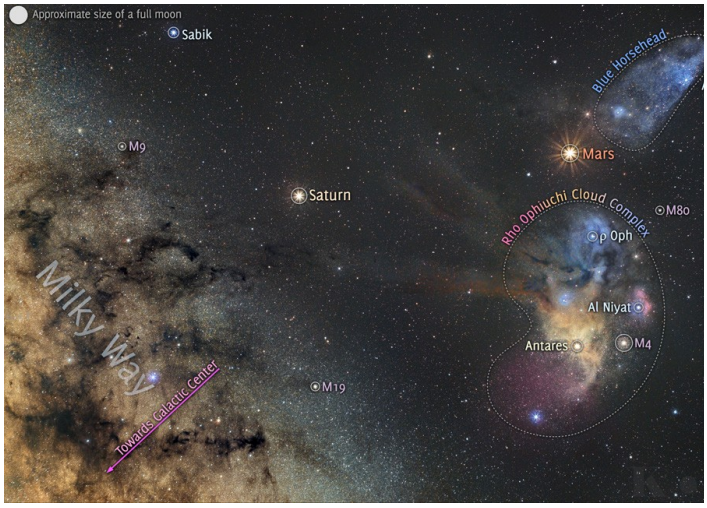
Temecula Valley Astronomer

The monthly newsletter of the Temecula Valley Astronomers Jan 2017

Events:

General Meeting : Monday, Jan 9, 2017 at the Temecula Library, Room B, 30600 Pauba Rd, at 7 pm. What's Up and refreshments by Chuck Dyson. Main presentation by Mark Baker - "NASA's Eyes".

For the latest on Star Parties, check the web page.



NASA APOD 10 May 2016 - Saturn and Mars visit Milky Way Star Clouds

Image Credit & Copyright: Carlos Eduardo Fairbairn ; Rollover Annotation: Judy Schmidt

WHAT'S INSIDE THIS MONTH:

Send newsletter submissions to Mark DiVecchio <markd@silogic.com> by the 20th of the month for the next month's issue.

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General information:
Subscription to the TVA is included in the annual $25 membership (regular members) donation ($9 student; $35 family).

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Cosmic Comments – Jan/2017
by President Mark Baker

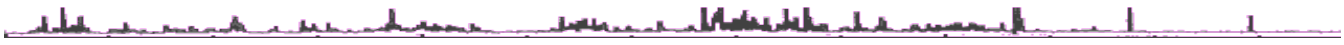
I don't think I can be labeled as a vindictive person, but that doesn't mean I don't appreciated being vindicated. Back in the Dark Ages, circa 1975, I had presented a dissertation proposal titled "A Case for the Propensity of H2O Compounds Being Pervasive throughout the Solar System". It was almost immediately rejected by the Review Board for being based on a non-supportable tenet, or in other words, it went against the prevailing modeling of the day. I was also of the opinion that they just plain couldn't grasp the math…

A few years later when I was part of the groundswell that became The Planetary Society, I had the temerity to present my paper to The Big 3 – Murray, Sagan, and Friedman. I never heard from Murray, and Sagan said it was "interesting", which I figured meant he couldn't grasp the numbers either. Only Louis Friedman encouraged me to pursue the angle, but by then I had moved into the development of apocalyptic weaponry systems!!!!

We now KNOW that there is "Water, Water, Everywhere", but I have followed the progression of observation, analysis, and evaluation of Mars with special interest. Not only is there MUCH more water than previously modeled, there is even evidence of humidity, which this atmosphere supposedly cannot support!!! Warm season features, such as recurring slope lineae, contain water soaked salts. But where does the water come from?? Since such features occur on steep slopes, it can't be an underground source…so it appears that deliquescence is the only answer. In other words, water being pulled from the atmosphere… I bring this up because every day we learn something new…science isn't absolute and therefore constantly evolves and corrects itself. Some buy into such change and some don't, but I always like the thought that only change is constant.

I'm proud to associate with so many that have a keen interest in the Cosmos and an even keener interest in sharing it…once again, thanks for all you TVA members do to keep our communities up to speed.

