Oklahoma Space Alliance OUTREACH
January 2017

January Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, January 21 (postponed from January 14), 2017 at Earl's Rib Palace, 920 SW 25th St, Moore, OK. This is between the 1-35 West Frontage Road and Telegraph Road, a couple of blocks south of Harry Bears. Telephone number is 793-7427.

Place: Earl's Rib Palace

Moore Oklahoma
2:00-5:00 PM

1) Introductions
2) What's Happening (Steve Swift)
   (Pictures, Videos & Links)
3) Presentation, Videos and Discussion on
   Different Visions of Space Exploration,
   Use and Settlement as Expressed by
   Elon Musk, Jeff Bezos, Richard Branson,
   Robert Bigelow, NASA and Congressman
   Jim Bridenstine.
4) Business
   a. Review OSA Accounts
   b. Annual Report
   c. New Business
5) OSIDA Meeting Report (None this month)
6) Chat

Minutes of December Meeting/Christmas Party

Oklahoma Space had its annual Christmas Party on at the McMurrays' on December 10. Attending were Steve Swift, Kay Fiel, Tom and Heidi Koszoru, Clifford and Claire McMurray, John Northcutt, Tim Scott, Dave Sheely, Brian Swift, Rosemary Swift, and Syd Henderson. This was mostly a social gathering, although we did re-elect our officers to serve in 2017.

--Minutes by OSA Secretary Syd Henderson

Space News

The apparent front-runner for the next Administrator of NASA is Republican Congressman Jim Bridenstine from the district containing Tulsa, Oklahoma. Congressman Bridenstine is former executive director of the Tulsa Air and Space Museum and Planetarium, and is chair of the Subcommittee on Environment within the House Committee on Science, Space and Technology, and a member of the Subcommittee on Space within the same Committee. He is also on the Committee on Armed Services.

Congressman Bridenstine has emphasized space policy while in the House, and has written a lengthy paper of his views on space policy. He introduced the American Space Renaissance Act (HR 4945) early in 2016. For a summary of

this bill, see https://www.congress.gov/bill/114th-congress/house-bill/4945. This bill was referred to the Subcommittee on Space on September 30. I'm not sure what happens to it within the new Congress. Part of the bill deals with the Department of Defense coordinating with the civilian space agencies, and part establishes an Office of Commercial Space Transportation within the Department of Transportation. [I thought we already had something similar.] He also wants NASA to develop a 20 year plan including a Mars mission, and a ten-year plan for the Asteroid Redirect Mission.

OSA's officers have been in contact with Congressman Bridenstine's office over the last couple of years and have a copy of his paper detailing his views on space. Several OSA members met him during the 2012 and 2014 Congressional Blitzes.

SpaceX is returning the Falcon 9 to service this month. They were going to try last Monday, but high winds and weather delayed the launch until at least January 14. This launch will carry telecommunications satellites for the Iridium network. SpaceX lost a Falcon 9 on September 1 in a launchpad accident.

A "luminous red nova" is a stellar explosion caused by the merger of two normal stars. These are much brighter than regular novae, reaching up to 600,000 times the brightness of the Sun, but dimmer than supernovae, the brightest of which are 570 billion times as bright as the Sun, (although 1 – 10 billion times is more typical). One type of supernova produced by the collision of two white dwarfs, which puts their combined mass over the Chandrasekhar limit, making the combined stars into a neutron star and producing a lot of energy and ejected matter.

Luminous red novae (or just red novae), are, of course red, and stay bright for weeks if not months. Interesting, the nova also expands very rapidly to a radius thousands that of the Sun, which means it becomes cool (hence red if not infrared). The result is what appears to be a red supergiant following the initial bright flash.

Figure 1: V838 Monocerotis, a Probable Red Nova Remnant (Wikimedia)

Luminous red novae aren't common, but several have been observed in recent years, including V1309 Scorpii in 2008, and V838 Monocerotis (the one that got 600,000 times as luminous as the Sun) in 2003. Larry Molnar of Calvin College in Michigan claims that he's found a binary system, KIC 9832227, with rapidly decaying orbits that will result in a merger within five years. If he's correct, we'll be able to observe entire collapse and explosion and a second magnitude star will appear in Cygnus. Currently KIC 9832227 is a contact binary, with the two stars sharing an atmosphere.

