



# Temecula Valley Astronomer

The monthly newsletter of the Temecula Valley Astronomers Jan 2018

## Events:

**General Meeting : Monday, Jan 8, 2018 at the Temecula Library, Room B, 30600 Pauba Rd, at 7 pm.** Skip Southwick will present "What's Up" and Mark Baker will speak about the history, status and achievements of the Perth Observatory.

Please consider helping out at one of the many Star Parties coming up over the next few months. For the latest schedule, check the Calendar on the [web page](#).



Credit: [Big Ear Radio Observatory and North American AstroPhysical Observatory \(NAAPO\)](#).

## WHAT'S INSIDE THIS MONTH:

**Cosmic Comments**

by President Mark Baker

**Looking Up Redux**

by Clark Williams

**Random Thoughts**

by Chuck Dyson

**WOW!**

by Clark Williams

**Snowy Worlds Beyond Earth**

by Linda Hermans-Killiam

Send newsletter submissions to Mark DiVecchio <[markd@silogic.com](mailto:markd@silogic.com)> by the 20<sup>th</sup> 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 by President Mark Baker

I can't but help get caught up in all the excitement that is so pervasive nowadays in my colleagues and associates at NASA JPL, Cal Tech, and other Space related entities. With the recent announcement that the USA has restored Space as a priority after almost a decade of banishment, the once flat lined enthusiasm has now got a heartbeat again. All the "walking on eggshells" inquiries, hushed water cooler discussions, and back room proposal developments are being brought to the forefront in quantity AND quality...I mean, they've had eight years to work out the kinks after all!!!

And it's not just a domestic euphoria either...foreign and even corporate organizations have expressed their relief to have our country back in the fold!!!

I have been duly impressed by the joint proposals that have been brought forth for just 2018...projects and programs that will serve to expand human understanding a thousandfold, no longer relegated to a bottom drawer or secondary laptop.

Here's to all those that kept the faith and the pioneering spirit that makes human endeavors so awesome...

And here's to all my fellow TVA members that have contributed to that spirit all along and got us "grounders" to look up, if just for a moment!! 2018 will prove to be a great year in so many ways I feel, and thank you for being a part of it...

Clear, Dark Skies my Friends...





## Looking Up Redux by Clark Williams

ALL TIMES ARE LOCAL PST WILDOMAR

Times are given in 24-hour time either as hh:mm:ss or hhmmss. A time given as hhmm+ indicates that it is the hour of the next day. Similarly a time hhmm- indicates a time in a previous day.

### Moon Phases for the month by date:

2018-01-01 Monday @ 18:25:13 PST FULL —

2018-01-08 Monday @ 14:26:29 PST LAST QTR

2018-01-16 Tuesday @ 18:18:28 PST NEW

2018-01-24 Wednesday @ 14:21:26 PST FIRST QTR

2018-01-31 Wednesday @ 05:27:48 PST FULL — BLUE MOON 1<sup>st</sup> of two this year

Perigee comes twice this month because of the BLUE MOON.

2018-01-01 @ 13:56 356,565 km (221, 560 mi) — Maximum perigee in 2018

Apogee comes on 2018-01-14 @ 18:11 406,459 km (252, 563 mi) — Maximum apogee in 2018

Perigee comes on 2018-01-30 @ 01:55 358,994 km (223, 069 mi)



2018 has: (12) new moons,

(12) 1<sup>st</sup> Qtr moons,

(14) Full moons,

(13) 3<sup>rd</sup> Qtr moons

(2) Blue moons and

(0) Black moons

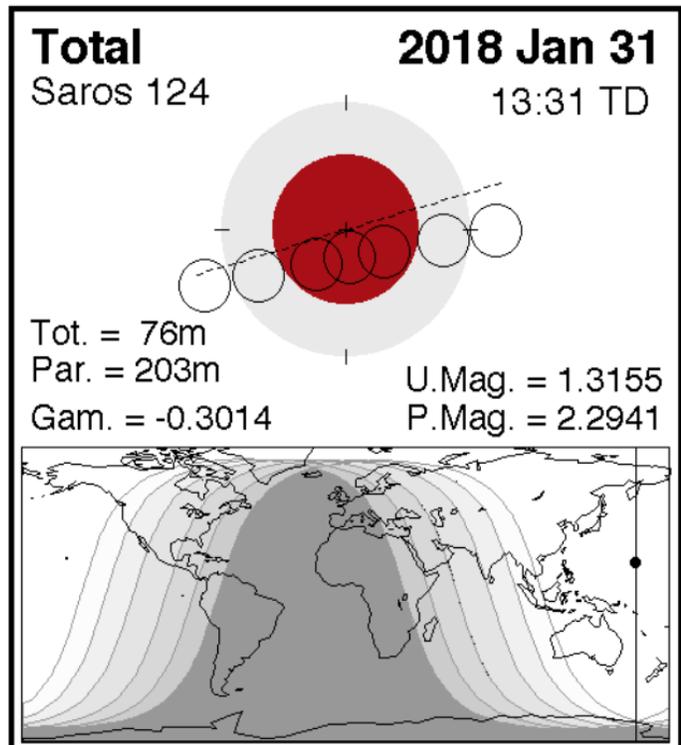
### Lunar Eclipse:

Temecula, California (UTC -8) Date: 2018-01-31 Begins: 05:30 Altitude: 16°

total lunar eclipse

X

<http://eclipse.gsfc.nasa.gov/eclipse.html>



Five Millennium Canon of Lunar Eclipses (Espenak & Meeus)  
NASA TP-2009-214172



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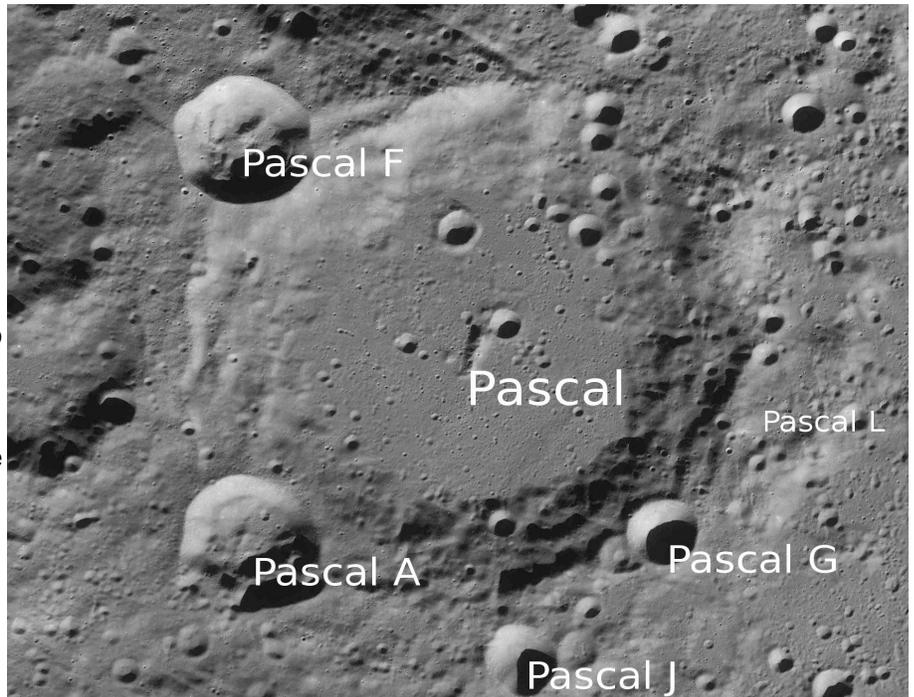
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## Luna:

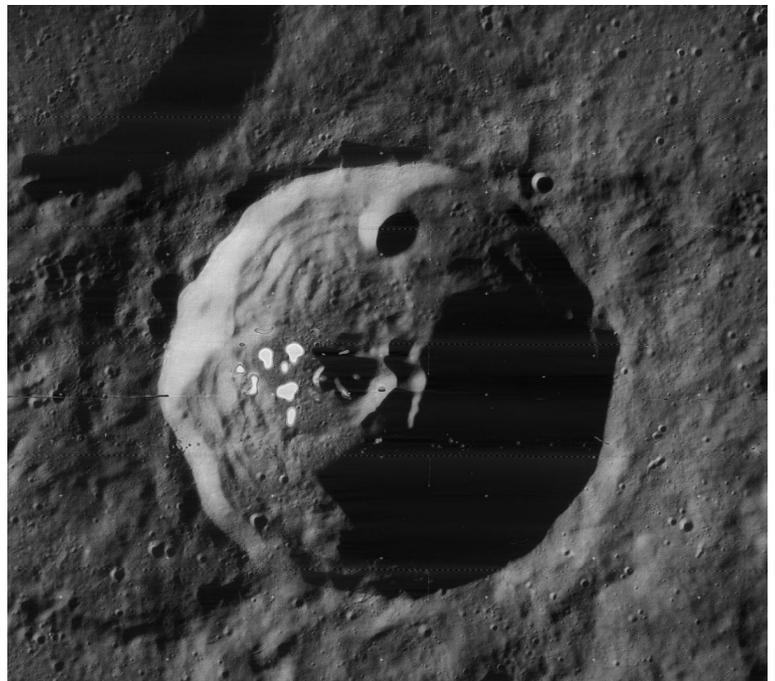
Luna can be found in Leo at the beginning of the month. Since the planets are all hard to see until May (unless you love EARLY mornings) Luna makes both a good viewing and imaging object. Especially if you want to catch some craters in Libration.

The first of January offers up Pascal's Crater.

Pascal is a lunar crater that lies near the northern limb of the Moon, on the western side of the pole. It is located to the north of the eroded crater Desargues, and just east of Brianchon. Pascal can be located by finding the crater Carpenter and then following the surface to the northwest towards the limb. January second offers up Scoresby Crater.



Scoresby is a lunar impact crater that is located in the northern part of the Moon's near side. It is nearly attached to the crater Challis along the north-northwestern rim, and is located just to the north of the walled plain Meton.





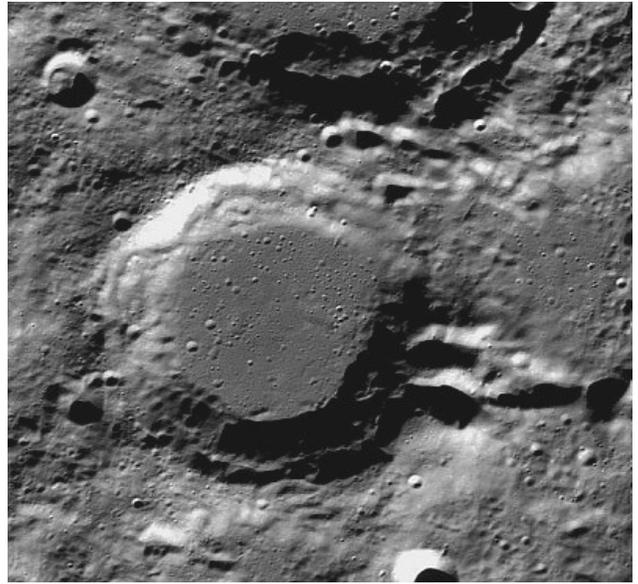
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On the 3<sup>rd</sup> of January look for Cusanus Crater:

Cusanus is a lunar impact crater that is located near the northeastern limb of the Moon. In this location the crater appears very foreshortened when observed from the Earth, and its visibility is affected by libration. The northern rim of Cusanus is nearly joined to the south-southeastern rim of the larger crater Petermann. To the west is Baillaud and to the southeast is Hayn.



Finally on the 30<sup>th</sup> of January you can find Gioja Crater:

Gioja crater is a lunar crater that is located in the vicinity of the north pole of the Moon. It is named after the Italian inventor Flavio Gioia. As it lies so close to the northern limb, it is viewed nearly from the edge making difficult to observe from the Earth.



A nice challenge is to capture all of these craters during this month and post them to the TVA email list and perhaps put them on the TVA WEB image gallery.

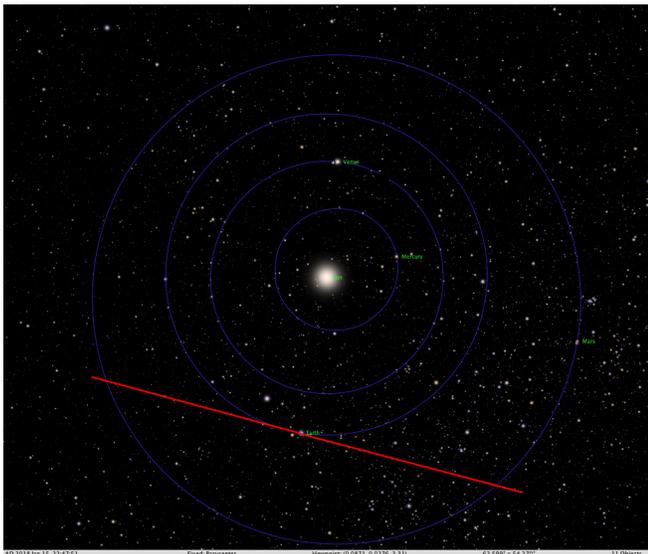
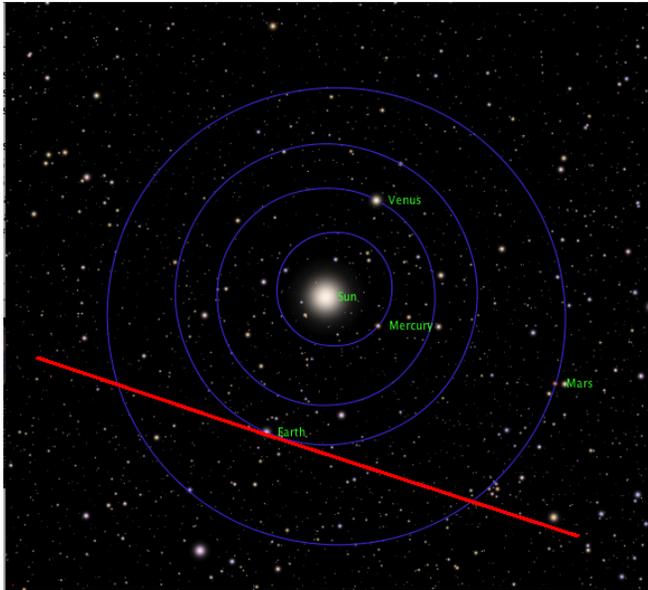


