Oklahoma Space Alliance OUTREACH
March 2016

March Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, March 12, 2016 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.

Program
Place: Earl's Rib Palace
Moore Oklahoma
2:00-5:00 PM

1) Introductions
2) Enjoy Meal or Snack During Meeting
3) What's Happening (Steve Swift)
   (Pictures, Videos & Links)
   a. Review Selected Events in 2015
   b. See Pictures and Videos
4) More Discussion of *Phase Shift*
5) Discuss Business
   a. Review OSA Accounts
   b. Summary of February Meeting
   c. Discuss Activities for 2016
   d. Yuri's Night
6) OSIDA Report
7) Chat

Minutes of February Meeting

Oklahoma Space Alliance met at Earl's Rib Palace in Moore on February 13, 2016. Attending were Steve, Karen and Brian Swift, Kay Ferrell, Syd Henderson, Claire and Clifford McMurray, Tim Scott, Dave Sheely, Rosemary Swift, Jerry, Kaitlyn, Rachelle and Stephanie Thibodeau, Dennis Wigley, and two attendees, Jared and Gary, whose last names I didn't catch.

The New Shepard suborbital spacecraft flew again, marking the first commercial reusable booster to be used on two space flights. We watched a video of the launch.

Steve elaborated on his article in the February *Update* about a "phase shift" in space with many new things happening at once. What the commercial space industry is doing now is amazing. We need to take advantage of Congressman Bridenstine's interest in space. Bridenstine has long had an interest in space and is a former director of the Tulsa Air and Space Museum and Planetarium.

NASA has awarded cargo transport contracts to Orbital Sciences, Sierra Nevada and SpaceX. We watched a video of Sierra Nevada's Dream Chaser cargo system. Kip McMurray mentioned that the maximum force on re-entry of the latter is only two G.

SpaceX's last Falcon 9 version 1.1 launched the Jason 3 spacecraft; however, the attempted landing of a Falcon 9 booster on a floating target was only partially successful, with the booster hitting the target then falling over.

We looked at a Moon Day article by Ken Murphy of the North Texas NSS Chapter.

Steve showed us a survey of the floor of the Indian Ocean that was created using NASA technology.

We watched a video of an astronaut who uses water-repellant ping-pong paddles to show how water behaves in microgravity.

We watched a video on mining asteroids from TED^{x} at Harvard University.

Steve and Karen Swift and Rosemary Swift attended Aviation and Aerospace Day at the State Capitol. Karen took pictures.

SpaceX has test-fired a recovered Falcon-9 booster. We watched a video.

Russia is building a large methane-powered engine.

Among the phase-shift technologies:

The Falcon-9 Dragon capsule will be carrying astronauts to space, returning that capability to the United States. Its launches are cheaper and will be much more common than those of the shuttle.

Elon Musk unveiled the "Iron Man" technology allowing us to view and rotate 3D images. We watched a video.

Upcoming satellite technology includes electric propulsion, denser electronics, improved imagery, inflatable space modules, and the Cygnus and Dragon capsules [as well as Blue Origin]. Countries with varying level of launch capacities include the United States, North and South Korea, Ukraine, France, Russia, Japan, Israel, China, India, and Iran, not to mention the European Union.

Oklahoma Space Alliance Business:

The annual report is ready to send in to NSS.

Can two people have access to our space account?

Can two people have access to our web site. [Yes, I just have to give them the username and password, which are not confidential with the secretary.]

Claire wants someone to send personal messages every time someone joins meetup.

Space News

The big news last month was confirmation of the first direct detection of gravitational waves by LIGO, interestingly before LIGO was officially looking for them. The detection was actually made last September, and a second instrument also detected the waves a fraction of a second later. This discovery will probably win a quick Nobel Prize for someone on the LIGO team, but nobody's quite sure who yet. It would be the second Nobel for gravitational waves, the first being for indirect evidence from the decay of the orbits of a double pulsar system back in the 1970s.

Although gravitational waves are barely detectable even by LIGO, they represent a method of observing distant events that are not dependent on electromagnetic radiation. As such, they could reveal events hidden from us.

The event detected by LIGO was the merger of two black holes with respective masses 29 and 36 times that of the Sun. The result was the creation of a black hole with 62 solar masses and the release of three solar masses worth of gravitational waves. Interestingly, a gamma-ray pulse was detected by the Fermi Gamma-Ray Space Telescope 0.4 seconds after the merger of the black holes was observed. This leads to speculation that the two black holes were actually the former core of a supermassive star whose remains still surrounded them and was destroyed by the merger of the black holes. In this scenario, the two black holes resulted from a rapidly spinning collapsing core, and merged within a few minutes of formation.