China has announced plans to launch its first Mars probe by the year 2020. The mission will include an orbiter, lander and a rover. This would actually be a move-up, and the actual launch will probably be in the summer of 2020, which is when the launch window starts.

China already has experience with a lunar rover, Yutu (Jade Rabbit), which landed on the Moon in December 2013 as part of the Chang'e 3 space mission and remained active into 2016. However, Chang'e 3 also carried a moon-based telescope (the first) that as near as I can tell is still active.

China is also planning a lunar sample return mission later this year as part of the Chang'e 5 mission.

NASA has selected two new missions to asteroids, with a bit of a twist. The Lucy mission, which will launch in 2021, will explore both of Jupiter's collections of Trojan asteroids. One of these, the Greek camp is at Jupiter's L4 point, and the other, the Trojan camp, is at its L5 point. (Two of these, Hektor and Patroclus, were named before the convention, and are hence spies in the enemy camps.) The Trojans are expected to be relics of the early solar system that were captured as Jupiter formed. If Jupiter's orbit has moved as some have speculated, the Trojans would have moved with it. There are a lot of Trojans near Jupiter's Lagrangian Points, so Lucy will have many targets.

The Psyche mission, which will launch in 2013, is a mission to the large metal asteroid also named Psyche. 16 Psyche is about 130 miles in diameter, and composed largely of iron and nickel, but may well contain a lot of siderophile (iron-loving) elements that are rare on Earth because they sank into the Earth's core when the Earth formed. Among these are the platinum group elements (platinum, palladium, osmium, iridium, rhodium and ruthenium), gold, silver, cobalt, nickel and rhenium. (Although silver can also combine with sulfur and stay in the Earth's crust, and iron itself forms compounds that make it abundant in the Earth's crust as well as the core.) Metal asteroids will be a major target for space mining since the metals are valuable, useful and rare. (Of course, Psyche is too big a target for the space miners. They want an asteroid small enough to be brought to Earth.