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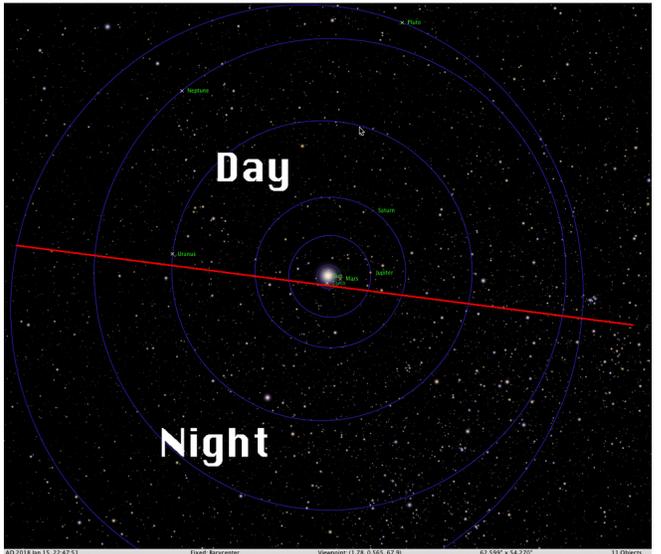
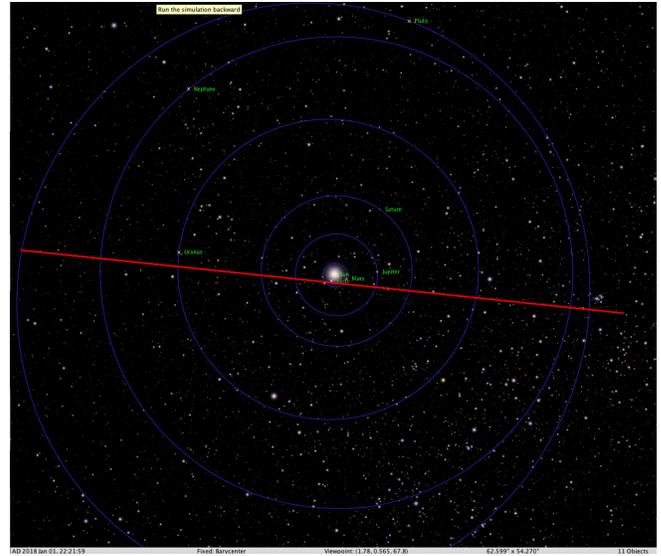
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## Planets: Planetary Positions January 2018:

Inner



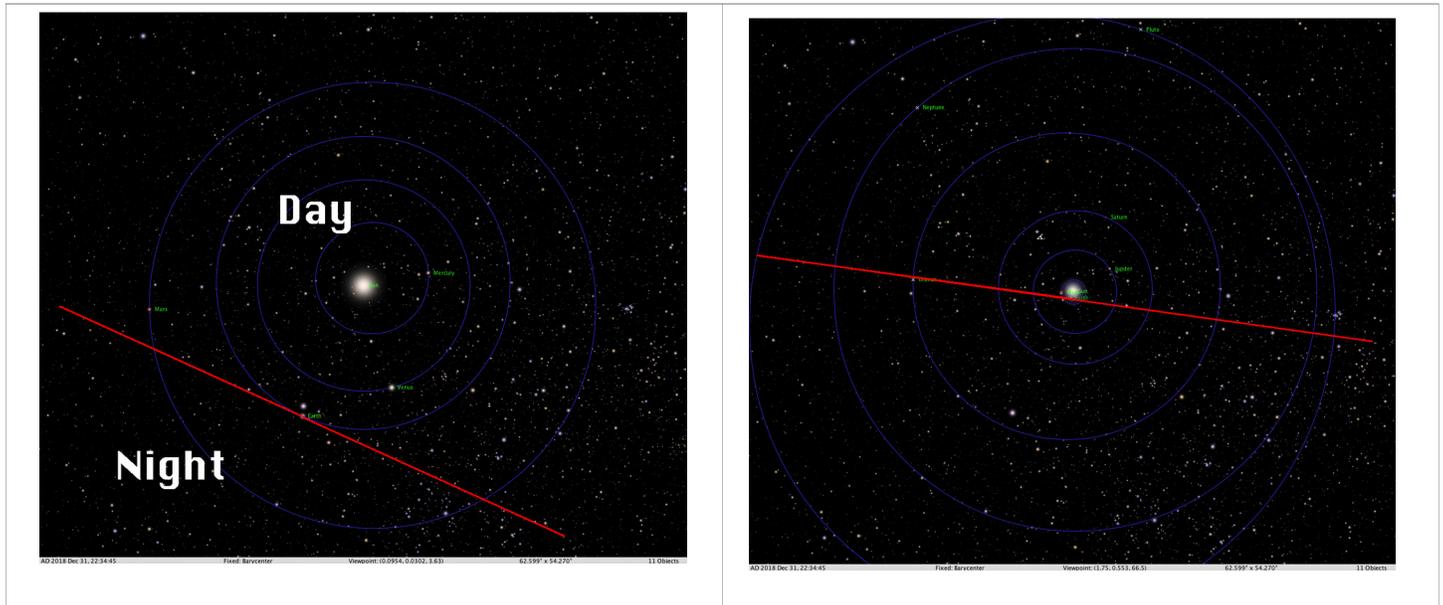
Outer





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- **Mercury:** Mercury will be at Greatest Elongation: 22.7°W on Jan 01 @ 1100 PST. On Jan 12 2300 PST you can find Mercury within 0.7° of Saturn. Finally in January on the 25<sup>th</sup> at 0200 Mercury is at Aphelion. All of this is very early or fairly late.
- **Venus:** Just as blase as Mercury this month on the January 8, at 2100 PST Venus at Superior Conjunction and Aphelion comes on January 23<sup>rd</sup> at 0800.
- **Mars:** Mars is no better: January 11 at 01:03 Mars will be 4.6°S of Moon.
- **Jupiter:** Jove is just gone for the entire month with only one event when on the 10<sup>th</sup> of January at 20:59 Jupiter is 4.3°S of Moon.
- **Saturn:** Saturn has nothing to display spending his time in the daylight this month.
- **Uranus:** Uranus and Neptune both are VIPs (Visually Interesting Planets) of the January night skies. Uranus starts the month rising at a reasonable 1208. This gives it a good time to climb out of the light muck and move into both a viewing and imaging position. George's planet will transit in the early month at about 1834 and won't be setting until nearly 0103 the next morning. Mid month is just as good with: 1113, 1739 and 0009+ for rise, transit and set. By the end of the month: rising at 1011, transiting at 1637 and setting at 2303.
- **Neptune:** Neptune is escaping into the daylight, setting earlier and earlier every night throughout the month. Times: (Rise:Transit:Set) Beginning of Month: (1016:1557:2138) Mid-month: (0922:1503:2044) End of Month: (0821:1402:1944)
- **Pluto:** My favorite PLANET (besides earth of course) is unfortunately a waste this month too. Visual Magnitude of +14.3 and spending most of its time in the Sun's glare.

## Meteors:

- In 2018, the first major shower of the year, the Quadrantids, The Quadrantids are visible from the 1st through the 7<sup>th</sup> and will peak on the night of January 3 and early morning hours of January 4. Unlike other meteor showers, the Quadrantids tend to peak only for a few hours.

## Comets:

- There are several comets coming in 2018 but for January they all have an apparent magnitude between 15 and 22. April will show an improvement in comets.



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## Deep Sky:

In each case you should look for the following on or about the 1<sup>st</sup> Day of January 2018 at 2100 PST and you will have about 20 minutes of viewing time total.

### Messier Objects:

- M34 – An open cluster in Perseus. At least 19 members of this cluster are [white dwarfs](#). These are [stellar remnants](#) of progenitor stars of up to eight [solar masses](#) that have evolved through the [main sequence](#) and are no longer engaged in [thermonuclear fusion](#) to generate energy. Seventeen of the white dwarfs are of spectral type DA or DAZ, while one is a type DB and the last is a type DC.
- M35 – An open cluster in Gemini. The cluster is scattered over an area of the sky almost the size of the full moon and is located 850 parsecs (2,800 light-years) from Earth.
- M36 – An open cluster in the Auriga constellation. It was discovered by Giovanni Batista Hodierna before 1654. M36 is at a distance of about 4,100 light years away from Earth and is about 14 light years across. There are at least sixty members in the cluster. The cluster is very similar to the Pleiades cluster (M45), and if it were the same distance from Earth it would be of similar magnitude.
- M41 (Little Beehive) – An open cluster in the Canis Major constellation. M41 lies about four degrees almost exactly south of Sirius, and forms a triangle with it and Nu2 Canis Majoris. All three can be seen in the same field in binoculars. The cluster itself covers an area about the size of the full moon.
- M42 (Orion Nebula) – A diffuse nebula situated in the Milky Way, being south of Orion's Belt in the constellation of Orion. It is one of the brightest nebulae, and is visible to the naked eye in the night sky. M42 is located at a distance of  $1,344 \pm 20$  light years and is the closest region of massive star formation to Earth.
- M45 (Pleiades Seven Sisters) – An open star cluster containing middle-aged, hot B-type stars located in the constellation of Taurus. It is among the nearest star clusters to Earth and is the cluster most obvious to the naked eye in the night sky.

### NGC Objects:

- NGC 2403 – NGC 2403 (also Caldwell 7) is an intermediate spiral galaxy in the constellation Camelopardalis. NGC 2403 is an outlying member of the M81 Group.
- NGC 869 – An open cluster located 7600 light years[2] away in the constellation of Perseus. The cluster is most likely around 13[2] million years old. It is the westernmost of the Double Cluster with NGC 884.

### Clusters:

- Mel20 – An open cluster in the constellation of Perseus. To the naked eye, the cluster consists of several blue spectral type B type stars. The most luminous member is the ~2nd magnitude white-yellow supergiant Mirfak, also known as Alpha Persei.

These are great for imaging especially in this no planet lull and may get you into practice for the March Messier Marathon.

For now – Keep looking up.





## Random Thoughts by Chuck Dyson

### THE CHRISTMAS STAR?

As I write this the holidays are coming and as you read this they will be behind us with all of the halcyon advertisements a thing of the past. But with the old reliable holiday ads of the past gone, [Ginsu](#) knives and [Chia Pets](#), and in the almost always warm and sunny Southern California days how does one get clued in that the winter gift buying season is, in fact, upon us?

For the last several years I have found an unmistakable sign of the approach of the holidays and it is a very short and to-the-point advertisement in the astronomy classified section of several web sites and it simply says "45 pounds of books and notes on the "Christmas star" -\$800". Can people actually be that interested in the "Christmas star" that they would be willing to fork over \$800 for someone's collection of papers on the subject? If you go to Google and just type in "was Jesus a real person", "when was Jesus born", "where was Jesus born", "were the three wise men real", and "what was the star of Bethlehem", you will bring up several plethora of web sites; so, yes it appears that people are that interested in the "Christmas star".

Let's see if we can figure out what happened and when; and from that, come up with at least a plausible explanation for the "Christmas star". The first question "was Jesus a real person" is a very solid yes as almost all reputable archaeologists and academicians agree that there is just too much evidence in the writings of different authors and [Jesus's](#) described actions fit too well into the political and social fabric of his time for him not to be a real person.

Second question "when was Jesus born" gets a little tough to answer even though we have a calendar, the [Gregorian](#), that has as its starting point the birth of Jesus, so what is the problem? For starters, even today there are about 40 recognized calendars in use, all with different starting points and 1,300 years ago it was calendar chaos so the monk [Dionysius Exiguus](#) starts a new version of the Julian calendar based on one that was originally started by [Julius Caesar](#) in 46 B.C. and later modified by [Emperor Diocletian](#) to commemorate his birth date. Dionysius has two goals for the new calendar, the first is to remove the name of Diocletian as he was a persecutor of early Christians and, second, set firm rules and dates for the observance of Easter. When Dionysius gets to work on the calendar it is A.D. (Anno Diocletian, year of Diocletian) 225 when he finishes it is A.D. (Anno Domini, year of Lord) 525 and there was a chart for the exact day of Easter for decades to come.