LIGO has apparently detected several other bursts of gravitational waves, but the team is still trying to detect whether that indeed is what they are,

The One-Year Space Mission finally ended on March 1 with the landing of a Soyuz space capsule in Kazakhstan. Astronaut Scott Kelly and Cosmonaut Mikhail Kornienko spent 340 continuous days in space, which for Kelly is easily the longest continuous stay in space for any American. It was only the fifth longest stay for a cosmonaut, Vladimir Titov and Musa Manarov spent a few hours less than a year on Mir in 1987 and 1988, and their record was broken by Valery Polyakov who spent 437 days aboard *Mir* in 1994 and 1995.

Adding all four of his missions together, Kelly has now spent 540 days in space. Kelly is weak, of course, but also expressed interest in a future flight into space aboard a commercial spacecraft.

Recently discovered exoplanet BD+20594b is one of those that defies theory. The planet is 16 times as massive as Earth but has a diameter 2.2 times as big. This comes to a density around 8 times that of water. By comparison, Earth has a density around 5.5 times that of water and is the densest planet in the solar system. This means BD+20594b must be composed almost entirely of rock and metal despite being almost as massive as Neptune. It had previously been thought that any planet that massive must be a gas giant. For a detailed article, see http://beyondearthlyskies.blogspot.com/2016/01/bd20594b-is-neptune-sized-mega-earth.html.

A couple years ago it was discovered that a number of galactic superclusters, including the Virgo Supercluster which contains the Milky Way, were part of a larger supercluster (or what I call a superdupercluster) called Laniakea, which contains 100,000 galaxies and was then the largest structure within the known Universe. This didn't last long. It is now superseded by the BOSS Great Wall, which is a billion light-years across, two-thirds larger than Laniakea. Note, though, that this is based on a study of only 830 galaxies, and there must be more than a hundred thousand we can't see,

The Hubble Space Telescope has (again) found the most distant known galaxy. This galaxy, GN-z11, has a red shift of 11.1 and we are seeing it at a time 400,000,000 years after the Big Bang. This is really young astronomically speaking: the first stars are believed to have started to form 100,000,000 years after the Big Bang, and GN-z11 has a billion suns worth of mass in its stars, and is forming stars at dozens of times the rate of the Milky Way. GN-z11 is so bright that it emits three times as much light in the ultraviolet as other early galaxies, although, since it has such an enormous red-shift, its light is now well into the infrared. This is fortunate for us because the Universe is transparent at many of the wavelengths we're receiving from GN-z11.

This distance record will probably only stand until 2018 or 2019 since the James Webb Space Telescope will be capable of seeing much farther into the infrared spectrum.

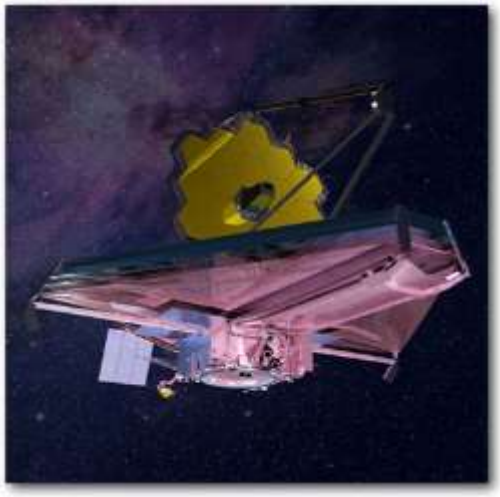

Figure 1 The James Webb Space Telescope (NASA)

The next generation beyond the next-generation James Webb Space Telescope will be the Wide Field Infrared Survey Telescope (WFIRST), approved on February 17, which is currently projected to launch in the mid-2020s. In a sense, this is a step backward since its mirror is much smaller than the Webb telescope—about the size of Hubble's as a matter of fact. However, it makes up for it by having a much larger field of view. In this case, NASA doesn't have to worry about making a new mirror, because it's using the one of the mirrors donated by the National Reconnaissance Office in 2011. Apparently the length of time for launch is for making all the other instruments associated with WFIRST. WFIRST also has the advantage that it photographs at a much higher rate of speed, and, since it will be an infrared telescope, be able to directly image exoplanets, using coronagraph to block the light of the parent stars. (The Webb telescope will also be able to do this, but WFIRST will do it more efficiently.) Both telescopes are going to the L2 point of the Earth-Sun system. This Lagrangian point lies on the side of the Earth away from the Sun, and, though unstable, requires satellites expend minimal fuel.

