

OUTREACH January 2016

January Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, January 9, 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) What's Happening (Steve Swift)
(Pictures, Videos & Links)
 - a. Review Selected Events in 2015
 - b. Look Forward to a Great 2016
- 3) Discuss Business
 - a. Review OSA Accounts
 - b. Summary of December Meeting
 - c. Annual Report
 - d. Discuss Activities for 2016
 - i. Including Yuri's Night
- 4) OSA Bylaws
- 5) OSIDA Meeting Report (none)
- 6) Chat

Minutes of Christmas Party

The December 12 meeting of Oklahoma Space Alliance was actually our Christmas party at the Koszorus, and the only business was electing officers, who, for 2016 are Steve Swift, president, Dave Sheely vice-president, Syd Henderson, secretary, and Tim Scott, treasurer. We had several mail-in ballots which confirmed the slate already nominated, so the final vote was by acclamation. Don Whitney renewed his family's membership by mail, while Russ Davoren, John Northcutt and Dave St. John renewed their memberships at the party.

Attending the party were Chris Carson, Russ Davoren, Syd Henderson, Claire and Clifford McMurray, John Northcutt, Don Robinson, Linda Shannon, David Sheely, Dave St. John, Steve and Bryan Swift, Rosemary Swift, and our hosts, Tom and Heidi Koszoru. Tom's daughter Jenny and several of the Koszorus' friends also came.

Space News

NASA received a substantial boost in funding in the budget agreement passed in December. NASA received an increase in funding of 1.3 billion dollars over 2015 for a total of 19.3 billion dollars. This was also \$750 million over what NASA requested. President Obama signed

the bill right before Christmas. Much of the increase is funding to keep the Space Station operational, including developing commercial crew transport. The funding also includes support for the James Webb Space Telescope, the Curiosity and Opportunity Mars rovers and the future Mars 2020 rovers and the Europa probe (including a lander). www.skyandtelescope.com/astronomy-news/nasas-budget-gets-a-boost-1230201545/

The US Postal Service has unveiled designs for a new set of Forever stamps commemorating *New Horizons* and Pluto. These are not the first stamps honoring Pluto, however. A set of stamps from 1991 showing the planets had “Pluto Not Yet Explored,” and the *New Horizons* team celebrated the flyby by striking the last three words from an image of the stamp. One of the original stamps is aboard *New Horizons*.

The USPS also plans to issue a set of eight stamps with images of the other planets, but not Pluto.



The US Postal Service to issue Pluto stamps
(Image from NASA.gov)

The Mars probe *InSight*, which was scheduled to launch next March, has been postponed until 2018 when a vacuum seal leaked while testing SEIS, the Seismic Experiment for Interior Structure, which is one of the essential instruments for the probe. Since SEIS has to work in pressures less than one microbar (or one-thousandth of the pressure of Earth’s atmosphere), this is a crucial failure. *Sky and Telescope* informs us:

Although CNES will absorb the cost of repairing its instrument, there'll be significant expense for NASA to store the spacecraft for two years and to keep the mission team intact.

Because InSight is a Discovery-class mission, which have strict cost caps, these extra expenses might conceivably lead to outright cancellation. (Online article, 12/23/15).

Although *InSight* won't make its March launch date, another Mars probe, the *ExoMars* orbiter (including the Schiaparelli lander) is still on for launch on March 14. The second part of the *ExoMars* mission, which includes the ExoMars rover, launches in May 2018.

On December 21, SpaceX made history when the first stage of its Falcon 9 rocket made a soft landing at Cape Canaveral. This was the first time the first stage of an orbital vehicle made a soft landing.

SpaceX had been trumped a bit on November 23, when Blue Origin's New Shepard rocket went into space, and vertically landed the first stage a few feet from the center of its launching pad. This was the time a first stage of a space-going vehicle made a vertical landing, although New Shepard was a suborbital vehicle that only ascended to 100.5 km, which is barely the edge of space.

Both landings are important steps in creating a reusable space vehicle. In fact, the Falcon 9 first stage is in such good shape that it quite possibly could be reused if SpaceX so desired. However, SpaceX intends to conduct a static test to see if this would be possible, but intends to keep the booster for historical interest. They do plan to reuse future boosters.

The mission, by the way, was to launch eleven small satellites for the telecommunications company ORBCOMM.

