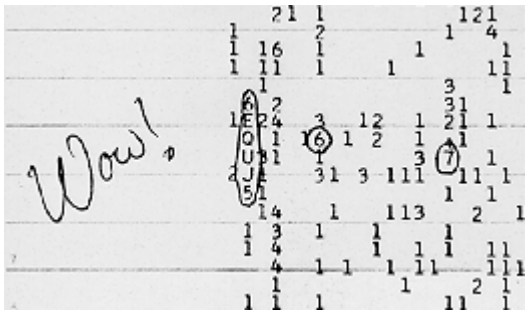
The Seti WOW signal
A Commentary



On August 15, 1977., SETI received a 1 shot signal that many have described as a WOW signal. It involved a short duration high energy pulse. Each of the first 50 columns of the computer printout shows the successive values of intensity (or power) received from the Big Ear radio telescope in each channel (10 kHz wide) in successive 12-second intervals (10 seconds was used for actual sampling and another approximately 2 seconds was needed for computer program. They used a system of only one alphanumeric character to denote the signal strength. Thus, the "6EQUJ5" code in channel 2 means successive intensities as follows:
6 --> the range 6.0 - 6.999...
E --> the range 14.0 - 14.999...
Q --> the range 26.0 - 26.999...
U --> the range 30.0 - 30.999...
J --> the range 19.0 - 19.999...
5 --> the range 5.0 - 5.999...

The next two groups of numbers on the computer printout (just to the right of the center of the row) are the right ascension and declination converted to epoch 1950. Declination is the angular distance above or below the projection of the earth's equator onto the celestial sky. Its range of values goes from -90 degrees (at the south celestial pole) through zero (on the celestial equator) up to +90 degrees (at the north celestial pole). The Big Ear radio telescope can observe in the 100-degree range of declination from approximately -36 degrees to approximately 64 degrees. Right ascension is analogous to longitude on the earth's surface. It is measured in either degrees (0 to 360) or in hours, minutes and seconds (00h00m00s up to but not including 24h00m00s). The starting point (0 degrees = 0 hours) is currently in the constellation of Pisces but is moving slowly although constantly (it takes about 26,000 years to make a complete circuit; the major component of this motion is called the "precession of the equinoxes"). Because of this precession and other related but smaller effects, astronomers convert the observed positions at any one instant into one appropriate for a convenient point in time so that locations can be more easily compared. The epoch (point in time) of 1950 was most

commonly used during the middle to late part of the 20th century. Nowadays, the year 2000 is the epoch most likely used.

For the strongest Wow! data point, the epoch 1950 right ascension shown on the computer printout was: 19h17m24s, while the corresponding declination was: -27 degrees and 3 minutes of arc (- 27d03m). Thus puts the source in the direction of the constellation Sagittarius.

Due to some errors in this initial calculation and based upon SETI's own data a correction to this can be made. In the table below the first column presents the character used for the intensity, the second column shows the original (incorrect) right ascension (epoch 1950) on the computer printout, the third column shows the corrected epoch 1950 R.A. for the end of the integration interval (adding 5m10s to the original R.A.), and the last column shows the corrected epoch 1950 R.A. for the middle of the integration interval (subtracting 5s from the third-column results).

Intensity	**Original R.A**	**Corrected R.A. (End)**	**Corrected R.A. (Middle)**
6	19h16m48s	19h21m58s	19h21m53s
E	19h17m00	19h22m10s	19h22m05s
Q	19h17m12s	19h22m22s	19h22m17s
U	19h17m24s	19h22m34s	19h22m29s
J	19h17m36s	19h22m46s	19h22m41s
5	19h17m48s	19h22m58s	19h22m53s

The computer printout showed 6 significant data points (with intensities ranging from 5 up to 30 sigmas). Each data point represented 10 seconds of data acquisition plus about 2 seconds of computer analysis. Thus, the signal lasted for about 6 * 12 = 72 seconds. The very curious thing about this signal was the fact that we should have seen it twice within a period of about 5 minutes as our two beams sequentially scanned the source, but we only saw one of the beam responses. Thus, if the signal came in the negative horn (the first one to be able to see the source), the signal could not have lasted more than about 2 minutes - 2.5 minutes or we would have seen it also in the second horn (positive horn). Similarly, if the signal came in the positive horn (the second one to be able to see the source), the signal could also not have lasted more than about 2 minutes - 2.5 minutes or we would have seen it also in the first horn (negative horn). This places a limit on the signal duration of 2.5 minutes with either horn.

