

## **OUTREACH March 2015**

### **March Meeting:**

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, March 21, 2015, at Denny's Restaurant, SW 29th and I35, Oklahoma City.

### **Program**

2:00 PM

- 1) What's Happening; Let's see and discuss articles, slides and videos of current Space and Space Industry news including launches, technology, developments, people and art. This segment includes a summary of OSA visit with Congressman Bridenstine and a special feature on Alan Bean (4<sup>th</sup> person to walk on the moon).
- 2) Business Meeting
  - a. Review Minutes
  - b. New mail
  - c. Treasurers Report
  - d. Report on OSIDA
  - e. Old Business
    - i. Yuri's Night
  - f. New Business
- 3) Informal Discussion and Departure

### **Minutes of February Meeting**

Oklahoma Space Alliance met at Harry Bears All-American Grill on Saturday, February 14. In attendance were Steve, Brian, and Karen Swift, Dave, Bill and Nathan Sheely, Rachelle, Gerry (sp.?) and Stephanie Thibedeau, Russ Davoren, Syd Henderson, Peggy McBride, Amanda Peaster, Vickey Richartz, Tim Scott, Rosemary Swift and Dennis Wigley. This was Bill, Nathan and Amanda's first meeting. (Nathan was more of a drop-in.)

Congressman Jim Bridenstine (1<sup>st</sup> District, which includes Tulsa) will meet with some of our members on Wednesday, February 18. He's on the Science and Space subcommittee. Steve, Dave and Dennis are going, as is Ross Robinson.

Yuri's Night: Russ talked to the Stafford Museum. They are having a series of Smithsonian-type talks. They haven't come up with anything definite. We may want to talk to them about Space Week in October.

Steve wants to keep meetings at 2:00 p.m., but is looking for a larger space.

What's Happening in Space:

We watched a video with Gwynne Shotwell, the President and Chief Operating Officer of SpaceX.

The Oklahoma Space Industry Development Authority has finally set its new website up. The website is <http://airspaceportok.com/#home>, and has a promotional video featuring Bill Khourie and Governor Mary Fallin.

We watched a promotional video animation of Space X's Falcon 9. SpaceX is accumulating landing pads at Cape Canaveral and Vandenberg Air Force Base.

### **E-mail from Don Whitney:**

"Gentlemen,

“I have been an interested but passive member of OSA for a few years. Another organization that I am active in is the Lions Club of Downtown OKC. I am looking for a lunchtime speaker for Tuesday, April 21 and I would like to expose our Club membership to the exciting current developments in space. Would a member of OSA be willing to speak to our group? I noticed that the online UPDATE magazine has interesting articles and photos which could be converted to a PowerPoint presentation if you desired.

“Please let me know if you would consider this space outreach opportunity and I will reply with more details.”

Steve’s been in touch with Don about this opportunity.

### **Space News: Dawn at Ceres**

The Dawn spacecraft finally arrived at Ceres on March 6, becoming the first spacecraft ever to visit a dwarf planet, and the first spacecraft ever to orbit two extraterrestrial objects (excluding orbiting the Sun). Orbital capture was at 6:39 a.m. The spacecraft started off with an orbit 38,000 above Ceres, but will slowly descend to an orbit 920 miles above Ceres for high altitude mapping and spectroscopy. In December, it will then descend to 230 miles above Ceres for more high altitude mapping as well as analyzing element abundances and the internal structure of Ceres.

Ceres is large enough that it has been rounded by its own gravity (the criterion that makes it a dwarf planet as well as an asteroid). Ceres may have differentiated into several layers by heating during its formation, much as Earth’s interior differentiated into a crust, mantle, outer and inner core. In the case of Ceres, it has a thin crust of rock and dust covering a mantle made of ice, which covers a core of rock and metal. There’s also speculation that Ceres has an ocean in its interior, much like Europa and Ganymede. (Or more likely, had one in its distance past.) Ceres is thought to be a quarter water and ice.

So far, Ceres has a rather bland-looking cratered surface. The biggest surprise is a pair of bright white spots inside a 57-mile wide crater. Speculation is running rampant, but the leading candidate is exposed ice from a pair of close impacts. Another candidate is ice volcanism.