Clear, Dark Skies my Friends…



Looking Up – Jan 2017
by Curtis Croulet

First Quarter Moon is Jan 5 at 11:47 AM PST; **Full Moon** is Jan 12 at 3:34 AM PST; **Last Quarter Moon** is Jan 19 at 2:13 PM PST; **New Moon** is Jan 27 at 4:07 PM PST.

Mercury climbs rapidly into the morning sky, reaching greatest western elongation (angular distance from the Sun) on Jan 19. The messenger planet subsides slowly toward the Sun after that.

Venus is high in the dusk sky, setting as much as 4 hours after sunset. During Jan, Venus continues to brighten from mag -4.4 to -4.7. Venus reaches greatest eastern elongation on Jan 12. Venus reaches inferior conjunction (between the Sun and the Earth) on Mar 25, 2017. Between these two events, Venus reaches greatest brilliancy on Feb 18 at mag -4.8.

Mars moves from Aquarius into Capricornus. Mars remains visible in the evening sky all month. Mars fades from mag +0.9 to +1.1. It's too small to see visible detail in amateur telescopes.

Jupiter rises a bit before 1 AM on Jan 1 and as early as a bit before 11 PM on Jan 31. Opposition is Apr 7.

Saturn remains in southern Ophiuchus, a pre-dawn object.

Uranus is almost on the meridian as night falls on Jan 1. It's in Pisces, the first half of the night.

Neptune is heading to its last hurrah. It's in Aquarius. You can see it early in the evening in the southwestern sky on Jan 1, but viewing will be a challenge by Jan 31. The Oct 2016 issue of *Sky & Telescope*, p.50, has excellent finder charts for both Uranus and Neptune.
Pluto is unavailable for viewing this month, being in the daytime sky.

The most significant meteor shower is on Jan 3, the **Quadrantids**. The Quadrantids are named for the obsolete constellation Quadrans Muralis, or the wall-quadrant. Perhaps you've seen pictures of one of those giant wall-mounted sighting gadgets the pre-telescope astronomers used to measure the positions of the stars. That's a wall-quadrant. But this one was built by Jerome Lalande in the late 1700s, long after the invention of the telescope. Lalande's proposed constellation was between the patterns of Boötes and Draco. Quadrans Muralis never caught on, and today its name survives only in the name of this meteor shower. The Quadrantids' peak on the morning of Jan 3. The predicted peak will be at 6 AM, just as the sky is starting to brighten.

Let's look up.

Let's look ahead to some astronomical events of interest in 2017.

By anybody's reckoning, the total solar eclipse on Aug 21, 2017, has to be the top event of the coming year. Your search for online information should probably start at www.greatamericaneclipse.com. The path of the eclipse crosses the nation diagonally from Oregon to South Carolina. Best weather prospects are in Oregon, east of the Cascades. I plan to view the eclipse from Menan, Idaho. Hotels and campgrounds along the path are filling up, and hotels and campgrounds are often charging sky-high rates. If you have not already made your plans, then you will be challenged to find overnight accommodations. I know some people will be tempted just to stay home to view the partial eclipse. A partial solar eclipse can be interesting, but it is orders of magnitude inferior to the profound and, for some, life-altering experience of a total solar eclipse.

Now, let's list some of 2017's important planetary dates.

Jupiter opposition: Apr 7. Saturn opposition: Jun 14. Pluto opposition: Jul 9.
Neptune opposition: Sep 4. Uranus opposition: Oct 18.
Mars's next opposition is Jul 27, 2018. It'll be a good one.

Oppositions are important, because most amateur astronomers don't begin serious study of the outer planets until they are conveniently place in the evening sky. If you don't mind staying up late, you can catch the planets in the preceding days, as they ramp up in size and brightness.

For the inner planets, we have the following events:
Venus greatest eastern elongation (evening sky): Jan 12.
Venus inferior conjunction: Mar 25.
Venus greatest western elongation (morning sky): Jun 3.
Mercury greatest eastern elongations (evening sky): Mar 31, Jul 29, Nov 23.
Mercury greatest western elongations (morning sky): Jan 19, May 17, Sep 12.

From this we can see that Venus, so high and bright as I write this, will be out of the evening sky and into the morning sky from the beginning of spring and for the rest of the year. Jupiter will be available for outreach events by mid-spring, Saturn not available until summer.