Now I wonder how powerful the mirrors are that the NRO keeps for itself.

The Kepler spacecraft has discovered an exoplanet orbiting the 16th magnitude red dwarf star K2-25 in the Hyades star cluster in Taurus. The planet is 3.5 times the diameter of Earth. This is remarkable since that is 10 percent the diameter of width of its star, which is unprecedented for a planet of a red dwarf. (Note, though, that Jupiter has almost exactly ten percent of the diameter of the Sun, so it's not *that* unprecedented.) Since K2-25b also orbits its star with a period of 3.8 days, it must be very hot with a puffed up atmosphere, and is probably very young. This isn't that surprising since the Hyades star cluster is no more than 800 million years old. Thus, this is one of the youngest planets known.

It's very likely that we will soon be finding much younger planets than this, since Kepler is also taking a close look at the Pleiades, which are only 110 million years old.

Kepler is also about to start trying yet another method of finding exoplanets. When a massive object lies between us and another object, the light from the farther object bends a bit around the nearer, an effect called gravitational lensing. Although this effect is most famous when the nearer object is a galaxy, this also applies if the nearer object is a planet, and Kepler should be able to detect planets around other stars because stars further out will be seen to wiggle. (WFIRST will also be able to do this.) This technique can potentially reveal planets a twentieth the mass of Earth.

[Sources: http://www.skyandtelescope.com/astronomy-news/nasa-unveils-wfirst-next-decade-space-telescope-02222016/ and Wikipedia.]

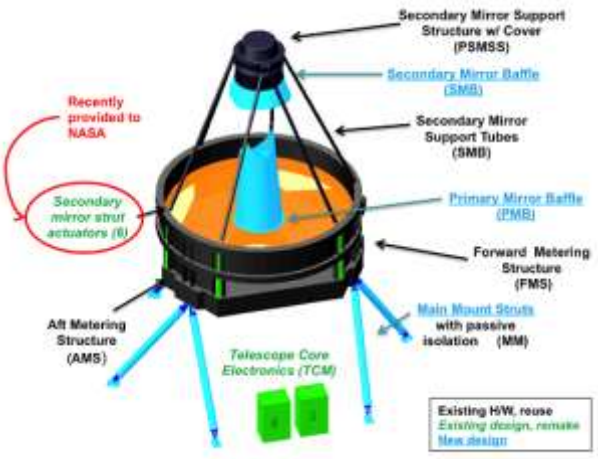

Figure 2 The WFIRST Space Telescope (From NASA.Gov)

Scientists are speculating from data from the *Messenger* mission that the reason that the surface of Mercury is darker than that of the Moon (which is itself as dark as coal) is because the surface of Mercury contains large amounts of graphite. This would have come to the surface when the surface of Mercury cooled because graphite floats on magma. No word why Mercury would have so much more graphite than the Moon or Mars, but it may have something to do with Mercury also having a relatively thin crust.

[Source: www.sciencemag.org/news/2016/03/mercury-covered-pencil-lead]

Sky Viewing

Jupiter was at opposition on March 8 and will be visible all night long in March and April. Jupiter is magnitude -2.5, almost a full magnitude brighter than Sirius, the brightest star in the night sky, and, with Venus only visible just before dawn, has no competition other than the Moon and the space station. It's currently in the constellation Leo, but away from the main stars in the constellation.

Mars will be at opposition at the end of May, and is already brightening rapidly. Currently it is at magnitude 0.2 and in the constellation Libra, not far from the first-magnitude star Antares in Scorpius. However, by the end of March, Mars will have brightened to magnitude -0.5, and by the end of April, will be magnitude -1.4, brighter than any star but Sirius. Currently it is rising around midnight, and rising earlier each night, so by late April it will be rising around 10 o'clock. In the meantime, it will cross into the constellations Scorpius and Ophiuchus, then go into retrograde motion as the Earth catches up to it, moving back in Scorpius and north of Antares again.

Saturn is already in Ophiuchus, about fifteen degrees east of Mars, and at magnitude 0.5. It will be in the constellation all March and April, brightening slightly as it nears an opposition at the beginning of June. Saturn's rings are also well-positioned this spring. On the night of April 25, the Moon, Mars, Saturn and Antares will all be within a 10° circle; that is, they would all fit within your fist at arm's length.