### **Space News**

Earth-like planets around red dwarf stars may not be tidally locked after all. What prevents this is a phenomenon known as thermal atmospheric tides, which is caused by a delay between stellar radiation and heating. A similar phenomenon on Earth accounts for the hottest time of the day being the afternoon, since the ground is also heating the atmosphere.

Although this doesn’t have much effect on the rotation of the Earth, it does on planets closer to their primaries. Indeed, this may account for Venus’s extremely slow retrograde rotation. Essentially, the atmospheric tides in Venus’s thick atmosphere produce enough torque to keep the planet rotating slowly. A Venusian sidereal day is longer than a Venusian year. (Although a solar day would be 116.75 Earth days long, so a Venusian year is about two Venusian solar days long.)

Where this will also have an effect is on planets in the habitable zone of red dwarf stars. These planets are much closer to their primaries, and if they have atmospheres, the effect of thermal atmospheric tides will be greater. This means such planets will continue to rotate, and if they are in the inner part of the habitable zone, can rotate with a period not much more than a month. The atmosphere doesn’t have to be as thick as Venus’s; in fact, it works better with an atmosphere as thick as Earth’s.

[Primary source: “Asynchronous Rotation of Earth-Mass Planets in the Habitable Zone of Lower-Mass Stars, by Leconte, Wu, Menou and Murray; Science, 6 February 2015, pp. 632 – 635.]

China just announced that they will be adding two more boosters to their family of rockets, Long March 6 and 7. The first will launch this year, the second next year. In addition Long March 5 will be launching in the next year with the Tiangong-2 space lab. Long March 5 will be capable of sending a payload of 25 tons

into low Earth orbit. Long March 6 and 7 will start off with less capacity, but presumably that will improve with later versions.

China's Xinhua news agency has also announced that the Chang'e 4 lunar probe will be launched before 2020. That seems like an awfully long time line since the Chang'e 3 mission landed on the moon in 2013.

Along with Europa, Jupiter's moon Ganymede has been suspected as having a subsurface ocean, and new observations by the Hubble Space Telescope seem to confirm that. The ocean would be sixty miles thick, which means it would contain as much water as all of Earth's oceans.

Hubble has been observing the effects of Ganymede's interior upon its aurorae, which are produced by Ganymede's magnetic field and affected by Jupiter's magnetic field.

The apparent discovery a couple of years ago by the BICEP2 of gravitational waves in the Big Bang has now been thoroughly abandoned, since polarization of the Cosmic Background Radiation by intervening dust clouds accounts for all but a tiny amount of the twisted polarization observed, and the amount left falls well below the confidence level that any evidence of gravitational waves has been found.

Regardless, the search is still going on. The BICEP2's idea of detecting gravitational waves through the CMB should be sound if the polarization due to dust can be eliminated. Among the searchers are BICEP2's successor BICEP3, the quintuple Keck array, and the South Pole Telescope. (All these telescopes are located at the South Pole.) Keck is concentrating on figuring out exactly how much of the polarization is due to dust. Keck will be looking at microwaves at higher frequencies, where the polarization due to dust is more pronounced. BICEP3 will be looking at lower frequencies where dust will have less effect. The SPT and POLARBEAR (which is in Chile), will be probing different areas of sky which are hopefully less dusty.

The European Space Agency's lost Mars lander, Beagle 2, has been found on the surface of Mars. The spacecraft did make a soft landing in 2003, but it looks like one of its four solar panels didn't unfold and covered its radio antenna. Although unsuccessful, Beagle 2 does give the ESA the distinction of being the third space agency to achieve a soft landing on Mars.