The three big meteor showers:
- Perseids: Aug 12-14, competes with last quarter Moon.
- Leonids: Nov 16-18, dark sky.
- Geminids: Dec 13-15, waning crescent Moon.

The Moon will occult the 1st magnitude star Aldebaran the evening of Mar 4. Unlike last October's occultation of Aldebaran, we are nowhere close to either of the graze lines.

There are doubtless other interesting events that haven't caught my attention. We'll be on the alert for anything additional.

Clear skies.

Note from the Editor:

In an article in last month's newsletter, Clark Williams mentioned "Alfvén waves".

A few months ago, I was working the Visitor's Gallery at Palomar Observatory where I am a volunteer Docent when a visitor told me a story.

Twenty-five years ago or so, she was selling paintings. A man came into her shop and bought two paintings because he could not decide which one he liked better. He told her that he was going to return one or the other.

A short time later, he called and asked the woman to come to his house in La Jolla and pick up the unwanted painting. She did that and over the next few years became friendly with the man as he bought more paintings from her. She learned that he spent half the year in La Jolla and half the year in Sweden. He always told her to visit if she were ever in Sweden.

As it turned out she did find herself in Sweden and arranged to meet at his house. She enlisted some help in finding the house from a local resident. She asked for directions to the home of Hannes Alfvén. The local was surprised and asked her if she knew who this man was. She told the story of the paintings in La Jolla.

Then the Swede told her that Alfvén was a world famous Noble Prize winning plasma physicist. The woman had no idea that she was dealing with such a famous person.

Hannes Alfvén, who died in 1995, won the Noble Prize in Physics (1970) for his work in magnetohydrodynamics and was the discoverer of what are known now as Alfvén waves. He spent time in La Jolla because he was a professor of Electrical Engineering at UCSD.

Along with Oskar Klein, he proposed the Alfvén-Klein model, an alternative to the two primary cosmological theories, the Steady State and the Big Bang theories. Being critical of religion, he was often cited as saying that the Big Bang was a myth devised to explain creation.

During his life, Alfvén considered his work to be generally under-acknowledged and not respected by other scientists.

Asteroid *1778 Alfvén* is named in his honor.

Cassini: Unrevealing Saturn

By Mauricio Guillen

Saturn has been a great mystery to scientists, manly its marvelous rings and moons. Before Cassini, the most valuable data that was obtained was through Pioneer 11 and Voyager 1 and 2 which consisted of pictures, measurements, and observations that were taken as they passed by. The problem here is that due to the time limit that these probes had, they weren't very resourceful to operate in-depth scientific research. Everything changed once Cassini went into orbit at Saturn on June 30, 2004. From then on, Cassini has been able to conduct ground breaking research about Saturn, and more importantly, it changed the course of future planetary exploration.

Cassini successfully launched on October 15, 1997 from Cape Canaveral. This started a seven-year journey that forever changed our understanding of Saturn. It became the first spacecraft to orbit Saturn and the data that has been obtained from it is invaluable. The most ground breaking data that Cassini obtained is about one of Saturn's moon, Titan, and the value that this moon really possesses.

Before Cassini we knew very little about Titan, Saturn's largest moon, but now we know about the assets this moon contains. Through Cassini, it was discovered that Titan has lakes and seas of liquid methane and ethane, replenished by rain of hydrocarbon. It was also discovered that underneath its surface, it hides a liquid ocean likely composed of water and ammonia. Before Cassini, it was only known that Titan was unique for having a dense nitrogen atmosphere, other than Earth of course, but what lay beneath the smoggy clouds was still a mystery up until now.

The spacecraft did flybys of Titan more than 100 times, and it eventually sent the ESA's Huygens Probe into the mysterious planet. During the probe's descent, it measured Titan's atmospheric composition, and took pictures of the surface. Not only did it survive the landing, but remained sending data for more than an hour until its batteries were drained.
Cassini helped us understand how Earth might've looked like before life. Titan has been revealed to contain seas, lakes, dunes, and it's argued that it might even have volcanoes. Currently, Cassini is reaching the end of its long journey and its Great Finale. That end is scheduled in 8 months. The spacecraft will be carried high above Saturn's north pole, and it will plunge into Saturn's ring for 22 orbits. After this, it will enter the upper atmosphere of the planet and will burn up like a meteor has an epic ending.