If the Wow signal was modulated at a frequency less than 0.00694 Hz (a period longer than 144 seconds) or at a frequency greater than 0.2 Hz (a period shorter than 5 seconds), we would not have seen that modulation, and hence we could say that modulation is within the realm of possibility. Data encoding, like that we did on our own one time one shot sent out signal would fit within that range.

SETI then looked at possible natural origins.

Planets

The positions of all of the planets in our solar system were looked up in an ephemeris (i.e., a book that provides information about a wide range of astronomical phenomena). None of the planets were close to the Wow! source position. Of course, one would not expect a planet to be generating a narrowband radio emission. Normally, when a planet is observed in the radio band, we detect the radio emission over the entire radio band (assuming the telescope is sensitive enough). That radio emission is "thermal emission" due to the temperature of the planet. Remember that every body with substance (mass) generates radio waves (including human beings). Radio telescopes have detected the thermal emission from most of the planets plus our moon. Besides the thermal emission, non-thermal radio emission from Jupiter in the decametric radio band (i.e., wavelengths of 10s of meters) was first detected from the early days of radio astronomy. This emission was moderately narrowband and occurred from charged particles moving in the magnetic field of Jupiter. So, not only did the Wow! source emission not fit the pattern of this Jupiter-style emission nor the thermal-type emission, but, in addition, none of the planets were in the proper position in the sky.

Asteroids

Asteroids are essentially small planets. Hence, they have negligible magnetic fields and hence negligible non-thermal radiation. Since their masses and surface areas are so much smaller than our planets, they generate much less thermal radiation. However, the ephemeris was consulted for the locations of some of the larger asteroids, but none were in the vicinity.

Satellites

If a satellite from the U.S. or Soviet Union or other country were broadcasting around 1420 MHz, the Big Ear would have been easily able to detect it when it was in the beam. The frequency band around 1420 MHz (a few MHz on either side) was declared off limits for satellite transmission or earth-based broadcasting over the entire world. Thus, no satellite should have been sending out any transmission in this protected band. If a satellite were violating this agreement, it is quite possible for the signal to be narrowband. For example, the AM (amplitude modulated) radio stations in the frequency range of around 0.5 - 1.6 MHz (500 - 1600 kHz) transmit over a bandwidth of approximately 10 kHz, the same bandwidth as each of the 50 channels in our receiver. [Note that the bandwidths of FM radio and television are much wider than 10 kHz.] An investigation of

the orbits of all known satellites revealed that none were in our beam at the time of the Wow! source.

Aircraft

There are two major ways to rule out airplanes and other aircraft: (1) no aircraft transmitters operate in the protected radio band around 1420 MHz; and (2) aircraft move with respect to the celestial background. The Wow! source intensity pattern received matched almost perfectly the pattern expected from a small-angular-diameter (point) radio source on the "celestial sphere" (i.e., at such a large distance that there is no perceptible motion relative to the background stars). An aircraft, which would show a significant motion with respect to the stars, would also cause the received pattern of intensities to depart noticeably from that expected for a point source.

Spacecraft

A check was made for known spacecraft and none were near the direction of Wow!. In addition, a spacecraft is not supposed to be transmitting in the protected band.

Ground-Based Transmitters

No transmitter on earth or in space should have been transmitting in the protected band around 1420 MHz. A transmitter in space (an aircraft, a satellite, or other nearby spacecraft) would not be able to generate a point-source type response in our receiver. But how about a ground- based transmitter?

A ground-based transmitter is fixed to the ground. The Big Ear radio telescope is also fixed to the ground. Therefore, even if a signal from such a transmitter were getting directly into our receivers, there would be no relative motion and hence, no way to have the signal intensity almost perfectly reproduce the antenna pattern.

Gravitational Lensing

When an electromagnetic wave (such as light or radio waves) travels past a star or galaxy or other condensation of matter, that wave is deflected slightly. If a radio source (including a radio beacon from an intelligent civilization) were located in the same line of sight but further away than this condensation of matter, it is possible for the waves to be seen (or imaged) as a ring or multiple points of enhanced light or radio waves. This phenomenon is called "gravitational lensing". Many instances of this phenomenon have been reported in recent years, both in optical and radio images. Could this be involved with the Wow! source?

Typically, the lensing phenomenon (rings, bright spots, etc.) remain in the images taken over a period of many days or months or even years, depending on the motion of the source and the condensed matter. On the other hand, the Wow! signal, which should have been seen twice (two beams) in about 5 minutes, was seen only once. The lensing effect

probably would not have changed significantly in 5 minutes. Of course, if Wow! were a signal from an intelligent civilization, the beings responsible for transmitting the signal could have directed it to another direction in their sky, or could have turned off their transmission within the 5-minute period.