Being that Saturn and Mars are close together in the sky, it's not surprising that a conjunction coming up. The next one will be August 24 in the constellation Ophiuchus, when they'll be about four degrees apart. However, they'll be pretty close in the sky for the next five months.

Mercury is currently near conjunction with the Sun, and is not visible. However it is approaching its best appearance of the year. By the end of the month, Mercury will reach magnitude -1.6 and may be visible through binoculars. Mercury reaches greatest elongation on April 18, at which time it will be visible ten degrees above the western horizon 45 minutes after sunset. On April 8, Mercury will be about eight degrees to the lower right of the Moon.

Venus is barely visible in the east-southeast right before sunrise, and will be in about that position through the end of March. It's not in superior conjunction with the Sun until June, but will be mostly not visible from mid-April through late August.

Uranus is low in the western sky after sunset and is potentially visible with binoculars. Soon even this will be impossible as it nears an April 9 conjunction with the Sun. **Neptune** was in conjunction with the Sun on February 28, and will not be visible until late April, which, since it never gets brighter than magnitude 7.8, it's not visible except through binoculars or a telescope.

The asteroid **6 Hebe** makes its closest approach to Earth on March 15 (about 176 million miles and is at opposition in Leo on March 17 with a magnitude of 9.5. This is a rather poor opposition: Hebe can reach magnitude 7.5. It was the sixth asteroid to be discovered (hence the 6 before its name), and is the fifth brightest asteroid, after 4 Vesta, 1 Ceres 7 Iris, and 2 Pallas. (If you're curious, 3 Juno is about as bright as Hebe and 5 Astraea is 17th in brightness.)

Hebe, and especially Astraea played a role in history similar to that of Eris in the early 21st century: up until 1847, only four asteroids were known, and they all got reasonably bright, with Vesta even reaching naked-eye visibility, and even Juno and Hebe occasionally getting brighter than Neptune. Hence all four of them were considered to be planets, especially since no asteroid had been discovered in nearly four decades. The discovery of Astrea and Hebe, and the nearly simultaneous discovery of Neptune led to the demotion of all the asteroids out of the list of planets, although Ceres has recently been elevated again to dwarf planethood with the discovery of Eris and the demotion of Pluto to dwarf planethood.

Hebe could be important in another way: some astronomers estimate that it is the source of forty percent of the meteorites that reach the surface of the Earth. Apparently it must have been shattered by some huge collision in the past.

Hebe is not super-bright, but it's in a good position for observation a couple of degrees north of the bright star Denebola, which marks the tail of Leo the Lion. There is a finder chart on page 43 of the April issue of *Astronomy*.

[Material for this section of *Outreach* derives from the March and April issues of *Astronomy* and *Sky & Telescope*, the *Sky & Telescope* and Astronomy web sites, and Wikipedia articles on Hebe and Astraea.]

Space-Related Articles

"Fire in Microgravity," by Indrick D. Wichman, Sandra L. Olson, Fletcher J. Miller and Ashwin Hariharan, *American Scientist*, January – February, 2016, pp. 44 – 51. This is not to be confused with those studies of candles burning in microgravity. There have been a number of studies on how to extinguish a fire in space, and one obvious thing to try is cutting down the oxygen. However, one effect is that the flame, rather than decreasing slowly to nothing, suddenly breaks into many three-dimensional firelets that survive even under conditions that would extinguish a normal flame. This, of course, is not good.

The effect isn't limited to microgravity, although its rare on Earth, but does occur in some situations where there is little air circulation, such as a forest fire when the wind dies down, or a confined electrical fire. It's believed such a fire destroyed the Swissair Flight 111, when a small fire burnt without the flight crew being able to find it until it breached a vent cap, and, finally finding an adequate air supply, burst fully into flame, destroyed the electrical system and crashed the plane killing over 200 people. This article concerns earthbound experiments to mimic those done in space.

"The Next Big Eye," by Daniel Clery, *Science*, 19 February 2016, pp. 804 – 809. Overview of progress on the James Webb Space Telescope.

"Our Two-Faced Moon," by Paul D. Spudis, *Sky & Telescope*. April 2016, pp. 16 – 21. It has been known since the first photographs from *Luna 3* that the far side of the Moon looks very different from the near side, with all the maria being on the near side. In fact, the crust of the far side is much thicker, and, since the crust is light compared with the mantle and core of the Moon, the center of mass of the Moon is actually a couple of miles closer to the Earth than its geometric center. This is a major reason the Moon presents only one side to the Earth. The difference in this crust thickness is a mystery, although there are no lack of hypotheses, including impacts (but why all on one side) and heat from the primordial Earth keeping one side of the Moon molten while rock solidified on the other side.