Random Thoughts - Best Practices and Radio Telescopes
by Chuck Dyson

When I retired from my clinical practice at the end of 2013, every specialty was just as busy as beavers producing white papers on “Best Practices”. The goal was to elucidate through an exhaustive literature review the best ways to give an anesthetic, conduct a surgery, and operate the heart-lung machine. Well, we did not succeed in coming up with the ultimate way to do operations but we did develop a generally agreed upon system for grading the quality of the data in research papers and thus how much clinical weight to give to a paper. The other thing that was learned from this exercise was that there is very little information that is used in today’s clinical practice that is at the “you really should do it this way level” (Type I) most of clinical practice is at the “it is reasonable to do it this way level” (Type IIa) or “it is not unreasonable to do it this way” (Type IIb) level of supporting research information. To get a procedure to the Type I level of certainty that it is better, and sometimes only slightly better, than the other options requires a ton of clinical data, carefully collected, and several large prospective research projects on the procedure; because the process is so slow and expensive, out of necessity, most clinical decisions are made using Type IIa and IIb information and this leaves plenty of room for interpretation as to which way is best.

What does the preceding paragraph have to do with astronomy? Absolutely nothing, except to point out that most of the time people, especially scientists, trying to probe the unknown are operating on data that merely suggests what a reasonable approach would be.

Today, in radio astronomy, there are two massive and expensive projects in progress to give us unprecedented views of our galaxy and universe in the radio spectrum. Why two projects? Please reread the first two paragraphs. Seriously, both are aimed at producing high resolution maps of different phenomenon in our galaxy and universe and each design has its advantages and limitations. Why are the projects so massive? Good question. If we look at an optical telescope with a diameter of 116 millimeters it has a resolution of about one arc second (1/3600 of a degree) in green light that has a wave length of 550 angstroms (one angstrom is one billionth of a meter) and that means that we can just see an object on the Moon that is about 1.8 kilometer in size. So, the smallest object that we can see with our instrument is dependent on the size of the instrument and the wavelength of the photon we are using. The wavelength of the radio photons are much, much longer than the wavelength of the optical photons. So much so that a radio telescope with a diameter of 100 meters and looking at photons with a wave length of 21 cm has an angular resolution of 9.4 minutes and this means that if you were looking at the Moon with its angular size of 30 seconds you would “see” absolutely nothing. If we now reduce our photon wave length to just 3 cm then our resolution drops to “only” 1.15 minutes, still too great to “see” the Moon. Finally if we tune our radio telescope to receive photons of 3.5 mm we will have an angular resolution of 10 seconds and we will be able to “see” the Moon but with much less resolution than our little 116 mm optical telescope. The reason that the word see is in parenthesis is because if the Moon is producing photons at the three frequencies

mentioned then there will be an energy blip on your recorder, but you cannot say that it comes from the Moon in the first two cases only that the Moon is in the area of the sky that the radio source is coming from. Only in our last case, where we are doing our observing with photons at the 3.5 mm wave length, do we have a resolution that is smaller than the diameter of the Moon and finally we can say that the signal is coming from the Moon and not just that the Moon is in the area of the sky that the signal is coming from. And that is why angular resolution is so important as it lets you say “this the source of the emission” and not just “this could be the source of the emission”.

In 1963 the Arecibo radio dish in Puerto Rico went on line and at 305 meters was the worlds largest radio telescope dish and remain so until September of 2016 when the FAST radio telescope was completed in China. The FAST dish is 500 meters and has adaptive optics to enhance its resolution. Because the Earth rotates and celestial objects do not stay in one spot, the suspended receiver of the radio signals must be continuously moved across the main dish to allow the signal to be recorded over time and the pointing accuracy of the receiver is 5 arc seconds and that is the resolution of the telescope. I should also mention that the 2,225 plates in the adaptive optics portion of the dish need to be continuously adjusted in order to keep the signal in sharp focus. And yes this telescope is operating at the very edge of what is possible with today’s computers.