On December 11, Patrick Kelly of the University of California at Berkeley and his colleagues became the first people to successfully predict the appearance of a supernova, namely Supernova Refsdal. There's a bit of a trick to it: Supernova Refsdal had made four previous appearances because of gravitational lensing caused by a large elliptical galaxy lying between it and us. However, the galaxy is a member of a cluster, which allowed for an encore performance. (There was also apparently a preview in 1998 that we missed.)

The International Astronomical Union has approved common names for 14 stars and their 31 exoplanets. This marks the first time the IAU has actually approved a new common name for a star.

Some highlights: The star 55 Cancri is now Copernicus and its five planets Galileo, Brahe, Lippershey, Janssen and Harriot (all pioneering astronomers from around 1600). Epsilon Eridani is Ran and its planet Aegir. Fomalhaut's planet is now Dagon; Mu Arae is Cervantes, and its planets Quixote, Dulcinea, Rocinante and Sancho. Edasich (iota Draconis)'s planet is Hypatia, named after one of my former cats (and presumably the ancient mathematician).

I mentioned in the November 2015 *Outreach*, that the Japanese spacecraft *Akatsuki* was about to make a second attempt to achieve orbit around Venus. The attempt was successful, and on December 7, *Akatsuki* entered a highly elliptical thirteen-day orbit around Venus. This marks the first time Japan has placed a spacecraft in orbit around another planet. The current orbit takes *Akatsuki* from 240 to 260,000 miles from Venus. Its final orbit will reduce the latter to 210,000 miles and the orbital period to nine days.

This highly elliptical orbit is not entirely an accident; the originally planned orbit would have taken *Akatsuki* from 200 to 50,000 miles.

Akatsuki is the first spacecraft to orbit Venus since the demise of *MESSENGER* on January 18, 2015. *Akatsuki* first flew by Venus on December 7, 2010, only a day before Japan's solar sail demonstrator *IKAROS*, but engine malfunction prevented it from achieving orbit. The five years in solar orbit may well have caused some damage to *Akatsuki* but it may be months before we find out how much.

Sky Viewing

Highlight this month is a very close conjunction of **Venus** and **Saturn** on the morning of January 9, when the planets are only half a degree apart. They should be easy to see in the southeastern sky an hour or two before sunrise. Venus is much the brighter at magnitude -4, while Saturn is magnitude 0.5. About seven degrees to their lower right is the first magnitude star Antares in Scorpius.

This conjunction is more spectacular in Europe where the two planets come within a tenth of degree of each other while the sky is still dark.

[Material for this section of *Outreach* derives from the November and December issues of *Astronomy* and *Sky & Telescope*, and the *Sky & Telescope* web site.]

Venus is currently rising about two-and-a-half hours before the Sun, but by the end of the month, that will be down to two hours and at the end of February it will be rising only an hour before the Sun. It's still bright but gradually getting dimmer as it moves away from us. Venus is gradually approaching superior conjunction with the Sun on June 6.

Saturn is going in the opposite direction, and will be rising around 3:00 a.m. by the end of February and 1:30 a.m. by the end of the month. It will stay at magnitude 0.5 for all that time.

Mercury is nearing inferior conjunction on January 14, so is not visible. However it will be relatively high (for Mercury) in the morning sky at the end of January and reach greatest elongation on February 7. It will be around magnitude 0 in early February, but will get hard to see toward the end of the month because it will be low in the sky.

Mars is currently rising about 1:30 in the morning, and will rise 1:00 a.m. at the end of the month and midnight at the end of February. Currently it is in Virgo not far from Spica, and is moving toward Libra, which it will cross during February. Its magnitude is around 1, but it will brighten to 0.3 by March 1. Mars is now approaching, and closest approach is on May 30.

Jupiter is rising about 10:00 p.m., but will be rising at 8:30 p.m. by February 1 and around 6:30 p.m. at the end of February, at which point it will be visible almost the entire night. Jupiter is magnitude -2.2, which is brighter than any star, and will brighten slightly as it nears its March 8 opposition.

Uranus should still be findable with binoculars in the evening, but Neptune is getting lost in twilight. There is a finder chart at www.skyandtelescope.com/wp-content/uploads/WEB_UrNep_Finders.pdf.

Pluto is in conjunction with the Sun on January 6, which means the *New Horizons* space probe is too, so we're going to have a month or so without transmissions.

[Material for this section of *Outreach* derives from the November and December issues of *Astronomy* and *Sky & Telescope*, and the *Sky & Telescope* web site.]