Interstellar Scintillation

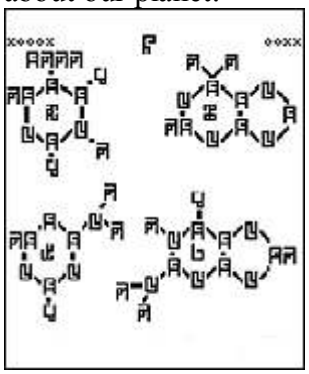
When we look at the stars in our sky, we see them "twinkling". That twinkling is due to each photon coming from the point source experiencing a slightly different travel path on the way to our eyes than other photons. The earth's atmosphere accounts for nearly all of the differences imposed on these photons. We do not see the planets twinkle because a planet has an observable angular diameter and the effects applied to the photons from the various directions of the planet tend to average out.

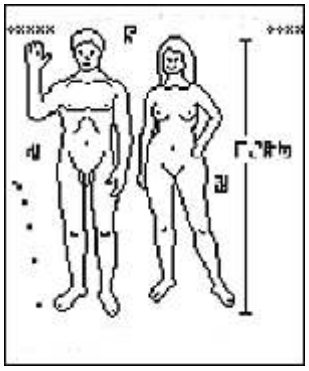
When radio and optical waves travel through the interstellar medium (which is somewhat like our atmosphere except much more rarefied), those waves (photons) experience a kind of twinkling effect called "interstellar scintillation". It is possible for there to be an enhancement of the signal passing through this interstellar medium due to a partial coherence effect. If this effect did occur for the Wow! source, it still points to a signal originating many light-years away from us, thus tending to give more support for the hypothesis of a signal of an extraterrestrial origin.

ETI

Thus, since all of the possibilities of a terrestrial origin have been either ruled out or seem improbable, and since the possibility of an extraterrestrial origin has not been able to be ruled out, one must conclude that an ETI source is highly possible.

Now, since this signal has never been properly explained because it could not be found again at any other time it has been rather dismissed as a real ET signal. But, let's suppose an alien world where to go about hunting for signals in the same way we do. That would mean they mostly just listen. However, we have at one point sent a direct signal out in 1974. That was when the main dish SETI uses was first put into operation. We sent a short duration high energy signal out that encoded some basic information about our planet.





That signal enoded DNA information and a bit of what we look like. That was a one shot signal, never repeated again. So, it is possible that some other intelligent race may have done exactly the same thing.

Now SETI, at present searches for pulses and triple pulses. They do not search for direct modulation within any signal. If we assume that aliens might follow our own pattern in searching the heavens for signs of life then a one shot sent out signal is highly possible.

But this bring to question certain scales of Developments for ET races. The following is a basic outline of development of races. Scale of Cultural Development.

Planetary Development Classification

AAA
No Known Intelligent Indigenous Life-Forms. Mars
AA
Prehistoric Age (No Tools)
A
Stone Age
B-
Agricultural Age
B
Metal Age
C
Scientific Age
D-
Pre-Industrialization
D
Steam Age
D+
Electric Age
E-
Liquid Fuels Age
E
Atomic Age

F
Early Space Age Earth in 1960's.
F+
Developing Space Age Earth at the present is good example. This can also be seen as a possible critical time in the development of a race. They may display inactive exploration of other star systems along SETI lines.
H
Colony Age Point at which a race begins to colonize its local star system. Development to this point requires some basic social stability for a planet.
I
Star Age Point at which a race begins active exploration of other Star systems. Planets that have begun to enter this age are to be considered advanced races with very stable social systems in place.

This brings us to our next step in finding life out there.

A STAR TO STEER BY

47 Ursae Majoris, a star that is sun-like, though a bit older. It is hotter and brighter, so its habitable zone is a little further out than the region around our Sun that's considered able to support life, as we know it. Two giant planets orbit the star 47 Ursae Majoris. The inner one, a bit farther from the star than Mars is from our Sun, is about 2.5 times as massive as Jupiter. The outer one is probably about the size of Jupiter. Other planets may well exist in the systemTwo giant planets orbit the star 47 Ursae Majoris. The inner one, a bit farther from the star than Mars is from our Sun, is about 2.5 times as massive as Jupiter. The outer one is probably about the size of Jupiter. Other planets may well exist in the system. This is how we can narrow the range down on looking for decent signals from other worlds.