The second big, literally, radio receiver project is the Square Kilometer Array (SKA) project. Instead of just one big dish this project will use thousands of small antennae linked together by computers to work as one giant antenna. This linking technique is called aperture synthesis and it is a well-established technique, think of the Very Large Array (VLA) in New Mexico. The advantage of the aperture synthesis approach is that the antennae can be very simple affairs, the ones for the Square Kilometer Array look like the wire cones that gardeners use to grow tomatoes in but turned upside down and welded to a flat ground plate. The problem with this approach is that each antennae receives the signal at a slightly different time and this must be corrected for before the signals can be added together to form a coherent picture. When the signals from all of the antennae are combined, the resolution is as if there was one radio telescope a kilometer in diameter. Tracking the signal as is done with the FAST 500 meter radio telescope is; however, another matter.

But wait there’s more and yes I lied to you because there are not just two new radio telescope programs but a whole slew of them based on this aperture synthesis technique and spurred on by a pilot program in England called the Multi-Element Radio-Linked Interferometer Network (MERLIN). MERLIN is a number of radio telescopes that are located in the English countryside and are 217 kilometers apart and are linked by radio signals to create a truly large radio telescope. Why stop there? The European Very Long Baseline Interferometry Network (EVN) aims to connect large radio telescopes in Europe, Asia, and the USA into one global telescope. Not to be out done, the Square Kilometre Array people are planning to setup at several sites and link the sites together for a 3,000 kilometer diameter telescope. There is only one small problem with this plan and that is there is not a computer available today that can process all of the signals (hundreds of thousands of them) into a coherent picture. So, the project is going forward on the

assumption that the computer processing capacity that is needed will be available when the project is nearing completion. If this all sounds a little crazy, please, ask yourself “if someone had approached me in the 1980’s with a chance to invest in a company that would produce a small hand held cell phone that was satellite linked to the entire world, would I have done it?” Crazy in the 80’s is something you use every day today. Crazy programs today, break through discoveries tomorrow.

Cheers,
Chuck

A Little Voyage Through the History of My Favorite DSN Mission
by Clark Williams

I am a child of Sputnik. In the same way that my parents knew where they were on December 7, 1941 at 0748 Hawaii Time, I know exactly where I was on October 4th 1957, at 2229 MSK or for me 1329 CST in southeastern Kansas.

My favorite Uncle, who was going to go to work as an aeronautical engineer, took me outside and showed me a moving dot in the night sky. We didn't need a telescope nor even binoculars. The sky was dark black with brilliant white stars.

I followed the space program through the 50s, 60s and 70s before I had a brief interruption to pay my dues to Uncle Sam. When I came back, I followed NASA's exploits even though it was clear that manned space flight was pretty much over for anything more than orbiting the earth. Still!, there was the science.

Being in the service can really destroy your sense of time. You are relatively unaware of the outside (non military) world. Although I was still in my nebulous service bible I know where I was 1977 September 5 12:56:00 UTC. That was the day Voyager I launched. Headed out on its "Grand Tour" of the outer planets.

Voyager I launched after Voyager II which launched in August of.1977. The original mission goals were to tour the outer planets and image Jupiter, Saturn, Uranus and Neptune. Voyager I got Jupiter and Saturn and Voyager II got the other two.

Once Voyager I completed the grand tour it was headed outside the solar system without a mission. Voyager was not the first spacecraft to head outside the solar system however. In March of 1972 Pioneer 10 was launched on a very similar mission. A grand tour followed by an extra solar system mission.

Pioneer 10 used four SNAP-19 radioisotope thermoelectric generators (RTGs). These used Plutonium-238 which has a half-life of 87.4 years. By 2001 steady deterioration of the thermocouples meant that the total power output was down to 65W and a selective instrument power conservation regiment was instituted.

The last attempt to communicate with Pioneer 10 was in March of 2006. No response was received. Pioneer 10 was expected to be at 100 AU 2009 October.

Even though it launched five years earlier, Pioneer isn't the first spacecraft to leave the solar system. Pioneer 10 is only traveling at about 12km/s and was passed by Voyager I, traveling at 17km/s in February 1998. Voyager I is traveling about 1AU per year farther than Pioneer 10.