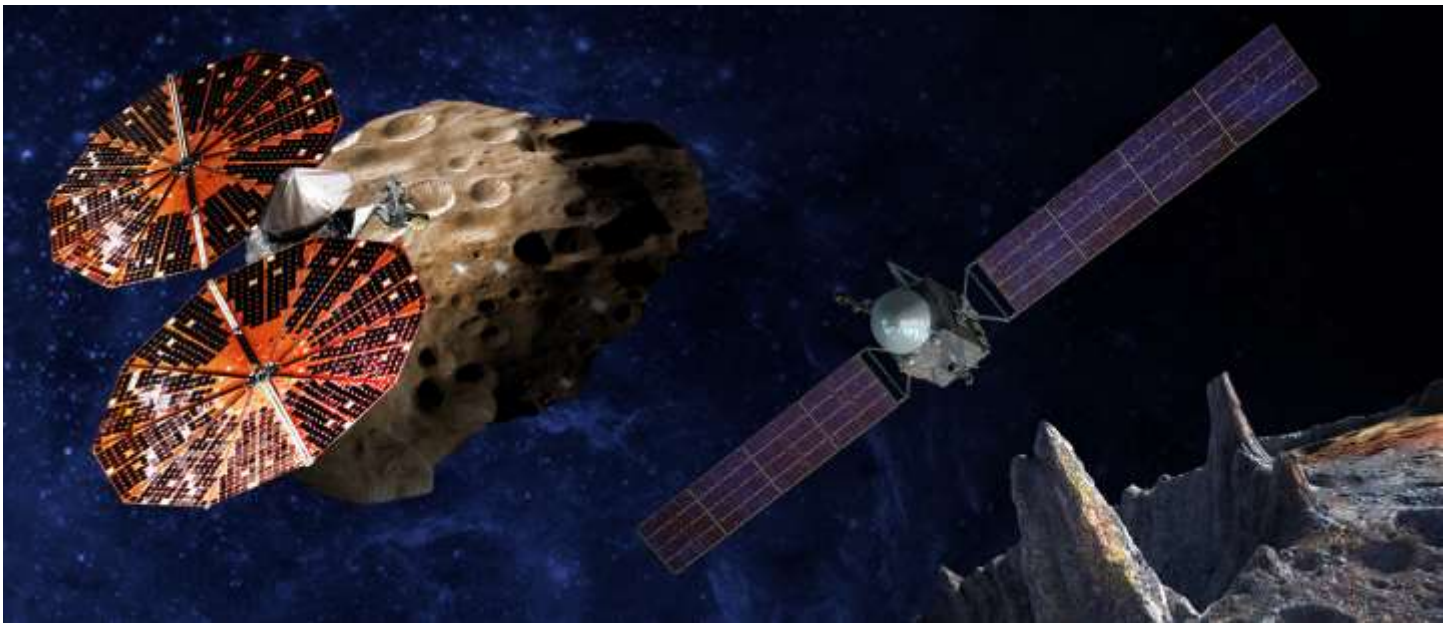

Figure 2 Artist's conception of Lucy and Phober (NASA website)

Sky Viewing

On February 26, there will be an **annular eclipse of the Sun** in the Southern Hemisphere. This will begin over the southeastern Pacific Ocean west of the southern tip of South America, cross southern Chile and Patagonia within Argentina, then cross the Atlantic to pass through Angola and end near the boundary of Zambia and the Democratic Republic of Congo. This eclipse will be partial over the southern two thirds of South America, about half of Antarctica, and western Africa south of the Sahara. It looks to me like peak eclipse is somewhere near the isolated island of Tristan de Cunha.

In addition, there is a penumbral eclipse of the Moon on the night of February 10. Penumbral eclipses are not usually worth looking at, but this time the eclipse is deep enough that the Moon almost enters the Earth's umbra, meaning the Moon will get perceptively dark.

Venus is, of course, blatantly obvious, dominating the western sky for three hours after sunset. It is currently magnitude -4.5 and getting brighter, and is in the constellation Aquarius about eight degrees to the upper left of **Mars**. However, Mars is moving away from us and is only magnitude 0.9. **Neptune** is also in Aquarius, and on January 12 was only four-tenths of a degree from Venus (a little less than the diameter of the Moon). Venus is, and will enter Pisces on January 23, which is where **Uranus** currently resides. But Mars actually visits Uranus: it moves into Pisces on January 18 and coming six-tenths of a degree from it on February 26.

Mars will be easily visible through February, but Neptune will be lost in the twilight after the Sun sets as it approaches its conjunction on March 1.

You can find finder charts for Uranus and Neptune at http://www.skyandtelescope.com/wp-content/uploads/WEB_UrNep16_Finders.pdf

Jupiter is still a morning star, rising around 1:00 a.m., and shining at a conspicuous -2.0 within the constellation Virgo. It's about four degrees from the first-magnitude star Spica but is much brighter. By the end of January, Jupiter will be rising at 11:00 p.m., and by the end of February at 9:00 p.m. It will get up to magnitude – 2.3 but, since it's also going to go into retrograde motion of February 6, it's going to be hanging around Spica for a few months yet.

Mercury will be at greatest elongation on January 19, at which point it will be ten degrees above the horizon a half-hour after twilight. At magnitude -0.2, it should be visible if you have a clear horizon, and will stay that bright through the rest of January. Mercury will get brighter in early February, but also harder to see because it will be in twilight, and will disappear by the end of the month.

Saturn is also a morning star, currently low in the southeastern sky before sunrise (though it is seven degrees higher than Mercury). At the moment, Saturn is rising about two hours before the Sun and is magnitude 0.5. By the end of January Saturn will be rising three hours before the Sun and will rise about 2:30 a.m. at the end of February, staying magnitude 0.5 all the while. It is still moving across the constellation Ophiuchus and is about 15 degrees to the left of Antares. Saturn will move into Sagittarius in late February.

[Information in this section comes from the January and February issues of *Sky & Telescope* and *Astronomy*.]