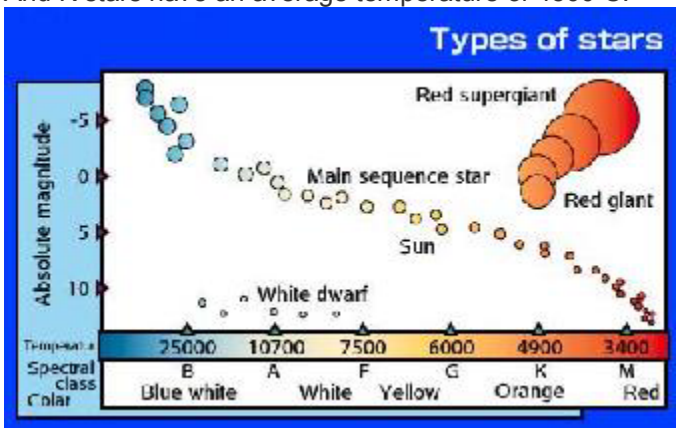
Another possible one is star 55 Cancri hosts a Jupiter-like planet occupying a near-circular orbit, much like Jupiter's. The planet, a giant ball of gas, takes about 14 years to circle 55 Cancri, a star 41 light-years away in the constellation Cancer. (A light year equals 5.89 trillion miles.) Epsilon Eridani, among the 10 closest star systems to the Earth, is known to have a comet belt similar to Sol. Its age is 500 million years to 1 billion years old. Our Sun is estimated to be 4.5 billion years old, and its inner region is believed to have looked very similar at that age.
In our solar system, the first 600 million years was a time of "heavy bombardment" when the planets were assaulted by massive meteorites and other celestial objects until the gravitation of Jupiter and Saturn cleaned out these destructive objects. Life on Earth probably did not start until after the era of heavy bombardment, says JAC astronomer Wayne Holland. So this star system would probably be an early developing one and not likely to harbor more than primitive life at this time.

Normally, in any search for other life we start with the Drake equation that was discussed a bit in the last issue of this Journal. But, we are at a point in observation that we can begin to put some direct limits on that equation. One limit is based on Stars of the right age and class to harbor life. Our sun is a G type star.

Spectral Class of Star		
Class	**Color**	**Temperature**
O	blue-white	35,000 degrees C
B	blue-white	21,000 degrees C

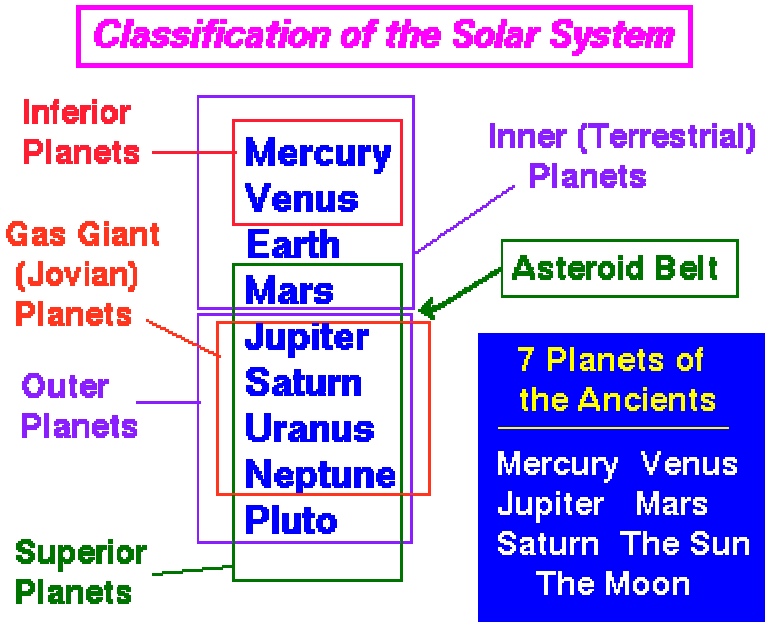
A	white	10,000 degrees C
F	creamy	7,000 degrees C
G	yellow	6,000 degrees C
K	orange	4,500 degrees C
M	red	3,000 degrees C

General we can narrow the range on stars down to those within the F, G, and K class as being most likely to be capable of sustaining life. The reason concerns the age of such stars and their temperature. F stars have a temperature of 7000 C. G stars have a temperature of 6000 C. And K stars have an average temperature of 4500 C.