Using lessons learned from the Pioneer missions, the Voyager spacecraft were built with three radioisotope thermoelectric generators (RTGs) mounted on a boom but packed and designed differently (see Figure I, from NASA copyright: public domain)

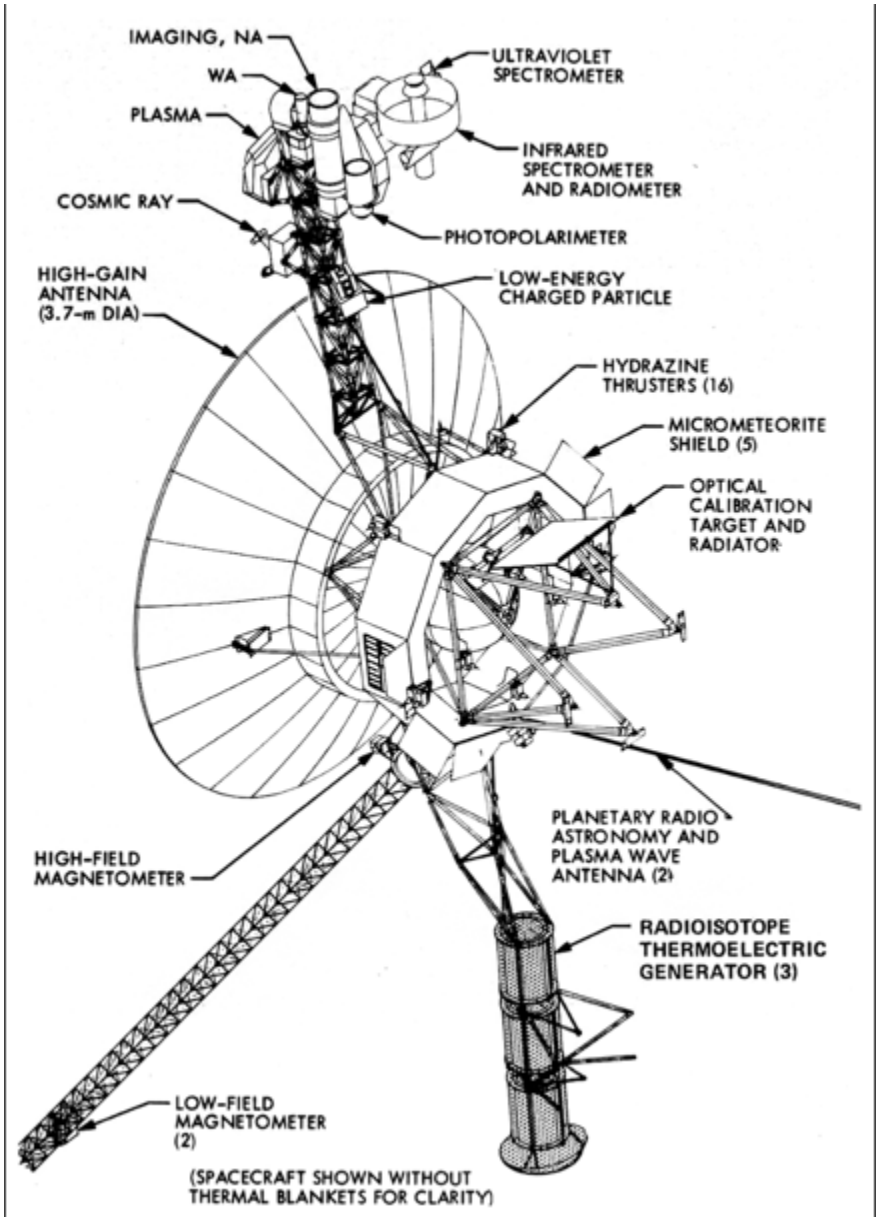


FIGURE I

Pioneer 10 and 11 become a real puzzle in the 2000s since they appeared to be slowing down compared to what their expected velocities should have been. This was a cause of excited debate at JPL over many lunches and commutes.

After gigabytes of data analysis and scratching of a lot of heads the problem tuned out to be the heat generated by current flow from the electrical instruments onboard the spacecraft. One person at JPL likened it to being in your car traveling at constant velocity on a frictionless road at night and you turn on your headlights. Eventually you will slow down because the photons are pushing you in the other direction.

Curiously though, the Voyager spacecraft do not exhibit the Pioneer Anomaly. The reason is that the Pioneer spacecraft have their electronics radiating in their direction of travel and the Voyager spacecraft radiate their heat perpendicular to their travel. Creating a kind of corkscrew heat trail along the line of travel. Both spacecraft spin to gyroscopically stabilize the earth-oriented antennae. Voyager also uses a 16 thruster RCS to fine tune the antennae orientation.

