a neutron star and a black hole. However, the most likely masses are 1.1-1.7 solar masses for the smaller component and 1.6-1.9 for the larger, which puts them firmly in neutron star territory.

The Japanese KAGRA detector is about to go live, and, with the help of other detectors coming on line, it's quite possible that in a few years we will be detecting thousands of black hole mergers and a dozen neutron star mergers (and presumably some neutron star and black hole mergers) per year

Also on January 6, a paper co-authored by Wolf Cukier reported that TESS had discovered a planet TOI 1338 b which is the first circumbinary planet: that is, it orbits around two stars. The stars orbit each other every 15 days, and the

planet transits the larger every 93 to 95 days. The transits occur irregularly due to this being a three-body problem. The stars are about 1.1 and .33 times the mass of the Sun, and the planet has about the mass of Saturn.

Space-Related Articles

With the end of 2019, we had several magazines giving their top science stories of the year, and they all seem to agree that the top story was the first imaging of a black hole. This was done by a set of radio-telescopes around the group, which through the magic of interferometry, combined to produce a radio telescope the size of the Earth. Thus the famous image of the black hole as a black pupil inside a red eye (promptly dubbed the Eye of Sauron by sf fans) is actually a false-color reproduction of a radio wave image showing the shadow of the black hole, and a fiery ring around it.

Discover magazine always does the top 50 science stories of the year, of which the black hole imaging was 1.

#3 is “Race for the Moon,” with the Chinese *Chang’e 4* mission being totally successful while achieving the first ever far side landing, the Israeli *Beresheet* mission successfully achieving Lunar orbit, but crash-landing on the Moon, and India’s *Chandrayaan 2*’s orbiter being successful, but the lander also crash-landing. Otherwise, private space companies, notably SpaceX and Blue Origin are working toward Moon landings, including support for NASA’s planned Moon base. #8 is “Exploring the Farthest World Yet” concerns *New Horizon*’s flyby of Ultima Thule (since renamed Arrokoth after the Powhatan word for “sky,” but I prefer the original for its historical associations with exploration and because nobody’s sure how “Arrokoth” was pronounced).

#12 is “The Bumpy Road for Launching a Dragon,” about SpaceX’s delays in launching crewed flights aboard its Dragon capsule.

#14 is “Remembering the Opportunity Rover,” which went silent after a prolonged Martian dust storm.

#21 concerns the prolonged mission of Scott Kelly and the twin study with his earthbound brother,

#24 is “InSight’s Frustrating First Year on Mars.” *InSight* is a Martian that drilled a hole to insert a probe to detect Marsquakes but repeatedly kept hitting stones and bedrock. It has, since this article was written, started detecting Marsquakes.

#37 is “The Mystery of Mars’ Raging Rivers.” Mars used to have lots of liquid water, seas and rivers. What’s surprising is that huge rivers appear to flow on Mars as recently as a billion years ago, by which time Mars would have lost most of its atmosphere. Scientists are puzzled and think something is wrong with their models. My thought is that Mars undergoes large fluctuations in the density of its atmosphere and is much more geologically active than commonly supposed (which is why we have *InSight* there).

#42: “A New Tool Turns Up Surprise Slash Across Saturn’s Largest Moon.” Analysis of images of Titan using “Principal Components Analysis” has revealed that a ribbon of water ice extends halfway around Titan in its equatorial region. This ribbon is longer than the United States is wide. This feature was totally unexpected, and we aren’t close to an explanation.

Science News also had the black hole image as #1. The only other space story among their top 10 was “Moon Landings Were All the Rage on 2019” at #9, but they also included the flyby of “Ultima Thule” and the asteroid sample return missions Hayabusa 2 and OSIRIS-Rex. The latter is still preparing to collect a sample of asteroid Bennu.

Sky Viewing

The bright stars Capella and Rigel have almost exactly the same right ascension, so Capella is almost due north of Rigel. This means that if you find Rigel in the foot of Orion and look five fist-widths due north of it, you’ll find Capella, and if you continue four-and-half fist-widths, you’ll find Polaris, the North Star. This will be pretty easy around 10 p.m. on January 8 (and some days later), when Capella and Rigel are highest in the sky at the same time.

Early January is an unusually bad time for planet viewing, with only Venus being in the evening sky and Mars alone and faint in the morning sky. Fortunately, things get better in late January and early February.