Space-Related Articles

Every year, *Discover* compiles a list of the 100 top science stories of the year, of which quite a few relate to space, including three of this year's top nine, all of which related to space probes.

#1, not surprisingly, is “*New Horizon* Unmasks the Mysteries of Pluto” [including Charon and Pluto's Other Moons.” Not only was this our first close-up view of an object that had been mysterious for more than eighty years, it also rewrote our expectations for the outer Solar System, because Pluto and Charon proved unusually dynamic, with surfaces far younger than thought possible.

#5 is “When Dawn Met Ceres”. Although Pluto grabbed the headlines, the less photogenic Ceres was the first dwarf planet to be visited by a space probe (and also used to be a planet). Ceres is by far the largest member of the asteroid belt, and is a dark, cratered body. The dark skin, however, is thought to be thin, and beneath lies an icy mantle and rocky core, with very likely an ocean of water in between. What caught initial attention was a pair of bright white spots now thought to be ice. Ceres also turns out to have miles-high mountains and craters several miles deep. *Dawn* will be orbiting Ceres for years to come, so we should get a thorough study of Ceres' surface and interior.

#9 is “Rosetta Reveals the Heart of a Comet.” *Rosetta*'s lander, *Philae*, woke up briefly as Comet 67P/Churyumov-Gerasimenko (henceforth referred to as Comet 67P), but soon died without doing much. *Rosetta*, meanwhile, accompanied Comet 67P toward the inner solar system as the comet came to life. Among the other discoveries is that the water comprising much of the comet has a different isotope ratio than that on Earth, indicating that the water on Earth's surface may not have come from comets after all.

#12 is “Hot Answer to a Solar Mystery”. The mystery is why the Sun's corona has a temperature of up to 4 million degrees Fahrenheit when the surface of the Sun has a temperature of 10,000° F. The explanation appears to be nanoflares. These are caused when convection twists magnetic field lines until they snap, causing a miniature solar flare that nevertheless produces temperatures of up to 20,000,000° F [!], sufficient to produce much, if not all, of the heating.

#23 is “Mars Wetter than Ever”. This is the *Mars Reconnaissance Orbiter*'s discovery of liquid water -- actually brine -- on the surface of Mars, as well as the realization that the glacial deposits on Mars contain enough water to cover the planet in an ocean three feet deep. It's also possible that there is brine right under the surface where *Curiosity* is travelling.

#26 is “A Final Message from Mercury,” about the end of the *MESSENGER* mission when the probe was intentionally sent crashing into the planet. Toward the end, *MESSENGER* also detected ice in craters, and the remnants of lava flows in the Caloris basin.

#32 is “Dark Matter Pushback”. In April, Richard Massey of Durham University in England and his colleagues found data from a galactic indicating that dark matter may be subject to friction from other dark matter. Dark matter is generally thought to act on itself by gravitational forces alone, but this discovery indicates that there are other forces that act on it, however weakly.

#33 is “Billionaire Backs Search for Aliens”. Russian Billionaire Yuri Miller is financing a project called “Breakthrough Listen” which will examine over a million stars and a hundred galaxies for signs of alien technology.

#44 is “Saturn's Watery Moon,” which is Enceladus. Enceladus has received attention the last few years because geysers are shooting from its south polar region. This year, we also found

out that the icy outer layer of Enceladus is detached from its core, which is only possible if there is a global ocean separating the two. How Enceladus can maintain such an ocean is a mystery.

#49 is “The Moon’s Violent Birth”. One of the theories for the Moon’s formation is that a Mars-sized planet (named Theia) collided with the Earth 4.5 million years ago, and parts of the remains of Theia became the Moon. This theory ran into problems because the composition of the Moon is too similar to the Earth, which would be hard to explain if Theia formed elsewhere in the Solar System. The theory presented here (which seems obvious) is that Theia likely formed close to Earth.

#59 is “Galactic Gains”. A new study suggests that the disc of the Milky Way extends fifty percent farther than previously thought, giving a diameter of at least 150,000 light-years.

#62 is “Blame It on the Iron Rain.” It’s generally supposed that most of the iron from planetesimals colliding with the infant planet Earth wound up in its core, but it appears a lot of it wound up in the mantle, because the iron in the planetesimals vaporized on impact and spattered across the planet.

#64, “Alien Aurora,” is about the first aurora detected around a brown dwarf. This suggests brown dwarfs have magnetic fields more like planets than stars.