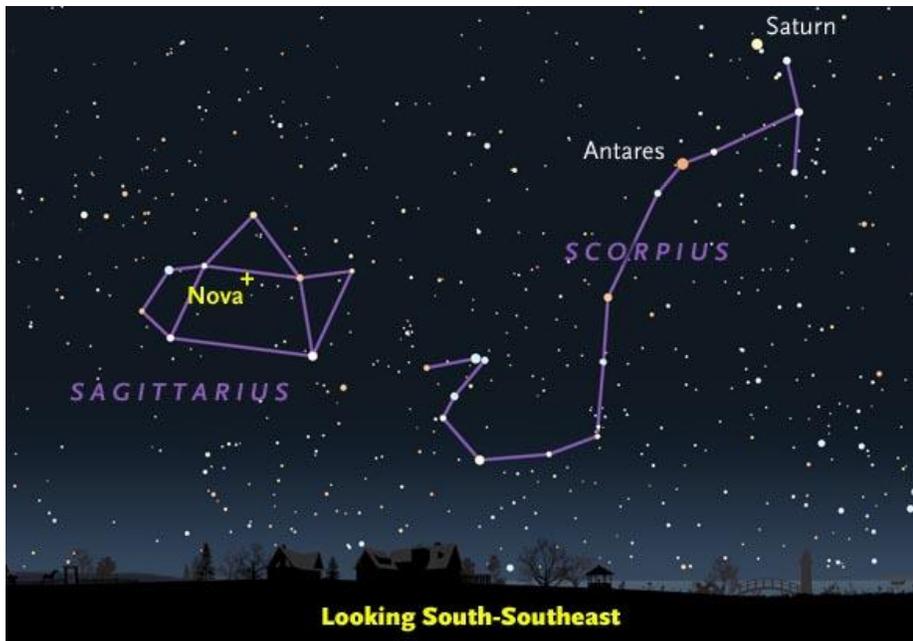
Earth-like planets around red dwarf stars may not be tidally locked after all. What prevents this is a phenomenon known as thermal atmospheric tides, which is caused by a delay between stellar radiation and heating. A similar phenomenon on Earth accounts for the hottest time of the day being the afternoon, since the ground is also heating the atmosphere.

Although this doesn't have much effect on the rotation of the Earth, it does on planets closer to their primaries. Indeed, this may account for Venus's extremely slow retrograde rotation. Essentially, the atmospheric tides in Venus's thick atmosphere produce enough torque to keep the planet rotating slowly. A Venusian sidereal day is longer than a Venusian year. (Although a solar day would be 116.75 Earth days long, so a Venusian year is about two Venusian solar days long.)

Where this will also have an effect is on planets in the habitable zone of red dwarf stars. These planets are much closer to their primaries, and if they have atmospheres, the effect of thermal atmospheric tides will be greater. This means such planets will continue to rotate, and if they are in the inner part of the habitable zone, can rotate with a period not much more than a month. The atmosphere doesn't have to be as thick as Venus's; in fact, it works better with an atmosphere as thick as Earth's.

## Sky Viewing

There is a naked-eye nova this month in the constellation Sagittarius. Nova Sagittarii 2015 No.2 is located in the "Teapot" asterism, just under the middle of the lid. The nova was first spotted by John Seach of New South Wales, Australia on March 15, so there's hope it will get brighter. Currently it is 6<sup>th</sup> magnitude.



This is a classical nova, which is a white dwarf that has undergone an explosion of hydrogen fusion, generally from matter falling on it from a companion star. Unlike a supernova, the star survives the nova outburst, and only a small percentage of the mass of the star is ejected, perhaps a hundredth of a percent of a solar mass. On the other hand, this is 33 times the mass of the Earth. If matter keeps falling on the white dwarf, it can go nova again. Although nuclei more massive than iron are fused in supernovae, sizeable amounts of lighter elements must come from novae, which are much more common.

Eclipse seasons have now moved to March-April and September-October. This month there are total solar and lunar eclipses. The solar eclipse is on March 20 and is visible in the North Atlantic and parts of the Arctic between the British Isles and Norway on one side and Iceland on the other. The only two places where the path of totality touches land are the Faroe Islands well off the northern coast of Scotland, and Svalbard (Spitzbergen) well north of mainland Norway.

The **total lunar eclipse**, on the other hand, takes place at dawn on April 4. This eclipse is notable because it is the shortest total lunar eclipse since 1529. The partial eclipse begins at 5:16 a.m., with totality beginning at 6:58 a.m. and ending five minutes later.