Space-Related Articles: Top Space Stories of 2016

The January/February issue of *Discover* contains their recap of the top 100 science stories of 2016, many of which are related to space, including the top two. I've been using various sources in producing this article, not just the *Discover* articles,

1) "Found: Einstein's Ripples in Space-Time." In September, 2015 the Laser Interferometer Gravitational-Wave Observatory (LIGO) in Hanover, Washington, made the first detection of gravitational waves[1]. Ten milliseconds later the waves were detected by a second LIGO in Livingston, Louisiana. The waves were produces by the collision of two binary black holes 1.3 billion light-years away with respective masses of 36 and 29 Suns. By the time the results were confirmed, and announced earlier in February, a second, smaller collision, was already detected (and announced in June), and a third one has since.

   These were the first direct detection of Einstein's predicted gravitational waves, but in 1974, Russell Hulse and Joseph Taylor, Jr., discovered a binary pulsar and the decay in their orbit matched that predicted if they were producing gravitational radiation. (They won the Nobel Prize in Physics in 1993.)

   The amount of energy released in these collisions is enormous. The first pair of black holes coalesced into a black hole with a mass of 62 Suns. The other three Suns-masses were converted into gravitational waves. In the second collision, black holes with masses 14.2 and 7.5 times that of the Sun produced a 20.8 solar mass black hole, the other 0.9 solar masses being converted into gravitational waves.

   Gravitational waves should also be produced in great numbers in supernova explosions (but only if the explosion is asymmetric), colliding massive stars (in which case we should also see a tremendous amount of electromagnetic radiation as well.)

   For the near future, we should be detecting several events per year producing gravitational waves, but they are so weak that we can only detect the most extreme events. Presumably more sensitive future detectors will be developed. One exciting property of gravitational waves is that they should have passed undisturbed during the peri-

[1] Not to be confused with *gravity waves*, which are waves produced when gravity tries to restore equilibrium in a medium that is being moved by another force, for example waves in the ocean being formed under the influence of wind and gravity.

od when the Universe was opaque, so they potentially give us a glimpse of a period of the Universe's history we would not otherwise be able to see. (Neutrinos have a similar property but are also hard to detect.)

2) "Earth's Surprise Neighbor Hints at Exoplanet Abundance." Two years of observations have confirmed to a very high probability that Proxima Centauri, the nearest star to the Sun, has at least one planet, and that that planet lies in Proxima's habitable zone. Since Proxima is a flare star, and the planet would likely have its rotation period locked to its orbital period (i.e., one side would always face Proxima and the other be in darkness), it doesn't seem likely that life exists there. However, there are proposals to send a probe there just in case. [See #100.]

6) "The Pace – and Problems – of Climate Change Accelerate." With the assistance of a powerful El Niño, 2016 was the hottest year since satellite records have been kept. Carbon dioxide levels reached 400 parts per million, the highest level in four million years (i.e. Lower Pliocene, the Pliocene being the epoch that ends with the first glaciation of the Ice Age.) Among the effects were extreme weather events, including once in a millennium rains in Louisiana, record floods in West Virginia, severe droughts in California and southern Africa, and 129″ F weather in Kuwait. (At least that's a dry heat—I hope. In Bandar Mahshahr on the Iranian coast of the Caspian Sea, it hit 115° which combined with high humidity produced a heat index of 165° F—which, amazingly, is not a world record, but it comes close.)

8) "Looking for Planet Nine." The discovery that the orbits of objects just beyond the Kuiper Belt tend to cluster in strange groups indicate to astronomers Mike Brown and Konstantin Batygin that a planet with about ten times Earth's mass orbits is perturbing their orbits. If such a planet exists, it should be within reach of telescopes, the catch being that no one knows where in its orbit it might be, and it would be in a highly elliptical orbit.

14) "The Ozone Hole Is Finally Healing." Back in the 1970s it was discovered that the ozone layer that surrounds the Earth was being depleted, particularly severely in the Polar Regions, a phenomenon called the 'ozone hole.' (Two holes actually, one around each pole, though the Antarctic one is the more severe and famous one.) This caused great alarm, since the ozone layer protects us from the energetic parts of the ultraviolet spectrum.