In February of 1990 Carl Sagan asked NASA to position Voyager take a family portrait of the solar system. Space scientists Candy Hansen of NASA's Jet Propulsion Laboratory (JPL) and Carolyn Porco of the University of Arizona made the necessary calculations and Voyager snapped the image of the solar system commonly known as “The Pale Blue Dot” (figure II from JPL/NASA copyright: public domain).

FIGURE II

The blue dot is the Earth and it is less than a pixel in size. Though as Sagan pointed out “every one who ever lived and died did so on that pale blue dot”. The light bands are lens artifacts.

If you want to hear Ann Druyan discuss the “Pale Blue Dot” follow this link:
http://www.jpl.nasa.gov/video/details.php?id=1363

Each Voyager also contains a golden record (see:
http://voyager.jpl.nasa.gov/spacecraft/goldenrec.html).

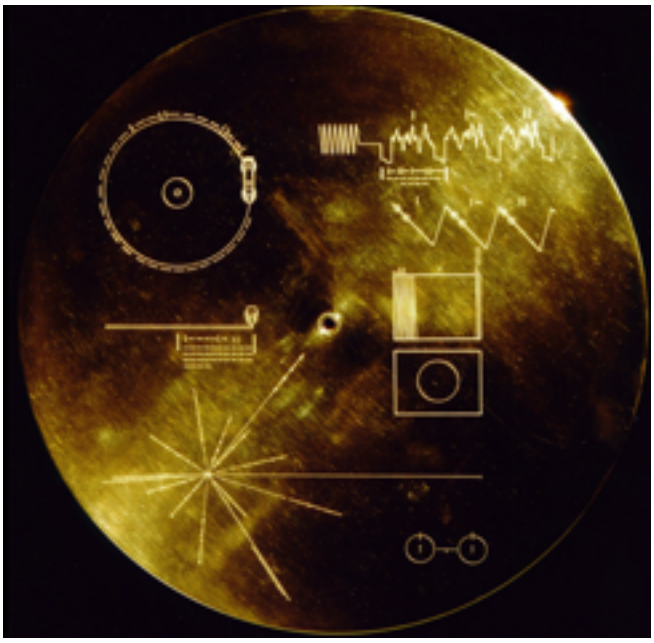


FIGURE III

FIGURE IV

Just in case the spacecraft are ever retrieved by intelligent life forms, the gold plated record contains photos of lifeforms on Earth a range of scientific information, spoken greetings, sounds and music. Included are the sound of a baby crying, whale song, Mozart's "The Magic Flute, Queen of the Night" aria, no. 14, Chuck Berry's "Johnny B. Goode", Bach's, "Brandenburg Concerto" No. 2 in F. First Movement and more.

In an act of cosmic karma the universe gave us back some sounds of its own. In April of 2012 the blast wave from a massive coronal ejection reached Voyager. The high energy particles caused the plasma to vibrate and Voyager was able to record the effects which were later processed here on Earth and turned into a music download. Audible had it on sale for awhile titled: "Symphonies of the Planets — NASA Voyager Space Sounds". I warn you now it is five hours long.

The next goal for Voyager: the Heliopause and interstellar space.

A "pause" is a transition from one set of conditions to another. On earth we have the tropopause which separates the troposphere from the stratosphere. Specifically it is the transition point where an abrupt change in lapse rate occurs. The heliopause is the point at which the stellar wind outward push is equaled by the push of the interstellar wind. The cosmic wind from the sun slows, bends perpendicular and even in some conditions reverses. Once you pass the heliosphere you should see the changes in magnetic field and the number of charged particles. Mind you, this is all theoretical since before Voyager no one knew what was out there.

Voyager's solar wind instrument had failed in 1990. This meant that other instruments would have to be used to infer the passage of the heliopause, shockwave and interstellar space.

Dr. Ed Stone (Project Director) and NASA announced in June of 2012 that Voyager had reached the heliopause. In August 2012 Voyager became the first spacecraft to exit the heliopause and enter interstellar space. Voyager was 121 AU distant and light took 17 hours to reach Voyager. the apparent magnitude of the Sun from Voyager was 16.3 and the spacecraft was traveling at 17.043 km/s (relative to the Sun)

Neither Voyager spacecraft are pointed toward a star. Each are destined to wander the Milky Way unless they are impacted by something or retrieved.