The **Lyrid Meteor Shower** peaks on the night of April 22-23 and the Moon will be nowhere in sight. The best time to look is before dawn. The Lyrids generally deliver fifteen to twenty meteors per hour, but this year could be better.

This is a good time for sky viewing after sunset, with Venus bright in the western sky, Jupiter bright in the eastern sky, and Sirius due south. Arcturus and Spica are rising about 10:00 p.m. and are still high in the sky at dawn.

**Comet Lovejoy** is still (barely) at naked-eye visibility, but I'd recommend binoculars. Fortunately, it's moving through the conspicuous constellation Cassiopeia, which is shaped like a W on the opposite side of Polaris from the Big Dipper. It's currently not far from delta and gamma Cassiopeiae. Gamma Cassiopeiae is the center of the W, and delta Cassiopeiae (Rukbat) is the point of the W that is above it in the early evening.

**Mercury** is currently too close to the Sun to be visible and will remain so through early April, with superior conjunction with the Sun on April 9. However, it will become visible through binoculars on April 19 and by the month's end will be visible low in the western sky an hour after sunset. This is the best time this year to see Mercury, with greatest elongation on May 6.

**Venus** is currently shining at magnitude -4 and is unmistakable in the western sky after sunset. Venus is still on the far side of the Sun and isn't quite as bright as it can get, but is still easily the brightest planet. It's also getting closer and will brighten slowly in April. Venus will enter the constellation Taurus in early April and pass three degrees south of the Pleiades on April 10.

**Mars** is visible low in the western sky at sunset, setting maybe 90 minutes and is only magnitude 1.3. Mars will be getting difficult to see by mid-April as it slowly approaches a conjunction with the Sun on June 14.

**Jupiter** is as prominent at sunset as Venus, since it is magnitude -2.4 and in a darker part of the sky, Jupiter was at opposition last month, and is still visible most of the night, and passes due south around 11:00 p.m. at night. Don't confuse it with Sirius, which is magnitude -1.5, passes south an hour or so earlier and doesn't get as high in the sky.

Jupiter is currently in the constellation Cancer, the dimmest of the Zodiacal constellations. Cancer, however, does boast the Beehive star cluster, which at the end of March will be five degrees east of Jupiter.

On the night of April 2 and 3, all four of the Galilean satellites will appear in order of distance to the west of Jupiter. At 10:51 on April 8, Europa will occult Io, so the two moons appear to merge for five minutes, and at 12:38 a.m., Europa's shadow will eclipse Io.

**Saturn** is currently rising about midnight, but will be rising around 10:30 p.m. at the end of the month and 8:30 p.m. by the end of April. Saturn is in the bright constellation Scorpius, and, at magnitude 0.2, is the brightest object in that constellation. It's also not far from the first-magnitude star Antares. (See map above.)

**Uranus** and **Neptune** are both near conjunction and not visible even with telescopes or binoculars. [Data for this section from *Astronomy, Sky & Telescope*, space.com Wikipedia and NASA.]

## Space-Related Articles

"The Very Ancient Origins of the Water Constellations," by Craig Crosson, *Sky & Telescope*, March 2015, pp. 36 – 40.

## Viewing Opportunities for Satellites (March 21 – April 21, 2015)

You can get sighting information at [www.heavens-above.com](http://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. Heavens Above has changed its detail view so that you can no longer get location coordinates. On the other hand, it does give useful maps.

<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. (Note: I'm having problems accessing this from my home PC, but not from the Mac at work.) 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](http://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 manned launch to the Space Station is that of the One Year Crew on March 27. The only other launch to the Space Station scheduled during the next month is a SpaceX resupply mission on April 10.