A primary cause was traced to the use of chlorofluorocarbons, which were heavily used in refrigeration and aerosol cans, partly because they were supposed to be inert and safe. But it turned out that CFCs decompose in the upper atmosphere, producing chlorine atoms which steal the third oxygen atoms from ozone molecules. The chlorine oxide (ClO) which is produced can steal an oxygen atom from another ozone molecule, in a reaction that produces an oxygen molecule and frees the chlorine atom to continue its career of marauding catalysis. It is estimated that a single chlorine atom can destroy 100,000 ozone molecules. (Bromine atoms are even more efficient ozone-killers but are much less common.) The career of a chlorine marauder is about two years before it finds something else to combine with and becomes a model citizen.

Evidence eventually became strong enough that an international agreement, the Montreal Protocol, banned ozone-depleting chemicals in 1989. It's been twenty-seven years since the Protocol, and the ozone hole has shrunk by 1.5 million square miles since 2000, and there's hope that it will be back to normal in about another forty years.

[A side effect of banning CFCs was to slow warming of the Earth since they are potent greenhouse gases.]

17) "The Falcon Has Landed. Now SpaceX Is Eyeing Mars." On April 9, a Falcon successfully landed on a drone ship, the first time SpaceX succeeded in doing that. The previous December, they'd succeeded in landing at Cape Canaveral. Elon Musk has also announced that sometime in 2018 he'll send an unmanned spacecraft to Mars, and continue to send spacecraft at 26 month intervals for the foreseeable future.

20) "Ceres Hosts an Ice Volcano." Yes, indeed. Ahuna Mons is about 16,000 feet tall and is apparently unique on Ceres. Because Ceres is cold and has low gravity, ice mountains are stable there. Ahuna Mons is almost directly opposite the largest impact crater on Ceres and perhaps that had something to do with its formation.

33) "Planets of the Milky Way." Analysis of Kepler data has revealed another 1284 exoplanets, almost doubling the number of confirmed exoplanets to 2591. Of the 2591, 219 are approximately Earth-sized (.7 to 1.2 Earth radii) and another 728 are "super-Earths" (meaning they have a radius between 1.2 and 1.9 times that of Earth.) There are also 17 confirmed exoplanets with radius .5 to .7 times that of Earth. These are termed "Mars." The most common kind of exoplanets is "Mini-Neptunes," with 1.9 – 3.1 Earth radii, but that's probably a bias since larger planets are easier to detect. There are 917 known mini-Neptunes, which is not that many more than super-Earths. On the other

hand, there are definitely more mini-Neptunes than larger planets. [The number of known exoplanets is now 3557, another big jump just since the article was written. I'm not sure if there's been a big jump in confirmed exoplanets or whether some people are using more lenient criteria.

40) "Pluto's Hidden Ocean." The *New Horizons* spacecraft discovered signs that Pluto has been unexpectedly active, with ice volcanos, glaciers and long mountain chains and fissures. One theory that's gaining support is that Pluto has a subsurface ocean that is slowly freezing. [Why it hasn't already frozen is a bit of a mystery, but then there are a lot of unexpected subsurface oceans being discovered in the outer solar system, including possibly Ceres as well.]

41) "Bad Moon Rising." A team led by Satoshi Ide of the University of Tokyo has discovered that there is a tendency for larger earthquakes to occur near the full or new Moon, which is when the Earth, Moon and Sun are in line. The effect is small and there are many other factors involved in creating earthquakes, so this is less useful for predicting specific earthquakes than giving seismologists (and relief agencies) a warning when to look for major catastrophes.

48) "Babylonian Tablets Tracked Jupiter." Well, of course they did; the Babylonians were the prime astronomers of the ancient world. The surprise here is that they used the trapezoidal method to track Jupiter, which anticipates the calculus. [Except that it's also how you do interpolation.]

57) "The Tsunamis of Mars." About 3.5 billion years ago, on two separate occasions, large meteors splashed into Martian oceans, producing waves over 400 feet tall. Not altogether surprising, except this indicates that there actually were Martian oceans at the time, which wasn't actually clear.

