SkyWAAtch

Flaming Star

The Flaming Star Nebula (IC 405) in the constellation Auriga is a surprisingly colorful and dramatic emission/reflection nebula. The most prominent star in the image is the variable blue dwarf AE Aurigae, burning with sufficient intensity to knock electrons off the hydrogen molecules found in a cloud 5 light years across, which in turn emit red light. The bluish gray area is not from ionized Oxygen (as found in the Veil Nebula); rather it is mostly a cloud of carbon dust, which reflects the blue light from the nearby star. The result is an emission/reflection nebula 1500 light years distant and accessible from the suburbs with a small telescope.

Mauri Rosenthal imaged this from his backyard in Scarsdale with a guided Questar 3.5" telescope over two nights in November using CLS (broadband) and H-alpha (narrowband) filters. Total exposure time was 9.5 hours.

In This Issue . . .

WAA January Lecture

"Light Pollution"
Friday January 8th, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

Charles Fulco will speak on light pollution, the International Dark-Sky Association and preserving our night sky. Mr. Fulco is a science consultant and curriculum writer with BOCES and the former Planetarium Director at Port Chester Middle School, Port Chester, New York. He is the IDA Local Area Director for Westchester County. An avid amateur astronomer, Mr. Fulco fosters dark-sky education, and participates in many astronomy events through NASA's Solar System Ambassador program. He enjoys astronomical and terrestrial photography, promoting environmental activities, and chasing eclipses. He is currently involved with the national educational and public outreach for the 2017 total solar eclipse. Free and open to the public. Directions and Map.

Upcoming Lectures

Pace University, Pleasantville, NY

Our speaker for February 5th will be Brother Novak. He will be speaking on Current and Future Observations of Mars Using Ground Based Telescopes and Space Probes.

Starway to Heaven

Ward Pound Ridge Reservation,
Cross River, NY

There will be no Starway to Heaven observing dates for January or February. The next scheduled monthly observing session is March 5, 2016.

New Members. . .

Frank Clemens - Larchmont

Renewing Members. . .

Mayan Moudgill - Chappaqua
George Gerbacia - Yonkers
Kevin Doherty - White Plains
Daniel R. Poccia - Cortlandt Manor
Larry and Elyse Faltz - Larchmont
The Dugan Family - Sleepy Hollow
Anthony Sarro - Scarsdale

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.

Club Dates 2016

2016 Lecture Dates	
January 8	June 3
February 5	Sept. 16
March 4	October 7
April 1	November 4
May 6	December 2

2016 Star Party Dates

Date	Event	Date	Event
03-05	Star Party	07-30	Star Party
03-12	Make-up date	08-06	Make-up date
04-02	Star Party	08-27	Star Party
04-09	Make-up date	09-03	Make-up date
04-30	Star Party	09-24	Star Party
05-07	Make-up date	10-01	Make-up date
05-28	Star Party	10-22	Star Party
06-04	Make-up date	10-29	Make-up date
06-25	Star Party	11-19	Star Party
07-02	Make-up date	11-26	Make-up date

Other Important Dates in 2016

Northeast Astronomy Forum, Saturday, April 9th and Sunday April 10th, Rockland Community College, Suffern, NY

Transit of Mercury May 9th

Club picnic: Saturday, June 18th (Trailside Museum, Ward Pound Ridge Reservation, 1:30-5 pm)

Check your emails for outreach events and other special activities.

WAA Apparel

Charlie Gibson will be bringing WAA apparel for sale to WAA meetings. Items include:

- Hat ($15)
- Polos ($15)
- Tee shirts ($12)

Westchester Amateur Astronomers

Almanac
For January 2016 by Bob Kelly

Jan 2 Jan 9 Jan 16 Jan 23

Among the wonderful holiday 'leftovers' are a fuzzy comet, brilliant planetary encounters, another occultation, some meteors……

Comet Catalina (C/2013 US10), which just about everyone has shortened to 'Catalina', arcs past Arcturus on the 1st on its way into the circumpolar sky, fading all the way. I guess if it were brighter, they'd call it 'Cat', but it has two tails on long-exposure photos, one gas tail pointing outward from the Sun and a dust tail trailing the comet's head.