## Tiangong 1 March 23, 2015

Time	Position	Elevation
8:25 p.m.	221°	10°
8:27	148	42*
8:30	79	15

Vanishes into Earth's Shadow

\*Passes very close to Sirius

## Tiangong 1 March 24, 2015

Time	Position	Elevation
8:50 p.m.	254°	10°
8:53	336	60*
8:54:09	50	24

Vanishes into Earth's Shadow

\*Passes between Venus and the Moon

## ISS March 30, 2015

Time	Position	Elevation
6:11 a.m.	325°	20°
6:12	349	35
6:13	39	52
6:14	95	35
6:15	111	20

## ISS April 3, 2015

Time	Position	Elevation
8:50 p.m.	200°	19°
8:51	183	34
8:52	137	47
8:53	84	33
8:54	67	19

## Tiangong 1 April 4, 2015

Time	Position	Elevation
8:28 p.m.	300°	10°
8:31	25	72
8:33	110	12

## ISS April 5, 2015

Time	Position	Elevation
8:39 p.m.	243°	21°
8:40	256	39
8:41	321	63
8:42	24	38
8:43	37	21

## Hubble April 17, 2015

Time	Position	Elevation
6:04 a.m.	219°	17°
6:05	200	26
6:06	174	30
6:07	148	26

Vanishes into Earth's Shadow

## Hubble April 18, 2015

Time	Position	Elevation
5:55 a.m.	223°	20°
5:56	204	27
5:57	174	30
5:58	148	27

Vanishes into Earth's Shadow

## Hubble April 19, 2015

Time	Position	Elevation
5:47 a.m.	226°	20°
5:48	207	27
5:49	180	31
5:50	153	27
5:51	134	20

## Hubble April 20, 2015

Time	Position	Elevation
5:40 a.m.	229°	20°
5:41	210	27
5:42	183	31
5:43	156	27
5:44	138	20

## ISS April 21, 2015

Time	Position	Elevation
8:47 p.m.	341°	16°
8:48	0	25
8:49	35	31
8:50	70	25
8:51	90	16

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 8:50 p.m. on April 21, measure two fist-widths north from due east, then two-and-a half 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 24, 8:30 a.m.: ISS In-Flight Educational Event with European Space Agency Flight Engineer Samantha Cristoforetti.

March 27, 1:30 p.m.: Launch Coverage of the ISS Expedition 43 (One Year Crew). Launch is set for 2:42 p.m.

7:45 p.m.: Docking coverage of ISS Expedition 43.

9:45 p.m.: Hatch opening for ISS Expedition 43.

There should be coverage of the April 10 SpaceX launch, although it hasn't yet been put on the NASA web page.

## Calendar of Events

March 20: Total eclipse of the Sun visible in the North Atlantic between Iceland on the one hand and Scotland and Norway on the other. The total eclipse will pass over the Faroe Islands and Svalbard in the Arctic Ocean.

March 21: Oklahoma Space Alliance meeting, 2:00 p.m., Harry Bear's in Moore, Oklahoma.

March 27: One Year Crew Launch to the Space Station, 2:42 p.m. CDT, Astronauts Scott Kelly, Mikhail Kornienko and Gennady Padlaka will spend a year on the Space Station.

April 4: Total eclipse of the Moon visible over the Pacific Ocean, west coast of United States, the east coast of Asia, Australia and New Zealand.

April 6: Uranus is in conjunction with the Sun.

April 8: [Tentative.] Oklahoma Space Industry Development Authority Meeting at 1:30 p.m., Oklahoma Department of Transportation Building in Oklahoma City.

April 9: Mercury is in superior conjunction with the Sun.

April 10: Launch of 6<sup>th</sup> SpaceX resupply mission to Space Station, 4:42 a.m. CDT.

April 10: 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.

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

April 12: Yuri's Night

April 17: Oklahoma City Astronomy Club's Messier Marathon at Lake Hefner, See <http://www.okcastroclub.com/> for details.

April 22 and 23: Peak of Lyrid meteor shower.

April 28: Launch of Progress resupply mission to Space Station.

May 5: Peak of Eta Aquarid Meteor shower.

May 6: Mercury is at greatest elongation, 21 degrees east of the Sun (so can be seen after sunset).

May 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.

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

May 13: [Tentative.] Oklahoma Space Industry Development Authority Meeting at 1:30 p.m., Oklahoma Department of Transportation Building in Oklahoma City.