67) "Mirror Image Molecule Far, Far Away." Any time you have a molecule with an atom (usually carbon) which has three different groups attached to it (or a compound where two carbon atoms have a double bond and each carbon has two different groups attached to it[2]), you have the possibility of having two different molecules which are mirror images of each other. (The technical term is that the molecule with a mirror image is chiral.) In 2016, astronomers detected 1,2 propylene oxide in space, and it is the first chiral molecule. [This strikes me as being inevitable once you find a sufficiently complex molecule. What would have been really notable is if only one of the chiral molecules had appeared. If that happened, it would revolutionize astrochemistry.]

72) "How Juno Met Jupiter." Although it is more notable now when Juno has had a chance to observe Jupiter's polar regions. Good though it got there.

78) "A Dark Milky Way." Not our Milky Way; astronomers are finding galaxies that have hardly any stars, one of which, Dragonfly 44, is about as massive as the Milky Way. The proposal is that Dragonfly 44 is composed almost 99.99% of dark matter. I think the ranking here is too conservative. This is a truly remarkable finding that has me baffled (how could dark matter be so completely segregated?) and indicates a process about which we haven't a clue.

87) "Supernova Shocker." I confess the explanation here doesn't make sense, but what happened is that astronomers observed the shockwave breakout produced by rebounding matter in a supernova. This shockwave lasts less about twenty minutes and it requires an amazing amount of luck to observe.

100) "Breakthrough to the Stars." On April 12, Yuri Milner revealed a program, Breakthrough Starshot, to send a flotilla of space probes to Alpha Centauri. These probes would weigh less than a gram, and be attached to light sails that would be propelled by Earth-based lasers. It would take 20 years for these miniprobes to reach Alpha Centauri. The miniprobes would be travelling at twenty percent of the speed of light, be incapable of slowing down, and it's not clear to me how any signal they sent back would be powerful enough to be detected from Earth. The proposal has gotten more attention than usual because it's attracted the support of Stephen Hawking.

With the detection of a planet orbiting Proxima Centauri, some of these probes will be turned in that direction.

[2] Actually important, because this is what distinguishes healthy fats from trans fats.

More Space-Related Articles

"'Alien Megastructure' Signal May Be Due to Star Eating a Planet," by Leah Crane, newscientist.com, 9 January 2017. Tabby's Star still attracts tons of theories because scientists still cannot explain its irregular dimmings. One hypothesis was that it was because of a megastructure constructed by extraterrestrials. This time the theory is that sometime in the recent past, Tabby's star ate one of its planets and the dimming is caused by debris left over from its messy lunch.

Viewing Opportunities for Satellites (January 14 to February 14, 2017)

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.

http://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/JavaSSOP.html gives coordinates at 20-second intervals from when the satellite rises, not from when it peaks. I'm using its information for the International Space Station and Hubble Space Telescope, interpolating when necessary. It doesn't give you information for Tiangong 1 or Tiangong 2, so I'm using Heavens Above for those. The *Sky & Telescope* web site carries International Space Station observation times for the next few nights at skyandtelescope.com/observing/almanac.

With the addition of the solar panels, the International Space Station can be as bright as magnitude -3.5, 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, although, since it is lower in the sky, it is more difficult to see. China's Tiangong 1 space station can get up to magnitude -0.6, which is brighter than all the night stars except Sirius and Canopus. With this issue, I'm also including data for Tiangong 2, which can get up to magnitude 0.4 at least.

Missions to and from the International Space Station or Tiangong-2 may change its orbit. The next launch to the ISS is in March, after the sightings below. There are no launches scheduled for Tiangong 2 during this time period.

The Hubble Space Telescope has no good viewing opportunities during this time period.