Viewing Opportunities for Satellites (March 12 to April 12, 2016)

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, so I'm using Heavens Above for that. 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.

Missions to and from the International Space Station may change its orbit. The next launch to the ISS is that of Expedition 47 at 4:26 p.m. on March 18. The next Cygnus launch to the Space Station is March 22.

HST March 14, 2016

Time	Position	Elevation
5:35 a.m.	223°	20°
5:36	204	27
5:37	177	31
5:38	150	27
Vanishes into twilight		

Tiangong 1 March 14, 2016

Time	Position	Elevation
6:38 p.m.	232°	10°
6:41	314	65
6:44	37	10

HST March 16, 2016

Time	Position	Elevation
5:25 a.m.	226°	21°
5:26	208	27
5:27	180	31
5:28	153	27
Vanishes into twilight		

ISS March 24, 2016

Time	Position	Elevation
5:54 a.m.	321°	21°
5:55	330	40
5:56	39	69
5:57	111	40
5:58	121	21

ISS March 26, 2016

Time	Position	Elevation
5:45 a.m.	288°	18°
5:46	269	30
5:47	227	39
5:48	184	30
5:49	165	18

ISS March 27, 2016

Time	Position	Elevation
4:53 a.m.	312°	22°
4:54	312	42
4:55	43	89
4:56	133	42
4:57	133	22

ISS March 30, 2016

Time	Position	Elevation
8:02 p.m.	213°	21°
8:03	201	39
8:04	134	65
8:05:16	69	39
8:05:52	64	32

HST April 1, 2016

Time	Position	Elevation
7:51 p.m.	220°	19°
7:52	201	26
7:53	175	29
7:54	149	26
7:55	130	20

HST April 2, 2016

Time	Position	Elevation
7:41 p.m.	224°	20°
7:42	205	27
7:43	178	30
7:44	151	27
7:45	132	20

HST April 3, 2016

Time	Position	Elevation
7:32 p.m.	226°	20°
7:33	208	27
7:34	180	31
7:35	153	27
7:36	134	20

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 5:54 a.m. on March 24, measure six fist-widths north from due west (or three west from due north), 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
Highlights: March 18, 3:30 p.m.: Coverage of launch of Expedition 47 to the ISS. (Actual launch is 4:26 p.m.) 9:30 p.m.: Coverage of Docking of Expedition 47. (Actual docking is 10:12 p.m.) 11:30p.m.: Coverage of hatch opening begins. (Actual opening is 11:55 p.m.)

March 22, 9:00 p.m.: Launch coverage of Orbital Services cargo mission to the ISS. (Actual launch at 10:05 p.m.)

March 26, 4:30 a.m.: Coverage of capture of Orbital Services cargo craft by the ISS. (Capture is about 6:00 a.m.)

March 31, 11:00 a.m.: Coverage of launch of Progress 63 Cargo Craft to the ISS. Actual launch is 11:23 a.m.

April 2: noon. Coverage of docking of Progress 63 Cargo Craft.

Calendar of Events

Sometime in 2016: Launch of the Chinese space station *Tiangong-2*.

Sometime in 2016: First launch from Russia's Vostochny Cosmodrome in eastern Siberia, in Amur Oblast which is north of the northern tip of Manchuria.

March 11: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). There will be a novice session in the planetarium at 6:45 p.m., followed by a club meeting at 7:30 p.m. See http://www.okcastroclub.com/ for details.

March 12: Oklahoma Space Alliance Meeting, location to be announced.

March 13 – 17, March Storm. See http://nss.org for details.

March 14: Launch of the *ExoMars* orbiter and Schiaperelli lander.

March 18: Launch of Expedition 47 to the Space Station.

March 21: Launch of Orbital Services Cygnus cargo craft on a resupply mission to the Space Station.

March 21 – 25, March Home District Legislative Storm. See http://nss.org for details.

March 23: Mercury is in superior conjunction with the Sun.

April 9: Uranus is in conjunction with the sun.

April 9: Oklahoma Space Alliance Meeting, location to be announced.

April 12: Yuri's Night.

April 18: Mercury is at greatest elongation, 20 degrees east of the Sun (so can be seen after sunset).

April 22: Peak of Lyrid meteor shower.

May: First launch of SpaceX's Falcon Heavy.