Mercury is in superior conjunction with the Sun on January 10, hence is not visible through most of January. But by January 31, it will set seventy minutes after the Sun and will be magnitude -1.0. On February 10, Mercury will reach greatest elongation and stand eleven degrees above the horizon a half-hour after sunset while it is still around magnitude 0. This is the best evening to see it in the evening this year, at least in the Northern Hemisphere. It will fade rapidly after that and be lost to view in late February as it approaches inferior conjunction on February 25.

Venus is currently brilliant in the western sky at sunset, shining at magnitude -4, which is far brighter than any star in the sky. It is still in the far side of its orbit and will be getting brighter for several months, peaking around -4.7 in midspring. It will also be getting higher in the sky at sunset each night through March 24, when it reaches greatest eastern elongation the same night Mercury reaches greatest western elongation. This means Venus will appear the farthest away from the Sun at sunset, while Mercury appears the farthest away at sunrise. Unlike Mercury, Venus is brighter when it is a crescent, which it will be in April. For the record, Venus is currently in Capricornus, the dimmest constellation of the Zodiac, and is more useful at locating Capricornus than vice versa.

The bright light that is south by southwest at sunset is not a planet, but the star Fomalhaut, which is easy to distinguish because there are no other bright stars anywhere near it. It's about five magnitudes dimmer than Venus, but still easy to locate.

Mars is returning from the far side of its orbit and is only magnitude 1.6 and near the boundary of Libra and Scorpius before sunrise. Mars is seven degrees above Antares, which is slightly brighter. Mars is approaching Antares and will be five degrees away from it on January 17. Mars will enter Sagittarius in February and brighten to magnitude 1.1 by the end of the month. On the morning of February 18, Mars will be occulted by the Moon.

Jupiter was in conjunction with the Sun on December 27, hence is currently not visible. It will become very visible a couple of hours before sunrise in late February, at which time it will be magnitude -2.0.

Saturn will be in conjunction with the Sun on January 13, hence is currently not visible. However, it will become more visible in February, but far dimmer than Jupiter, only reaching magnitude 0.7. The two planets are gradually approaching each other in the sky on the way to the great conjunction in December.

On February 19, after occulting Mars, the Moon will pass four degrees to the right of Jupiter, and on February 20, 2.5 degrees to the right of Saturn.

Uranus is pretty high in the sky at sunset, in the inconspicuous Zodiacal constellation Aries. It is magnitude 5.8, which is barely visible to the naked eye under very dark skies.

Neptune is magnitude 7.8 and is in the constellation Aquarius. It can't be viewed without binoculars at least, and in any case is approaching a March 8 conjunction with the Sun. On January 27, Neptune will be 0.2 degrees north of Venus. *Sky & Telescope* has finder charts online for Uranus and Neptune through the rest of 2019 and early 2020. The URL is <https://s22380.pcdn.co/wp-content/uploads/UrNep-2019-2020.pdf>

Information from the January and February issues of *Sky & Telescope* and *Astronomy*, their websites, and Wikipedia.

Viewing Opportunities for Satellites (January 11 – February 11, 2020)

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 NASA site <https://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/JavaSSOP.html> is back up. It gives coordinates at 20second intervals from when the satellite rises, not from when it peaks. (This program requires Java. I'm currently using Internet Explorer to run it and making an exception for the site in the Java Control Panel.) I'm using its information for the International Space Station and Hubble Space Telescope, interpolating when necessary. 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 can change its orbit. A Dragon capsule undocked on January 7. The next mission after that is the return on Expedition 61 on the morning of February 6.

There are no good viewing opportunities of the Hubble Space Telescope during the time period.

ISS, 20 January 2020

Time	Position	Elevation
7:08 p.m.	248°	21°
7:09	264	37
7:10	321	55
7:11	217	37
Vanishes into Earth's shadow		

ISS, 21 January 2020

Time	Position	Elevation
6:20 p.m.	220°	23°
6:21	214	43
6:22	130	78
6:23	58	42
6:24	53	22

ISS, 7 February 2020

Time	Position	Elevation
7:19 p.m.	306°	22°
7:20	298	42
7:21	219	74
7:22:22	149	41
7:22:48	142	27
Vanishes into Earth's shadow		

ISS, 8 February 2020

Time	Position	Elevation
6:31 p.m.	327°	21°
6:32	342	38
6:33	40	57
6:34	98	38
6:35	113	21

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 ISS at 6:22 p.m. on January 21, measure four fist-widths south of due east, then a bit less than eight fist-width from the horizon. (Alternatively, look one fist-width southeast of straight up.)

All times are rounded off to the nearest minute except for times when the satellite enters or leaves the shadow of the Earth. The highest elevation shown for each viewing opportunity is the actual maximum elevation for that appearance.