Tiangong 2 January 18, 2017

Time	Position	Elevation
6:53 a.m.	232°	10°
6:56	151	63
6:59	68	10

Tiangong 2 January 20, 2017

Time	Position	Elevation
Appears from Earth's Shadow		
6:25 a.m.	252°	28°
6:27	333	77
6:30	61	10

Tiangong-1 January 24, 2017

Time	Position	Elevation
6:48 p.m.	195°	10°*
6:51	152	75
6:52:44	70	26

*Passes five degrees below Venus
Vanishes into Earth's Shadow

ISS January 27, 2017

Time	Position	Elevation
7:23 p.m.	228°	22°
7:24	229	42
7:25	304	88
7:25:23	44	60

Vanishes into Earth's Shadow

ISS January 28, 2017

Time	Position	Elevation
6:30 p.m.	195°	19°
6:31	177	30
6:32	133	40
6:33	89	30
6:34	71	18

ISS January 29, 2017

Time	Position	Elevation
7:14 p.m.	247°	17°
7:15	287	27
7:16	333	33
7:17	1	26

Vanishes into Earth's Shadow

ISS January 30, 2017

Time	Position	Elevation
6:22 p.m.	239°	21°
6:23	250	40
6:24	295	68
6:25	28	40
6:26	39	21

Tiangong 1 February 4, 2017

Time	Position	Elevation 6:50
p.m.	301°	10°
6:53	24	65
6:55:30	105	17

Vanishes into Earth's Shadow

Tiangong 2 February 11, 2017

Time	Position	Elevation
7:07 p.m.	217°	10°
7:09	147	38

7:10:39	97	25	6:36 a.m.	234°	10°
Vanishes into Earth's Shadow			6:39	151	68
			6:42	67	10

Tiangong 2 February 13, 2017

Time	Position	Elevation

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 see the International Space Station at 6:23 p.m. on January 30, measure two fist-widths south from due west, then four fist-widths above the horizon.

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

Calendar of Events

Sometime in 2017 [tentative]: China launches the *Chang'e 5* lunar sample return mission.

Sometime in 2017: India launches *Chandrayaan 2*. This mission will include a lunar rover. For more information, visit http://en.wikipedia.org/wiki/Chandrayaan-2. [Moved from 2014.]

February 26: Annular solar eclipse touching the southern tip of South America, the south Atlantic Ocean, and Angola.

February: Launch of expedition 50 to the Space Station.

March: Launch of the Green Propellant Infusion Mission (GPIM) by a SpaceX Falcon Heavy rocket. This mission is "green" because the fuel it uses, hydroxylammonium nitrate produces nontoxic gases when it burns, unlike hydrazine.

March 1: Neptune is in conjunction with the Sun.

March 11: Launch of Expedition 51/52 to the Space Station.

March 25: Venus is in inferior conjunction with the Sun.

May 12: First demo flight of SpaceX's Dragon 2 Spacecraft, which will be the first commercial spacecraft capable of carrying humans to orbit (as well as the first human-rated space vehicle capable of making a soft landing on Earth.) Possibly may be postponed after the launch pad explosion earlier next month.

May 29: Launch of Expedition 52/53 to the Space Station.

June 3: Venus is at greatest western elongation, 46 degrees from the Sun (so can be seen before sunrise).

August: First crewed demo flight of SpaceX's Dragon 2 Spacecraft.

August 21: The next total solar eclipse visible in the United States, on a pretty straight path from Portland, Oregon to Charleston, South Carolina. St. Louis is the biggest city in-between.

September 15: The *Cassini* spacecraft will end its mission with a plunge into Saturn's atmosphere.

September 30: Launch of Expedition 53/54 to the Space Station.

November: Launch of Expedition 54/55 to the Space Station.

December: Orbital test flight of Boeing's CST-100 Starliner, which will be capable of carrying humans to orbit. See https://en.wikipedia.org/wiki/CST-100_Starliner for details.

December: Launch of the European Space Agency's CHEOPS space telescope, which will study exoplanets, which transit their star's disc. Project website is http://sci.esa.int/cheops.

December: Proposed launch of TESS, the Transiting Exoplanet Survey Satellite. Unlike *Kepler*, TESS will (if approved) conduct a full sky search for exoplanets. For information, visit space.mit.edu/TESS.