These stars all fit within the main sequence area. They are rather long lived and they provide decent habital ranges for planets.

To this we can add a classification system on planet types. The below figure shows a bit of this.



1. **The planets inside the orbit of the earth are called the *Inferior Planets*: Mercury and Venus.**

2. **The planets outside the orbit of the earth are called the *Superior Planets*: Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.**
3. **The planets inside the asteroid belt are termed the *Inner Planets* (or the *Terrestrial Planets*): Mercury, Venus, Earth, and Mars.**
4. **The planets outside the asteroid belt are termed the *Outer Planets*: Jupiter, Saturn, Uranus, Neptune, and Pluto.**

We could further divide this down. Such a system might follow something similar to the following:

1. CLASS D
Planets of this class are small, rocky planetoids
2. CLASS H
Theses Planets are generally extremely dry. altough sometimes habitable. Mars is an example.
3. CLASS J
Gas giants with turbulent atmospheres in which wind speeds of over 10,000 kilometers per hour are not unknown. Planets of this class are found in a star's hot zone. They are typically 1,000 to 10,000 kilometers in diameter. They have high surface temperatures due to the proximty to the star. Their atmospheres are extremely tenuous with few chemically active gases. Jupter and Saturn are examples.
4. CLASS K
Planets of this class are unsuitable for humanoid life, even though their gravity field can fall within class-M norms. Some Class-K planet are adaptable for humanoid life only with the use of pressure domes and life-support systems. Mercury is an example.
5. CLASS L
Small, rocky, terrestrial worlds with oxygen-argon atmospheres. Titan, if nearer the sun would be a possible example of this.
6. CLASS M
Small rocky terrestrial worlds with oxygen-nitrogen atmospheres, and hightly supportive of organic life. Planets of this class are found in a star's "habitable zone". They are typically 10,000 to 15 thousand kilometers in diameter. Water and life-forms are typically abundant. Earth is a prime example.
7. CLASS Y
Hot atmosphere governed by runaway green house effect. Venus is prime example of this class.
8. CLASS F
They are typically 10 to 15 thousand kilometers in diameter and have surfaces that are still crystalizing. Their atmospheres still contain some toxic gases. Larger rock worlds such as Luna or Mercury in the Sol system fall into this class. Class F planets have no water or atmosphere of any kind present, but are larger than class D worlds. The Moon is a prime example of this type.
To these we could even further narrow our search for life down to systems that contain class L and M planets. The reason follows from the logic above with Jupter like worlds and to the fact water is a prime factor in life development. At the present we can detect type J planets only. So we cannot narrow our search as far as we would like. But this

may change in the near future. Type H, Mars like planets might also one day be usable as Colony bases since they can provide some sources of local water as Mars has proven out. Other races may have already utilized them. That being the case they do offer a search factor in themselves.

With further development in the future it may become possible to study the atmosphere of other planets outside of our system. A possible system of classification would be:

1. **Class D**
Rocky, lack atmosphere or very tenuous, or likely planetary/moon debris that has approached within the Roche limit of another planet. Pluto and the Moon fit in this area.
2. **Class H**.
Very dry planets. They are often desert like and bathed in radiation. Atmosphere would generally be most Co2 with other trace gasses all with very limited surface pressure. Mars has a similar atmosphere to this.
3. Class M
Nitrogen-oxygen-carbon dioxide atmospheres, that are modifications of the volcanic outgassing. Usually higher surface pressure than Class H type atmospheres. Capable of supporting life. Earth is prime example on this type of atmosphere.
4. **Class L**
Class L planets are characteristically high in Co^2 levels. May also contain high amounts of of other chemicals. These are terrestrial worlds where high heat levels above 500 kelvins is combined with thermionic radiation. Usually possess a very slow rotational period, and lack a central self perpetuating dynamo effect . This allowed radiation to strip the atmosphere of need hydrogen to create water with. The atmosphere is dense and contains corrosive compounds. Usually promotes runaway Green House effects. Venus is an example here.
5. **Class J**
Gas giant class, both Saturn and Jupiter are class J. Other gas giants are not mentioned but there are significantly different forms of gaseous planet, condensed ammonia is absent in many atmospheric layers of Uranus and Neptune suggesting it is very abundant in lower levels where ammonium slush is very held in the clouds. The upper atmosphere of Neptune consists of 85% hydrogen, 13% helium. Other upper cloud layers are dominant in hydrogen sulphide and various hydrocarbons such as acetylene and ethylene. High Cirrius clouds are thought to be methane dominant.