May 22: Saturn is at opposition.

May 26: Launch of Expedition 44 to Space Station 2:46 p.m. CDT.

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

June 6: Venus is at greatest eastern elongation, 45.4 degrees from the Sun (so can be seen after sunset).

June 10: [Tentative.] Oklahoma Space Industry Development Authority Meeting at 1:30 p.m., Oklahoma Department of Transportation Building in Oklahoma City.

June 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.

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

June 13: Launch of 7<sup>th</sup> SpaceX resupply mission to the Space Station.

June 14: Mars is in conjunction with the Sun.

June 14: The Moon occults Mercury.

June 24: Mercury is at greatest western elongation, 22 degrees from the Sun (so can be seen before sunrise).

June 30: Venus and Jupiter are having very close conjunction, approaching to 0.3 degrees from each other.

Sometime in July: The European Space Agency launches *LISA Pathfinder*. LISA=Laser Interferometer Space Antenna, a gravitational wave detector that is a joint ESA/NASA project. Web site is <http://sci.esa.int/lisapf>.

July 8: [Tentative.] Oklahoma Space Industry Development Authority Meeting at 1:30 p.m., Oklahoma Department of Transportation Building in Oklahoma City.

July 10: 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.

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

July 14: The *New Horizons* probe passes through the Pluto-Charon system. The New Horizons web site is [pluto.jhuapl.edu/](http://pluto.jhuapl.edu/).

July 18: The Moon occults Venus.

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

July 28: Peak of Delta Aquarid meteor shower.

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

August 12: Peak of Perseid meteor shower.

August 14: 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.

August 15: Venus is in inferior conjunction with the Sun.

August 17: Launch of JAXA's HTV5 Cargo Craft to the Space Station. This launch includes the Calorimetric Electron Telescope (CALET) and the Multi-User System for Earth Sensing (MUSES).

August 26: Jupiter is in conjunction with the Sun.

August 31: Neptune is in opposition.

September 1: Launch of Expedition 45 to the Space Station.

September 2: Launch of 8<sup>th</sup> SpaceX supply mission to the Space station.

September 4: Mercury is at greatest elongation, 27 degrees east of the Sun (so can be seen after sunset).

September 12: [Tentative] Oklahoma Space Alliance meeting, location to be announced.

September 28: Total lunar eclipse visible from most of North America (including Oklahoma), all of South America, all but the eastern part of Africa, western Europe and the entire Atlantic Ocean.

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

October 11: Uranus is at opposition.

October 15: Mercury is at greatest western elongation, 18 degrees from the Sun (so can be seen before sunrise).

October 10: [Tentative] Oklahoma Space Alliance meeting, location to be announced.

October 21: Peak of Orionid meteor shower.

October 26: Venus is at greatest western elongation, 46 degrees from the Sun (so can be seen before sunrise).

November: Launch of *ASTRO-H* (or NeXT), the Japanese X-ray astronomy satellite.

November: Japan's *Akatsuki* space probe flies by Venus and there will be a second attempt to achieve orbit.

November: Venus, Mars and Jupiter will be close together in the sky, with a couple of conjunctions.

November 14: [Tentative] Oklahoma Space Alliance meeting, location to be announced.

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

November 17: Peak of Leonid meteor shower.

November 20: Launch of Expedition 46 to the Space Station.

November 29: Saturn is in conjunction with the Sun.

December 12: [Tentative] Oklahoma Space Alliance meeting, location to be announced.

December 14: Peak of Geminid meteor shower.

December 22: Peak of Ursid meteor shower.

December 28: Mercury is at greatest elongation, 20 degrees east of the Sun (so can be seen after sunset).  
Sometime in 2016: ESA launches the *ExoMars Mars Orbiter*. This mission will include a static lander, but the rover will be launched in 2018. For more information, visit [en.wikipedia.org/wiki/Exomars](http://en.wikipedia.org/wiki/Exomars).

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

March 2016: Launch of Expedition 47 to the Space Station.

March 8 – 17, 2016: Proposed launch date for *InSight*, a lander that will probe the interior of Mars. For information, see <http://insight.jpl.nasa.gov/>.