Late in 2017: SpaceX launches the Google Lunar X Prize Moon landing. This includes a lander and a rover. See http://lunar.xprize.org/ and en.wikipedia.org/wiki/Google_Lunar_X_Prize for details. Sometime in 2018: Launch of *InSight*, a lander that will probe the interior of Mars. For information, see http://insight.jpl.nasa.gov/. [Postponed from March 2016.]

Sometime in 2018: Possible unmanned SpaceX mission to Mars.

February 2018: Crewed orbital test flight of Boeing's CST-100 Starliner to the ISS. See https://en.wikipedia.org/wiki/CST-100_Starliner for details. April 2018: The European Space Agency/JAXA *Bepi-Colombo* Mercury Orbiter is launched. [Postponed from January 2017.] Home page is http://sci.esa.int/bepicolombo.

May 2018: ESA launches the *ExoMars Mars Rover*. For more information, visit en.wikipedia.org/wiki/Exomars.

July 31, 2018: Proposed launch date for *Solar Probe Plus*, which will study the corona of the Sun from within four million miles. For more information, visit http://en.wikipedia.org/wiki/Solar_Probe_Plus or http://solarprobe.jhuapl.edu/. (This spacecraft will fly by Venus seven times to refine its orbit.)

October 2018: Earliest date for the launch of the James Webb Space Telescope.

October 2018: Launch from Cape Canaveral of the European Space Agency/NASA Solar Orbiter (SolO), which will orbit the Sun at a distance closer than Mercury. Web site is sci.esa.int/solarorbiter. [Moved from July 2017.]

January 1, 2019: *New Horizons* flies by the Kuiper Belt object 2014 MU_{69}.

September 2019: Arrival of OSIRIS-Rex at the near-earth asteroid 101955 Bennu to return samples. For more information, visit http://en.wikipedia.org/wiki/OSIRIS-REx or http://science.nasa.gov/missions/osiris-rex/.

Sometime in 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.

Sometime in 2020: First launches of the modules of the Chinese space station *Tiangong-3*. The station should be finished by 2022.

Sometime in 2020: Launch of ESA's *ExoMars Mars Rover*. For more information, visit en.wikipedia.org/wiki/Exomars.

July 2020: United Arab Emirates launch the Mars probe *Hope*.

Sometime in 2022: Proposed launch date of JUICE, the Jupiter Icy Moon Explorer, by the European Space Agency. The JUICE web site is http://sci.esa.int/juice.

January 2022: *BepiColombo* arrives at Mercury orbit.

December 19, 2024: *Solar Probe Plus* makes its first pass through the outer corona of the Sun. [See July 31, 2018.]

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. This one is also visible in Salt Lake City, Denver, Little Rock (again), Tampa Bay and New Orleans.

Oklahoma Space Alliance Officers, 2017 (Area Code 405)

Steve Swift, President & *Update* Editor	496-3616 (H)
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E-mail for OSA should be sent to sydh@ou.edu. Members who wish their e-mail addresses printed in *Outreach*, and people wishing space-related materials e-mailed to them should contact Syd. Oklahoma Space Alliance website is chapters.nss.org/ok/osanss.html. Webmaster is Syd Henderson.

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 202-429-1600. Executive Director e-mailnsshq@nss.org. The Chapters Coordinator is Bennett Rutledge 720-641-7987, rutledges@chapters.nss.org. The address is: National Space Society, 1155 15th Street NW, Suite 500, Washington DC 20005 Web page is www.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].

OKLAHOMA SPACE ALLIANCE
A Chapter of the National Space Society

MEMBERSHIP ORDER FORM

Please enroll me as a member of Oklahoma Space Alliance. Enclosed is:
_____ $10.00 for Membership. (This allows full voting privileges, but covers only your own newsletter expense.)
_____ $15.00 for family membership

_____ TOTAL amount enclosed

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.

Do you want to be on the Political Action Network?
_____ Yes_____ No. [See brochure for information.]

Name_____

Address_____

City_____ State___ ZIP_____

Phone (optional or if on phone tree)_____

E-mail address (optional)_____

OSA Memberships are for 1 year, and include a subscription to our monthly newsletters, *Outreach* and *Update*. Send check & form to **Oklahoma Space Alliance, 102 W. Linn, #1, Norman, OK 73071.**