Despite Dionysius's good work, his calendar had drifted out of sync with the seasons by the 1500's and in 1583, Pope Gregory puts forth his new calendar the Gregorian calendar and that is the one we use today.

In order to determine the exact date of the birth of Jesus you need to walk back today's calendar to the exact time of the birth and then correlate it to the calendar as if it had been in use on that day and year, obviously no easy task and even though Dionysius had less time to walk back, he had less resources to work with and today it is generally accepted that he missed the date by five years. That is not a bad thing because by the same dating methods King Herod, who was the monarch at the time of Jesus's birth and tried to kill him, is thought to have died in the year 2 B.C. The generally accepted dates for the birth of Jesus are now 4 to 6 B.C. and this gets the birth date to before the death of King Herod and so is a reasonable time frame.

The third question "where was Jesus born" is a tough one for several reasons. The first is we have at least a two year window where the family could have been anywhere and second, the goings and comings of a carpenter did not register on anybody's chart. So we need evidence of habitation that predates the birth of Jesus to prove that the family could have been in the places claimed, and in the case of Bethlehem, evidence of a center of government. At the time of Jesus the "towns" of Bethlehem and Nazareth had populations of 300 to 400 people and today the populations are 25,000 and 75,000 people respectively. Finding evidence of size and function of these small early "towns" buried under modern large cities is extremely difficult; so, the best we can do is ask is there any reason for the family to go to Bethlehem and the answer to that question is "yes" as the Romans often at various times had people go to government centers to pay their taxes. In the town of Bethlehem there is the



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Church of the Nativity that was established in A.D. 330 by the [Emperor Constantine](#) over the site of a cave that was already venerated as the birth place of Jesus. Then, as now, it is common practice in the Middle East to use caves as mangers and it would be reasonable for Jesus to be born in a manger that was in a cave, not a barn, and this would be reason number two to suppose that Jesus was born in Bethlehem.

The fourth question “were the three wise men real” is a real problem because, to start off with, only two of the four gospels mention the birth in Bethlehem and only one of these, Matthew’s, mention wise men, please note that I have left out the number three as there is absolutely no mention in the Gospel of Matthew that there were three, it says only the “wise men”. The number three comes from the assumption that, because there were three gifts, there were three wise men. These wise men would have been priests and astrologers and thus have an interest in a special celestial event, but are they real - as there is no mention of them in all of the records about King Herod or from any other source other than Matthew.

Archaeology 101 says that absence of evidence is not absence of fact; however, it would be nice to have something else to go on.

Bob Brier of Kellogg University on a 2004 TLC episode entitled *The Three Kings* explains how three mummies in the cathedral in Cologne Germany may just be the three wise men spoken of in the bible. The three mummies were collected by Emperor Constantine’s wife in about 320 A.D. When she went to the Holy Land to build the Church of the Nativity and collect artifacts from the life of Jesus. The queen was shown the tomb of the three wise men and she returned to Constantinople with the boney remains of the three men. On the show, Brier points out that the remains were collected before the age of forgeries in these things and that the pieces of clothing visible are of the type and design that are appropriate for the time period in question. Brier’s final piece of evidence that the three men of Cologne are the real deal is that the [Ravenna Mosaic](#) in Italy shows the three wise men as one older and one middle aged and one younger. The problem with this is the mosaic is from the middle ages, and a high definition photograph of the three skulls shows that one has suture lines between the skull bones that are those of an old man, one has sutures of a middle aged man, and one has sutures of a young man. The problem with this analysis is that it is based on a 1400 A.D. interpretation of the bible and the three men needed to die at the same time. I actually do not have a problem with the men dying at the same time as I am aware of a French expedition to Baja California in 1791 to observe the transit of Venus and while the 28 man expedition was there a plague broke out. Twenty-seven of the 28 men died; so, the possibility that three travelers could die together is very real. The 1400 A.D. date of the mosaic is another matter.

If we say that there is at least a little possibility that Matthew and Bob Brier are believable and we have an accurate time, within several years, of the birth event, then we can look for celestial events that could qualify as the “Christmas star”. The **first** contender that can be definitely eliminated is Halley’s Comet because it appeared in the sky in 12 B.C. and that is just too early for our needs. The **second** contender is a Venus/Jupiter conjunction in 2 B.C. and this event, besides only lasting three to four nights, would have left precious little time for the wise men to get to Judea, alert Herod and have him do his thing before dying. The **third** contender is in May of 7 B.C. there was a conjunction of Jupiter and Saturn, followed in September of 7 B.C. of a second Jupiter/Saturn conjunction, followed in December of 7 B.C. by a third Jupiter/Saturn conjunction and then in February of 6 B.C. there was a Jupiter/Saturn/Mars conjunction and finally in May of 5 B.C. Jupiter emerges from the Sun and goes antegrade until October and then goes retrograde and stands still for almost a week before resuming its antegrade motion.

It is possible that this series of celestial events in the third contender would have caught the attention of our priest/astrologers and have convinced them that this represent the sign that the birth of a king of kings was imminent and thus was our “[Christmas star](#)”.

Cheers  
Chuck







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The first step is to find out why the code "6EQUJ5" is so interesting. In the late 1970s we still got most of our signals served up to us via non-LASER, meaning non-visual, means. Radio signals had been the preferred communications-of-choice method since Marconi stole Tesla's ideas. Any SETI mission would naturally look for signals based on radio waves.

The signals, if they existed at all, would spread out and diminish as the inverse-square-law would dictate and therefore would end up being a strong burst above the background noise perhaps well modulated but perhaps just a burst. If the latter then it would probably be repeated.

"The Big Ear Radio Observatory" was designed to listen for just that kind of signal. It was only capable of making adjustments for declination and used the Earth's rotation to account for RA. It could listen to any part of its exposed sky for only 72 seconds. During that time a continuous extraterrestrial signal would be expected to register for exactly 72 seconds. The recorded intensity of such a signal would display a gradual increase for the first half of the time (36 seconds), peak at the center of the observation and then gradually decrease as the telescope moved away from it. All of these characteristics are present in the Wow! Signal.

The Wow! signal was a narrowband emission. Its bandwidth was less than 10 kHz. The Big Ear telescope was equipped with a receiver capable of measuring fifty 10 kHz-wide channels. The output from each channel was represented in the computer printout as a column of alphanumeric intensity values. The Wow! signal is essentially confined to one column just as one would expect from an extraterrestrial signal.

Now we have a better way of understanding what we are looking at and why Jerry Ehman was so startled by what he saw on the printout. We just need the alphanumeric encoding values to fill in the rest of this part of the mystery. Look at the paper above and note the columns of values going from left to right. Those represent a portion of the fifty 10 kHz receivers. Time is going from top to bottom. Earlier near the top and later toward the bottom.