May 5: Peak of Eta Aquariid meteor shower.

May 9: Mercury transits the Sun's disk. Oklahoma sees most of the transit, but it is visible in its entirety in the eastern US, western Europe and all of South America.

May 14 [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

May 18 – 22: International Space Development Conference in San Juan, Puerto Rico. For more information, visit http://isdc2016.nss.org/isdc.

May 21: Launch of Expedition 48 to the Space Station.

May 22: Mars is at opposition.

May 31: Sixth Orbital Sciences Commercial Resupply Mission to the Space Station launches from Cape Canaveral.

June 2: Saturn is at opposition.

June 5: Mercury is at greatest elongation, 24 degrees west of the Sun (so can be seen before sunrise).

June 6: Venus is in superior conjunction with the Sun.

June 10: Launch of SpaceX's Dragon capsule on a resupply mission to the Space Station.

July 4: *Juno* arrives at Jupiter. The NASA *Juno* page is http://www.nasa.gov/mission_pages/juno.

July 6: Mercury is at superior conjunction with the Sun.

July 2016-2020: The *New Horizons* probe visits the Kuiper Belt. For details, visit https://en.wikipedia.org/wiki/New_Horizons or http://pluto.jhuapl.edu. (Also see January 1, 2019.)

July 20: Moon Day: anniversary of the Apollo 11 landing on the Moon.

June 25: Peak of Delta Aquariid meteor shower.

August 12: Peak of Perseid meteor shower.

August 15: Launch of SpaceX's Dragon capsule on a resupply mission to the Space Station.

August 16: Mercury is at greatest elongation, 27 degrees east of the Sun (so can be seen after sunset).

September: Launch of *OSIRIS-REx,* the Origins Spectral Interpretation Resource Identification Security Regolith Explorer, which will orbit the near-earth asteroid 101955 Bennu and return samples. For more information, visit http://en.wikipedia.org/wiki/OSIRIS-REx or http://science.nasa.gov/missions/osiris-rex/.

September 1: Annular solar eclipse, visible in Africa on a path crossing Gabon the two Congos, southern Tanzania and northern Madagascar,

September 2: Neptune is at opposition.

September 12: Mercury is at inferior conjunction with the Sun.

September 22: Launch of Expedition 49 to the Space Station.

September 26: Jupiter is in conjunction with the Sun.

September 28: Mercury is at greatest elongation, 20 degrees west of the Sun (so can be seen before sunrise).

September 28: *InSight* lands on Mars (see March 4).

Late 2016: 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.

October 4 – 10: World Space Week. See http://www.worldspaceweek.org for details.

October 4: Seventh Orbital Sciences Commercial Resupply Mission to the Space Station launches from Cape Canaveral.

October 15: Uranus is at opposition.

October 27: Mercury is at superior conjunction with the Sun.

November 15: Launch of Expedition 50 crew to the International Space Station.

December: ESA's *ExoMars Mars Orbiter* arrives at Mars, together with the Schiaparelli lander. (The rover will be launched in 2018.) For more information, visit en.wikipedia.org/wiki/Exomars.

December 10: Mercury is at greatest elongation, 21 degrees east of the Sun (so can be seen after sunset).

December 10: Saturn is in conjunction with the Sun.

December 14: Peak of Geminid meteor shower.

December 19: Launch of SpaceX's Dragon capsule on a resupply mission to the Space Station.

December 28: Mercury is in inferior conjunction with the Sun.

Sometime in 2017: 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.

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.]

January 12, 2017: Venus is at greatest eastern elongation, 47 degrees from the Sun (so can be seen after sunset).

January 27, 2017: The European Space Agency/JAXA *BepiColombo* Mercury Orbiter is launched. Home page is http://sci.esa.int/bepicolombo.

February 26, 2017: Annular solar eclipse touching the southern tip of South America, the south Atlantic Ocean, and Angola.

March 25, 2017: Venus is in inferior conjunction with the Sun.

June 3, 2017: Venus is at greatest western elongation, 46 degrees from the Sun (so can be seen before sunrise).

August 2017: 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.

August 21, 2017: 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.

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. Some-

time in 2018: Launch *InSight*, a lander that will probe the interior of Mars. For information, see http://insight.jpl.nasa.gov/. [Postponed from March 2016.]

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 2019: ESA's *ExoMars Mars Rover* arrives at Mars. For more information, visit en.wikipedia.org/wiki/Exomars.

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. [See September 2016.]

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.

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, 2016 (Area Code 405)

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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

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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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