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 are some spacewalks in January, but nothing else going on until the launch of the Solar Orbiter and the departure of Expedition 61 in early February. The times for that haven't been released yet, though we do know the landing is projected for 3:16 a.m. Central time. The next manned launch to the ISS is in April.

Calendar of Events

First quarter of 2020: SpaceX's Dragon 2 space capsule will take a two-man crew to the ISS.

First quarter of 2020: Boeing's first crewed flight of Starliner to the ISS.

Early 2020: ALINA, the *Autonomous Landing and Navigation Module* will be launched aboard a Falcon Block 5, 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://ptsScientists.com/products/alina>.

Sometime in 2020: India launches *Aditya-L1* to the Earth-Sun L1 point, on a mission to study the Sun's corona.

January 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 <http://www.okcastroclub.com/> for details.

January 10: Mercury is in superior conjunction with the Sun.

January 11: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence.

January 13: Saturn is in conjunction with the Sun.

January 27: Neptune is 0.2 degrees north of Venus.

February 6: Launch from Cape Canaveral of the European Space Agency/NASA Solar Orbiter (SoLo), which will orbit the Sun at a distance closer than Mercury. Not to be confused with NASA's *Parker Solar Probe*. Web site is sci.esa.int/solarorbiter.

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

February 10: Mercury is at greatest eastern elongation, 18.2 degrees from the Sun (hence can be seen after sunset).

February 14: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details. February 25: Mercury in inferior conjunction with the Sun.

March 1: Last launch of a Commercial Resupply Service Mission by SpaceX under the first phase of the CRS contract.

March 8: Neptune is in conjunction with the Sun.

March 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 <http://www.okcastroclub.com/> for details.

March 14: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

March 24: Mercury is at greatest western elongation, 27.8 degrees from the Sun (hence can be seen before sunrise).

March 24: Venus is in greatest eastern elongation, 46 degrees from the Sun (hence is visible after sunset.) March 20; Launch of Expedition 62/63 from Baikonur Cosmodrome in Kazakhstan to the ISS. April 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 <http://www.okcastroclub.com/> for details.

April 11: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

April 11 – 17: 50th anniversary of *Apollo 11* lunar flight.

April 21-22: Peak of Lyrid meteor shower.

April 26: Uranus is in conjunction with the Sun.

May: SpaceX will launch its first crew rotation to the Space Station.

May 4: Mercury is in superior conjunction with the Sun May 4: Peak of Eta Aquarid meteor shower.

May 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 <http://www.okcastroclub.com/> for details.

May 9: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

May 28 – 31: International Space Development Conference, Hilton-Dallas-Frisco Hotel & Convention Center. Web site is <https://isdc2020.nss.org>

June: Launch of the earth observation satellite *Amazônia-1* by an Indian rocket. *Amazônia-1* is the first satellite built entirely within Brazil See <https://en.wikipedia.org/wiki/Amaz%C3%B4nia-1> for details.

June 3: Venus is in inferior conjunction with the Sun.

June 4: Mercury is at greatest eastern elongation, 23.6 degrees from the Sun (hence can be seen after sunset).

June 12: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details.

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

June 30: Mercury is in inferior conjunction with the Sun.

July: United Arab Emirates launch the Mars Hope, aka as *Al-Amal* or the *Emirates Mars Mission*, from the Mohammed bin Rashid Space Center in Dubai. For more information, visit https://en.wikipedia.org/wiki/Hope_Mars_Mission.

July: Maiden flight of South Korea's *Blue Whale 1*.

July 11: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 14: Jupiter is at opposition

July 17, 8:00 a.m.: Launch of the *Mars 2020* space rover, which will arrive on Mars at the beginning of 2021. For more information, see https://en.wikipedia.org/wiki/Mars_2020 or <https://mars.jpl.nasa.gov/mars2020/>.

July 20: Saturn is at opposition.

June 21: Annular solar eclipse visible on a path including the Democratic Republic of the Congo, Sudan, Ethiopia, Eritrea, southern Arabia, Pakistan, India southern China and Taiwan. The biggest cities on this path are New Delhi and Chongqing.

July 22: Mercury is at greatest western elongation, 20.1 degrees from the Sun (hence can be seen before sunrise).

July 23: Launch of *Huoxing-1*, the Mars Global Remote Sensing Orbiter, Lander and Small Rover by China. For more information, see https://en.wikipedia.org/wiki/Mars_Global_Remote_Sensing_Orbiter_and_Small_Rover. (China really needs to work out an acronym for this.)