#70 is “Ferocious Black Hole Found”. The black hole inside the galaxy J0100+2802 is about 10 times the mass of other black holes its age (about 900 million years younger than the universe). No one knows how it grew so rapidly.

#71 is “NASA Hunts for Life on Europa.” NASA’s putting together a Europa orbiter to be launched around 2026.

#77 is “NASA Tech Finds Buried Survivors”. FINDER is a device that can detect a heartbeat under thirty feet of rubble, which came in handy after the Nepal earthquake last April. The device relies on the same technology that satellites use to measure changing land levels and motions of satellites orbiting other planets.

#83 is “Hubble Revisits an Iconic Stellar Nursery,” the famous ‘Pillars of Creation.’ This time with a better view in the ultraviolet.

#85 is “Organic Molecules Solves Space Mystery.” In 1919, Nary Lea Heger observed certain stars were missing some colors in their spectra. In 1993, it was noticed that buckyballs absorb these wavelengths. Last year, it was demonstrated that buckyballs behave the same way in space, solving the mystery.

#86 is “Testing Gravity’s Reach.” Analysis of 21 years of data from a pulsar and its white dwarf companion shows that the gravitational constant is, well, constant.

#94 is “New Earth-Like Planet”. Kepler-452b has 1.4 times the mass of Earth and is within its system’s habitable zone. It actually looks to me that it would be hotter than Earth but cooler than Venus. It’s also 1400 light-years away, so more details are going to be hard to come by.

#100 is “This is the End.” A study of the emission of galaxies over time indicates the galaxies of the Universe are producing half as much energy as two billion years ago. This is an indication of the impending heat death of the Universe. We can expect this in a trillion years or so, so best start preparing now.

The British magazine *Astronomy Now* also has its top ten astronomy stories seven of which are also in the *Discover* list. #1 is New Horizon at Pluto, #2 is Water on Mars, #3 is Dark Matter is Sticky, #4 is Kepler 452b, #5 is the galaxy shutdown (#100 on the *Discover* list), #6 is Dawn at Ceres, and #9 is *Rosetta*.

#7, “Is That You, Beagle 2,” is about the rediscovery of the *Beagle 2* lander, lost in 2003, which it turns out did make a soft landing. Apparently its solar panels didn’t open properly, leaving the lander without enough power to function. However, it was still the first soft landing by a European space probe on an extraterrestrial body, beating out the *Huygens* lander on Titan.

#8, “The Most Luminous Galaxy in the Universe,” is WISE J224607.57-052635.0 because astronomers really know how to name things. The WISE Galaxy is as bright as a thousand Milky Ways, and has a central black hole thousands of times the mass of the one at the center of our galaxy. It is also 12.5 billion light-years away and is buried within a huge cloud of dust, so much of its light is reradiated in the infrared. WISE happens to be the Wide-field Infrared Survey Explorer, which is why it discovered the galaxy.

And #10 is “Solving the Lithium Mystery.” The Big Bang produced only three elements, hydrogen, helium and lithium (although I’ve also seen some claims a little beryllium might have been produced). But the oldest stars only have a third of the lithium predicted. So where did all the lithium go to? It turns out that the stars ate it after all. Sun-like stars consist of three layers, the core, a radiative layer in which energy is conducted by radiation, and a convective layer in which energy is conveyed by convection currents. It turns out that during stars’ formation, mixing between the three zones carries lithium into the radiative zone, which is hot enough to burn lithium.

This doesn’t seem that surprising since heavier brown dwarfs are capable of burning lithium and regular stars consume it after a hundred million years or so.

Viewing Opportunities for Satellites (January 9 to February 13, 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. SpaceX is launching a cargo mission to the Space Station on February 7, which is after any of the sighting opportunities listed below. The next manned launch to the Space Station is in March.

Tiangong 1 January 15, 2016		
Time	Position	Elevation
Appears from Earth’s Shadow		
6:55:13 a.m.	299°	12°
6:59	26	81