Beyond the heliopause is the Oort cloud which Voyager should reach in about 300 years. It will take it about 30,000 years to pass through the Oort cloud. If all continues to work well Voyager should arrive in the vicinity of Gliese 445 in about 40,000 years.

The New Horizons spacecraft will not catch up to Voyager. New Horizons is traveling at about 15km/s and is slowing down. When it gets to the point where Voyager is now it will only be going about 13km/s.

Voyager will be long cold by then. In 2007 the plasma subsystem was powered down, followed by the Planetary Radio Astronomy experiment in 2008 and the scan platform and UV Spectrometer observatories in 2015.

Sometime in 2017 gyroscopic operations will terminate followed in 2018 by the loss of the Data Tape Recorder. In 2020 will see the shutdown of the science instruments and sometime between 2025 and 2030 the RTGs will not have enough energy to power the spacecraft.

Then, like the ghost ships of lore or the wagon tracks of the pioneers in the Mojave desert, the gold records will be the final testimony of the Voyagers.

Current Voyager dynamics can be found at: http://voyager.jpl.nasa.gov

NASA used to make a Voyager paper kit you could download and assemble free of charge. I could not find a link to it that was valid anymore. You can purchase a Voyager paper kit for assembly at: http://spacecraftkits.com/Voyager.html

Big Science in Small Packages
by Marcus Woo

About 250 miles overhead, a satellite the size of a loaf of bread flies in orbit. It's one of hundreds of so-called CubeSats—spacecraft that come in relatively inexpensive and compact packages—that have launched over the years. So far, most CubeSats have been commercial satellites, student projects, or technology demonstrations. But this one, dubbed MinXSS ("minks") is NASA's first CubeSat with a bona fide science mission.

Launched in December 2015, MinXSS has been observing the sun in X-rays with unprecedented detail. Its goal is to better understand the physics behind phenomena like solar flares – eruptions on the sun that produce dramatic bursts of energy and radiation.

Much of the newly-released radiation from solar flares is concentrated in X-rays, and, in particular, the lower energy range called soft X-rays. But other spacecraft don't have the capability to measure this part of the sun's spectrum at high resolution—which is where MinXSS, short for Miniature Solar X-ray Spectrometer, comes in.

Using MinXSS to monitor how the soft X-ray spectrum changes over time, scientists can track changes in the composition in the sun's corona, the hot outermost layer of the sun. While the sun's visible surface, the photosphere, is about 6000 Kelvin (10,000 degrees Fahrenheit), areas of the corona reach tens of millions of degrees during a solar flare. But even without a flare, the corona smolders at a million degrees—and no one knows why.

One possibility is that many small nanoflares constantly heat the corona. Or, the heat may come from certain kinds of waves that propagate through the solar plasma. By looking at how the corona's composition changes, researchers can determine which mechanism is more important, says Tom Woods, a solar scientist at the University of Colorado at Boulder and principal investigator of MinXSS: "It's helping address this very long-term problem that's been around for 50 years: how is the corona heated to be so hot."

The $1 million original mission has been gathering observations since June.

The satellite will likely burn up in Earth's atmosphere in March. But the researchers have built a second one slated for launch in 2017. MinXSS-2 will watch long-term solar activity—related to the sun's 11-year sunspot cycle—and how variability in the soft X-ray spectrum affects space weather, which can be a hazard for satellites. So the little-mission-that-could will continue—this time, flying at a higher, polar orbit for about five years.

If you'd like to teach kids about where the sun's energy comes from, please visit the NASA Space Place: http://spaceplace.nasa.gov/sun-heat/

Astronaut Tim Peake on board the International Space Station captured this image of a CubeSat deployment on May 16, 2016. The bottom-most CubeSat is the NASA-funded MinXSS CubeSat, which observes soft X-rays from the sun—such X-rays can disturb the ionosphere and thereby hamper radio and GPS signals. (The second CubeSat is CADRE — short for CubeSat investigating Atmospheric Density Response to Extreme driving - built by the University of Michigan and funded by the National Science Foundation.) Credit: ESA/NASA

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