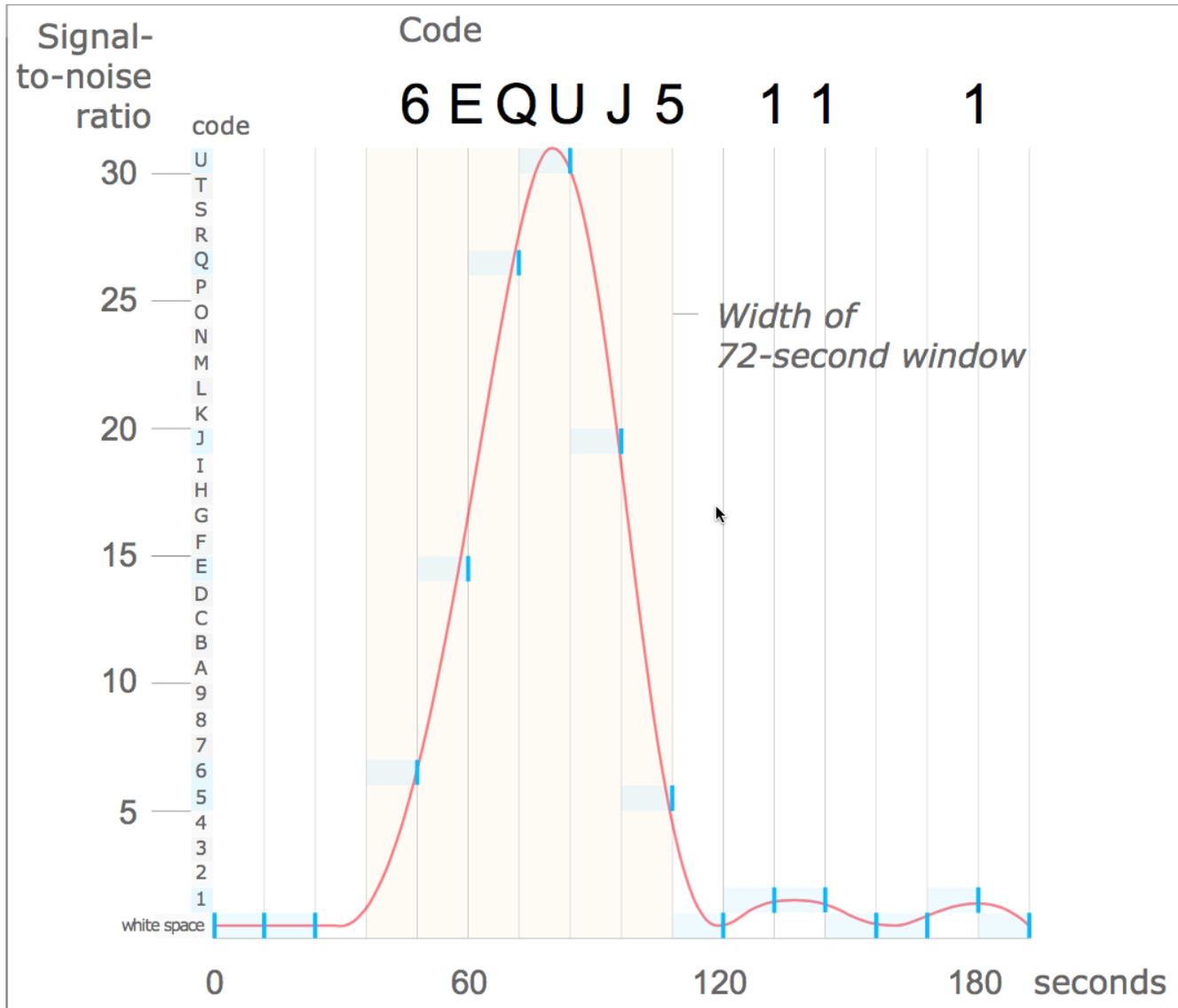
The alphanumeric code hashed values from 0 to 36 into a single character. A space represented a value [0..1) (from and including zero up to but not including one) while a 1 represented a value [1..2) etcetera through and including the encoded digit 9. An "A" represented a value [10..11) repeating this encoding all the way through "Z" for [35..36).

The encoded value represents the intensity variation of the radio signal over time, measured as unit-less signal-to-noise ratio. What we are seeing is: as the earth rotated the "Big Ear" antennae intercepted a 10 kHz radio source for 72 seconds. The radio burst may have lasted longer (more on this later). It may or may not have been modulated but the segment we got was not. Now here is one of the weird parts. By the time we got around to listening to that part of the sky again it was gone and it has never repeated.



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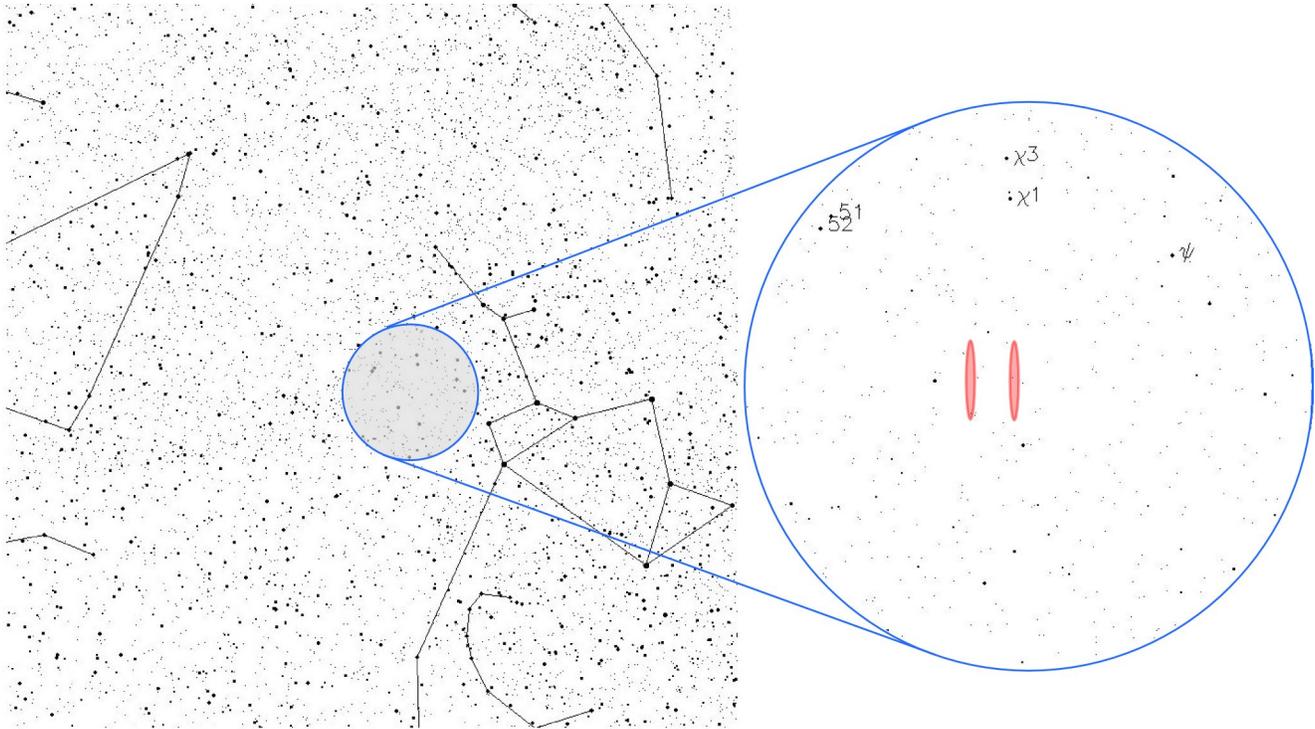
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<https://commons.wikimedia.org/wiki/User:Maxrossomachin>