July 25: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*, and the *Exomars 2020 surface platform*. For more information, visit en.wikipedia.org/wiki/Exomars.

July 27: Peak of Delta Aquarid meteor shower.

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

August 12: Peak of Perseid meteor shower.

August 13: Venus is in greatest western elongation 45.8 degrees from the Sun (hence is visible before sunrise.)

August 17: Mercury is in superior conjunction with the Sun.

September 11: Neptune is at opposition.

Last quarter of 2020 (postponed from July): Maiden flight of Ariane 6 from Kourou, French Guiana.

October 1: Mercury is at greatest eastern elongation, 25.8 degrees from the Sun (hence can be seen after sunset).

October 13: Mars is at opposition, 39 million miles from Earth.

October 20 – 21: Peak of Orionid meteor shower.

October 23: Mercury is in inferior conjunction with respect to the Sun.

October 30: Uranus is at opposition.

November: [Moved from June] Maiden flight 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 10: Mercury is at greatest western elongation, 19.1 degrees from the Sun (hence can be seen before sunrise).

December: Test flights begin for India's *Gaganyaan* program, which will eventually launch people into orbit.

December (Postponed from December 2019): Launch of China's *Chang'e 5* lunar sample return mission. This will be the first such mission since 1976.

December 13-14: Peak of Geminid meteor shower.

December 14: Total eclipse of the Sun visible in southern Chile and Argentina, Kiribati and a long path across the wastes of the southern Pacific and Atlantic Oceans.

December 20: Mercury is in superior conjunction with the Sun.

December 21: Great conjunction between Jupiter and Saturn. The two planets will be separated by six minutes of arc.

December 22: Peak of Ursid meteor shower.

Sometime in 2021: *Hope*, aka *Emirates Mars Mission*, arrives at Mars (see July 2010).

Sometime in 2021: The *ExoMars Mars landers* land on Mars. These in the Russian Kazachok surface platform and the ESA's *Rosalind Franklin Mars rover*.

Sometime in 2021: China launches the first module of their space station.

January 31 – February 9, 2021: 50th anniversary of *Apollo 14*.

February 2021: Maiden flight of KSLV-II (aka *Nuri*), the first South Korean indigenous orbital launch vehicle.

February 18, 2021: The *Mars 2020 rover* lands at Jezero Crater on Mars. It will be carrying the Mars Helicopter Scout, which will deploy in two or three months.

March 30, 2021: Launch of the James Webb Space Telescope.

April 2021: Launch of the IXPE X-Ray Telescope by Falcon 9.

May 26, 2021: 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.

July 2021: 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 2021: 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.

July 26 – August 7, 2021: 50th Anniversary of *Apollo 15*.

August 2, 2021: Saturn is at opposition.

August 19, 2021: Jupiter is at opposition.

September 2021: First Dream Chaser cargo mission to the ISS.

October 2021: 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 2021: Launch of *Hakuto -R*, Japan's lunar lander. (Hakuto is Japan's Moon rabbit, so is equivalent to China's Jade Rabbit.

October 29, 2021: Venus is in greatest eastern elongation 47 degrees from the Sun (hence is visible after sunset.)

December 2021 [VERY 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.]

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

June 2022: Proposed launch date of JUICE, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <http://sci.esa.int/juice>.

June 2022: First crewed launch of an *Orion* space capsule.

June 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 <http://sci.esa.int/euclid>. July 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.

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)).

September 26, 2022: Jupiter is at opposition.

December 2022 (Tentative): Launch of the first module of the Gateway Lunar Orbiter Platform.

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

Last quarter of 2022: Launch of NASA's VIPER lunar rover, which will hunt for ice near the Moon's South Pole.

Last quarter of 2022: Launch of the Einstein X-Ray Probe from China's Xichang Space Center.

Last quarter of 2022: Launch of RSGS (Robotic Servicing of Geosynchronous Spacecraft).

March 2023: Launch of *Hakuto – R Mission 2*, Japan's lunar lander and rover.

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 freereturn mission.

Sometime in 2023 [tentative]: India and Japan launch *Chandrayaan-3*, which will include a lander and a longlived rover which will explore craters around the Moon's South Pole in search of ice.

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

Sometime in 2024: First crewed flight of Russia's *Federatsiya*.

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 Japans *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>.

December 2025: *BepiColombo* arrives at Mercury orbit.

Sometime in 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))

Sometime in 2030: JUICE achieves Jupiter orbit. [See 2022.]

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

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 email 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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