June 6, 2016: Venus in superior conjunction with the Sun.

July 4, 2016: *Juno* arrives at Jupiter. The NASA *Juno* page is [http://www.nasa.gov/mission\\_pages/juno](http://www.nasa.gov/mission_pages/juno).

July 2016-2020: The *New Horizons* probe visits the Kuiper Belt.

July 9, 2016: The European Space Agency/JAXA *BepiColombo* Mercury Orbiter is launched. Home page is <http://sci.esa.int/bepicolombo>.

September 2016: 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/>.

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).

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

July 2017: Launch of the European Space Agency/NASA Solar Orbiter (SolO), which will orbit the Sun at a distance closer than Mercury. Web site is <http://sci.esa.int/solarorbiter>.

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.

Sometime in 2018: ESA launches the *ExoMars Mars Rover*. For more information, visit [en.wikipedia.org/wiki/Exomars](http://en.wikipedia.org/wiki/Exomars).

Sometime in 2018: Russia launches the lander of the "Luna-Glob" mission, which will deploy 13 mini-probes upon the lunar surface. For more information, see <http://en.wikipedia.org/wiki/Luna-Glob>.

Sometime in 2018 or 2019: Russia launches the orbiter of the "Luna-Glob" mission.

July 30, 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](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.

Sometime in 2019 or 20: Russia launches the "Luna-Resurs mission, which will deploy 13 mini-probes upon the lunar surface. For more information, see <http://en.wikipedia.org/wiki/Luna-Glob>.

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 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.

Sometime in 2023: Arrival of OSIRIS-Rex at the near-earth asteroid 101955 Benu to return samples. [See September 2016.]

April 8, 2024: A total solar eclipse crosses the US from the middle of the Mexico-Texas border, crosses Arkansas, southern Missouri, Louisville, Cleveland, Buffalo and northern New England.

December 19, 2024: *Solar Probe Plus* makes its first pass through the outer corona of the Sun. [See July 30, 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, 2015 (Area Code 405)

Steve Swift, President & <i>Update</i> Editor	496-3616 (H)
David Sheely, Vice President	821-9077 (C)
Syd Henderson, Secretary & <i>Outreach</i> Editor	321-4027 (H) 365-8983 (C)
Tim Scott, Treasurer	740-7549 (H)
Claire McMurray, Communications	329-4326 (H) 863-6173 (C)

### OSA E-mail Addresses and Web Site:

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 cliffclaire at hotmail.com (Claire McMurray)  
 sydh at ou.edu (Syd Henderson)  
 ctscott at mac.com (Tim Scott)  
 t\_koszoru01 at cox.net (Heidi and Tom Koszoru, new address)  
 sheely at sbcglobal.net or david.sheely.1 at us.af.mil (David Sheely)  
 john.d.northcutt1 at tds.net (John Northcutt)  
 lensman13 at aol.com (Steve Galpin)

E-mail for OSA should be sent to [sydh@ou.edu](mailto: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](http://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](http://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](http://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](http://www.marsociety.org).

The National Space Society's Headquarters phone is 202-429-1600. Executive Director e-mail [nsshq@nss.org](mailto:nsshq@nss.org). The Chapters Coordinator is Bennett Rutledge 720-641-7987, [rutledges@chapters.nss.org](mailto: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](http://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](http://www.planetary.org). E-mail is [tps@planetary.org](mailto:tps@planetary.org).

NASA Spacelink BBS 205-895-0028. Or try [www.nasa.gov](http://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 (\$35 for new international members). Regular membership rates are \$55, international \$65. Student memberships are \$18 new, \$25 renew. Senior memberships are \$20 new, renew \$40. Part of the cost is for the magazine, *Ad Astra*. Mail to: National Space Society, 1155 15th Street NW, Suite 500, Washington, DC 20005, or join at [www.nss.org/membership](http://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](http://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, Box 273, Indian Hills CO 80454.

Do you want to be on the Political Action Network?

\_\_\_\_\_ Yes \_\_\_\_\_ No. [See brochure for information.]

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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**