7:01 114 10

Tiangong 1 January 15, 2016

Time Position Elevation

Appears from Earth's Shadow

6:40 a.m. 278° 20°

6:41 212 46*

6:42 137 10

*Passes just south of Jupiter

ISS January 22, 2016

Time Position Elevation

6:24 a.m. 328° 20°

6:25 345 36

6:26 40 52

6:27 95 35

6:28 111 20

ISS January 24, 2016

Time Position Elevation

Appears from Earth's Shadow

6:16 a.m. 280° 36°

6:17 225 52

6:18 170 36

6:19 152 20

HST January 24, 2016

Time Position Elevation

6:30 a.m. 219° 19°

6:31 200 26

6:32 174 29

6:33 148 26

6:34 130 19

HST January 25, 2016

Time Position Elevation

6:20 a.m. 223° 20°

6:21 205 27

6:22 177 30

6:23 150 27

6:24 132 20

HST January 26, 2016

Time Position Elevation

6:11 a.m. 226° 20°

6:12 207 27

6:13 180 31

6:14 153 27

6:15 134 20

HST January 27, 2016

Time Position Elevation

6:01 a.m. 228° 20°

6:02 209 27

6:03 182 30

6:04 155 27

6:05 137 20

HST January 28, 2016

Time	Position	Elevation
5:52 a.m.	230°	19°
5:53	211	26
5:54	185	29
5:55	159	26
5:56	141	19

Tiangong 1 January 28, 2016

Time	Position	Elevation
7:11 p.m.	233°	10°
7:14	150	66*
7:14:39	92	48

*Passes close to Aldebaran

Vanishes into Earth's shadow

Tiangong 1 January 30, 2016

Time	Position	Elevation
6:53 p.m.	254°	10°
6:56	336	62
6:57:56	52	22

ISS February 1, 2016

Time	Position	Elevation
7:05 p.m.	226°	21°
7:06	226	42
7:07	151	88
7:08	49	42
7:08.26	49	28

ISS February 3, 2016

Time	Position	Elevation
6:56 p.m.	265°	17°
6:57	285	27
6:58	323	34
6:59	2	27
7:00	22	17

Tiangong 1 February 9, 2016

Time	Position	Elevation
6:59 p.m.	301°	10°
7:03	25	69
7:04:38	106	20

Vanishes into Earth's shadow

Tiangong 1 February 11, 2016

Time	Position	Elevation
6:41 p.m.	290°	10°
6:44	211	59
6:47	130	10

Key: Position is measured in degrees clockwise from north. That is, 0° is due north, 90° is due east, 180° is due south, and 270° is due west. Your fist held at arm's length is about ten degrees wide. "Elevation" is elevation above the horizon in degrees. Thus, to see Tiangong-1 at 7:03 a.m. on February 9, measure two-and-a-half fist-widths east from due north, then seven 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: NASA's having a quiet month with no major launches and no resupply missions to the Space Station. However, expect coverage around February 7 when SpaceX launches its next resupply mission.

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.

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

January 8: 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.

January 9: Oklahoma Space Alliance Meeting, 2:00 p.m., Earl's Rib Palace in Moore (see page 1).

January 13: Oklahoma Space Industry Authority meeting, 1:30 p.m., Attorney General's Building in Oklahoma City.

January 17: *Jason-3*, and mission to examine the height of the Ocean, is launched by SpaceX at 12:42 p.m. This is the last launch of the original Falcon 9 v1 1 rocket.

February 6: Mercury is at greatest elongation, 26 degrees west of the Sun (so can be seen before sunrise).

February 7: SpaceX launches CRX 8, a cargo supply mission to the Space Station. This marks the resumption of such flights after the explosion of CRX 7 on June 28, 2015. The Bigelow Expandable Activity Module will be delivered by this flight. [Postponed from January.]

February 10 [Tentative]: Oklahoma Space Industry Development Authority meeting, location to be announced.

February 12: Launch of *ASTRO-H* (or NeXT), the Japanese X-ray astronomy satellite. Home page is <http://astro-h.isas.jaxa.jp/en/>.

February 12: 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.

February 13: Oklahoma Space Alliance Meeting, location to be announced.

February 28: Neptune is in conjunction with the Sun.

March 8: Jupiter is at opposition.

March 9 [Tentative]: Oklahoma Space Industry Development Authority meeting, location to be announced.

March 9: Total solar eclipse visible from Indonesia and the central Pacific Ocean.

March 10: Fifth Orbital Sciences Commercial Resupply Mission to the Space Station launches from Cape Canaveral.

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 Schiaparelli lander.

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

March 21: Launch of SpaceX's Dragon capsule 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 Benu 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.

Sometime 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 MU₆₉.

September 2019: Arrival of OSIRIS-Rex at the near-earth asteroid 101955 Benu 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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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-mail nsshq@nss.org. The Chapters Coordinator is Bennett Rutledge 720-641-7987, rutledge@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.)

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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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