There is one other weird part: there is NOTHING in the sky where the signal came from. NOTHING! It is a veritable desert of stars or other astronomical phenomenon.

There are two possible locations for the actual RA value of the signal but there is nothing at the other location either. The reason there are two frequencies is that the University was requested to order a crystal at 1450.4056 MHz but the poorly paid data entry person actually entered 1450.5056 MHz (i.e., 0.1 MHz too high). Even correcting for this discrepancy there just is nothing in the sky. There were also two feed horns but more on this later.



By Benjamin Crowell - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=8887333>

In 2017, Antonio Paris proposed that the hydrogen cloud surrounding two comets, 266P/Christensen and 335P/Gibbs, now known to have been in roughly the right position, could have been the source of the Wow! signal. This theory has attracted strong criticism, including from members of the original "Big Ear" research team, as a more detailed analysis shows the cited comets were not in the beam at the correct time. Furthermore, comets are not radio-bright at these frequencies, and there is no explanation for why a comet would be observed in one beam but not in the other.

There were two receiving feed horns on the "Big Ear". As the Earth rotated the sky overhead was scanned in right ascension and radio waves received from above would bounce off two reflectors and into two feed horn detectors. The two feed horns were separated by 40 arc-minutes in angular distance so a radio source passing overhead in the sky would appear in one horn, then disappear for 72 seconds of time, before reappearing in the second horn. Curiously the Wow! Signal was only detected by one of the feed horns. This means that the signal either switched itself on or off during those 72 seconds between the horns. Paris' comets can't do that.

We are rapidly coming down to one of two things:

- 1) a transient signal from some unknown astrophysical phenomenon
- 2) aliens turned their transmitter on or off during that 72 seconds gap

Either way the comet proposal is just becoming untenable.

I have spent many hours locked in contemplation of the Wow! Signal. Late night listening to background noise and many an email to Jerry Ehman over the years. I'm fairly convinced that the signal isn't earth-based nor even near-earth-based. In a 2012 podcast, scientific skeptic author Brian Dunning concluded that a radio transmission from deep space in the direction of Sagittarius, as opposed to a near-Earth origin, remains the best technical explanation for the emission, although there is no evidence to conclude that an alien intelligence was the source. There is of course no evidence that alien intelligence was not the source either. As Ehman has said many times, drawing conclusions from half-vast data is pointless.



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So where does this leave us? Searching of course. That is what science does. We don't typically search in the radio-bright areas anymore though. Look how quickly we, as a species, moved on to more narrow cast methods of communications as the digital age progressed. Even our "radio" broadcast era was extremely short lasting only a few years.

SETI typically searches for more optical sources rather than radio sources now via programs like SETI@home. These are more difficult to detect as they involve lower power levels. However my original goal was to solve the origins of the "Wow! Signal" not SETI. I figured there were enough people working on SETI.

Is it solved? No. There is plenty of speculation and conjecture. What do I really think the origin is? Well if you pushed me really hard then I'll tell you what I REALLY think: "A long time ago, in a galaxy far, far away..."

To comply with the Creative Common License use of the images on this article neither TVA, nor I am affiliated in any way with Ohio State University nor the Big Ear Project nor its personnel. The views expressed in this article are my own, especially the one about galaxies far far away.

Editor's note: The night of August 15<sup>th</sup> 1977 was the night before Elvis died.

## NASA SpacePlace

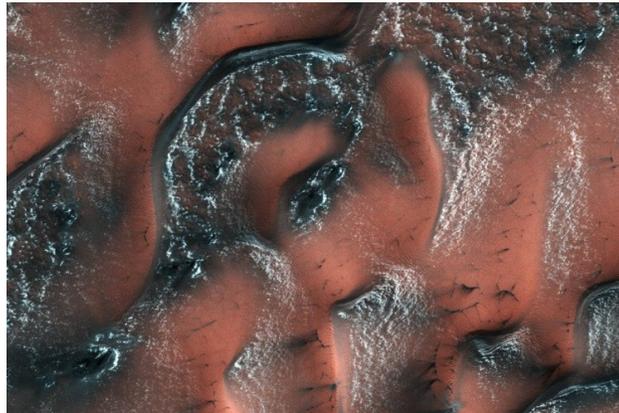
### Snowy Worlds Beyond Earth

By Linda Hermans-Killiam

There are many places on Earth where it snows, but did you know it snows on other worlds, too? Here are just a few of the places where you might find snow beyond Earth:

#### Mars

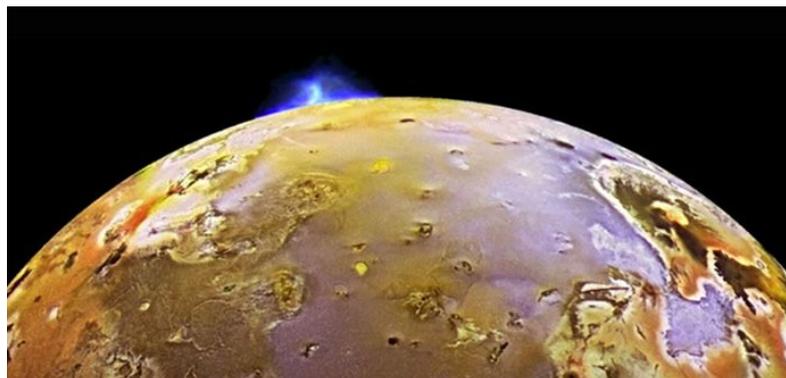
The north pole and south pole of Mars have ice caps that grow and shrink with the seasons. These ice caps are made mainly of water ice—the same kind of ice you'd find on Earth. However, the snow that falls there is made of carbon dioxide—the same ingredient used to make dry ice here on Earth. Carbon dioxide is in the Martian atmosphere and it freezes and falls to the surface of the planet as snow. In 2017, NASA's Mars Reconnaissance Orbiter took photos of the sand dunes around Mars' north pole. The slopes of these dunes were covered with carbon dioxide snow and ice.



*NASA's Mars Reconnaissance Orbiter captured this image of carbon dioxide snow covering dunes on Mars.  
Credit: NASA/JPL/University of Arizona*

#### A Moon of Jupiter: Io

There are dozens of moons that orbit Jupiter and one of them, called Io, has snowflakes made out of sulfur. In 2001, NASA's Galileo spacecraft detected these sulfur snowflakes just above Io's south pole. The sulfur shoots into space from a volcano on Io's surface. In space, the sulfur quickly freezes to form snowflakes that fall back down to the surface.





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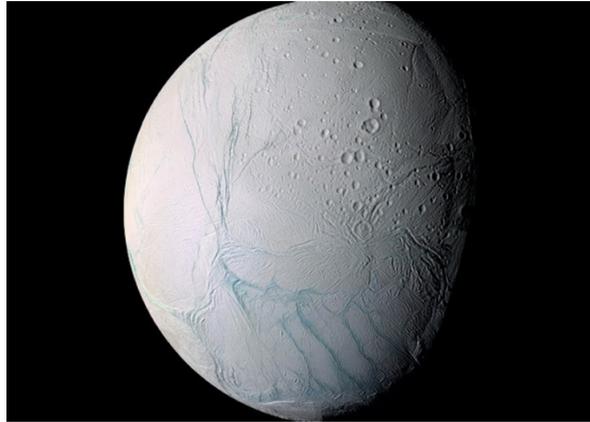
The monthly newsletter of the Temecula Valley Astronomers Jan 2018

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*A volcano shooting molten sulfur out from the surface of Io. Credit: NASA/JPL-Caltech*

## **A Moon of Saturn: Enceladus**

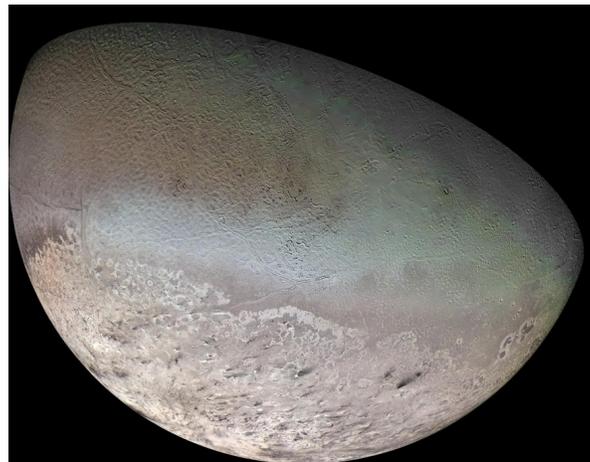
Saturn's moon, Enceladus, has geysers that shoot water vapor out into space. There it freezes and falls back to the surface as snow. Some of the ice also escapes Enceladus to become part of Saturn's rings. The water vapor comes from a heated ocean which lies beneath the moon's icy surface. (Jupiter's moon Europa is also an icy world with a liquid ocean below the frozen surface.) All of this ice and snow make Enceladus one of the brightest objects in our solar system.



*Enceladus as viewed from NASA's Cassini spacecraft. Credit: NASA*

## **A Moon of Neptune: Triton**

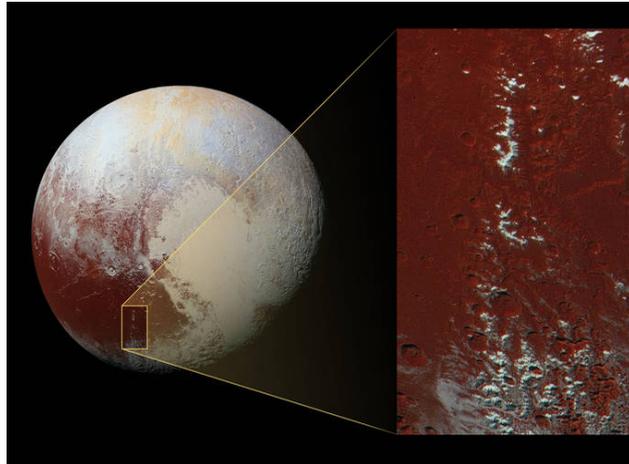
Neptune's largest moon is Triton. It has the coldest surface known in our solar system. Triton's atmosphere is made up mainly of nitrogen. This nitrogen freezes onto its surface covering Triton with ice made of frozen nitrogen. Triton also has geysers like Enceladus, though they are smaller and made of nitrogen rather than water.



*The Voyager 2 mission captured this image of Triton. The black streaks are created by nitrogen geysers. Credit: NASA/JPL/USGS*

## **Pluto**

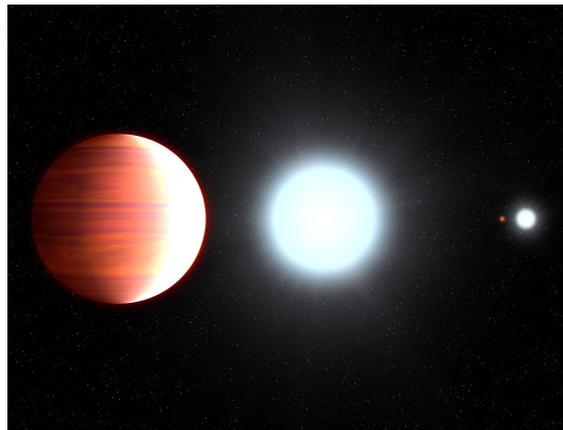
Farther out in our solar system lies the dwarf planet Pluto. In 2016, scientists on the New Horizons mission discovered a mountain chain on Pluto where the mountains were capped with methane snow and ice.



*The snowy Cthulhu (pronounced kuh-THU-lu) mountain range on Pluto.  
Credits: NASA/JHUAPL/SwRI*

## **Beyond Our Solar System**

There might even be snow far outside our solar system! Kepler-13Ab is a hot, giant planet 1,730 light years from Earth. It's nine times more massive than Jupiter and it orbits very close to its star. The Hubble Space Telescope detected evidence of titanium oxide—the mineral used in sunscreen—in this planet's upper atmosphere. On the cooler side of Kepler-13Ab that faces away from its host star, the planet's strong gravity might cause the titanium oxide to fall down as "snow."



This is an artist's illustration of what Kepler-13Ab might look like. Credit: NASA/ESA/G. Bacon (STScI)

Want to learn more about weather on other planets? Check out NASA Space Place:  
<https://spaceplace.nasa.gov/planet-weather>

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