This month's finest naked-eye sight will be Venus welcoming Saturn to the morning sky, especially on the 9th when they pass less than a degree apart. The contrast between flashy Venus and exquisitely sublime Saturn will be impressive in a telescope, appearing about the same size. Once again, Saturn won't offer a ring to Venus and they will go their separate ways. Saturn is up in the morning sky to stay. Mars is already there, rising after midnight, pretty dim for a nearby planet at magnitude +0.8 and one-third the width of Venus or Saturn.

Venus noticeably sinks toward the southeast horizon, rising before twilight begins, but still blazing at magnitude minus 4.0 and looks like a gibbous moon in a telescope, best viewed when the sky brightens. Latest dawn occurs on the 8th with sunrise approaching 7am by the end of the month.

Jupiter is highest during the post-midnight hours, within ten percent of its largest size for the year. So it's well worth any viewing you can manage.

The Moon sails high in the evening sky during mid-month, as the terminator sweeps across the face of the Moon during the waxing phases. It's great for viewing, although alt-azimuth scopes might have awkward viewing when looking near zenith.

Aldebaran, the brightest star in Taurus the Bull, is occulted by the Moon Tuesday evening the 19th. The Moon is mostly full at that point, so Aldebaran will be a surprise to people glancing at the Moon that night with binoculars or a telescope. The reddish spark disappearing on the darker limb of the Moon will be a striking contrast to the nearby blazing bright portion of the sunlit lunar landscape. This is one of a series of occultations of Aldebaran this year, and one of the few at night, so it's worth a look if skies are mostly clear. Disppearance will be about 9:32EST in our area, reappearing on the bright limb of the Moon about 10:42pm. The event is visible in most of the United States and Canada.

If you like to be up and out after midnight, on the 4th the Quadrantid meteors may put on a good show. This meteor shower doesn't last long – peaking for only a few hours. At peak hours, it often averages over a meteor a minute. We hope they show up then! Standard models have the Quandrantids peaking about 3am, but Sky and Telescope reports an alternative model predicting the main strand of this stream of cosmic debris to peak during our daytime. The Moon will rise about 2am, but it's only a crescent, so keep it out of sight and you'll be fine if the sky is clear.

Mercury tries to give us a bright planet in the evening sky, hanging low in the west-southwest through the 9th. For the last ten days of the month, Mercury joins the planet party in the morning sky, but it's better seen from the southern hemisphere. In a telescope, Mercury appears slightly larger than Mars, much smaller than Venus and Saturn, but is the closest planet to Earth from now until Mars takes the crown in late February. Most years, Mercury is generally the closest planet to Earth, but not this year. This year, Mars makes a long, slow pass by Earth, tens of millions of miles away in its outer orbit. If you can spot Mercury low in the morning sky, check out the other four brightest planets, and you'll have seen the unusual five-planet line-up! They span most of the dawn sky, closest together on the 25th.

In between Mercury's evening and morning apparitions, it makes the scene in the SOHO LASCO C3 telescope.

Orion, and the many sights of the winter sky surrounding it, is highest in the sky between 9 and 10pm in January.

Earth is a tiny bit closer to the Sun at this time of year, closest on the 2nd. The International Space Station soars overhead in the pre-sunrise sky through the 24th.

Westchester Amateur Astronomers

Vivian Towers
1933-2015

Throughout the years Vivian and I have discovered that the Westchester Amateur Astronomers is a very special organization. It is not just a group of individuals who share a common interest, but truly an extended family who are there for each other when the need arises. Therefore it was no surprise to me that the first person to show up at the funeral home to pay respects to Vivian was a WAA member. Club members sent flowers, and more importantly, were there to support us at the funeral home, the church service and at the graveside. This outpouring of love is much appreciated.

It was Vivian who, in 1986, noticed a newspaper article about an astronomy club in Yonkers. At that time it was called the Andrus Observers Group and met at the Hudson River Museum. Vivian and I joined and have been members ever since. Vivian was more of a "social" member rather than a "scientific member." She didn't attend many star parties, but never missed a club picnic, except for the last one, when increasing loss of mobility kept her at home. But she was there for the big events: the 1999 annular solar eclipse, the bright comets and both transits of Venus. However, if I mentioned that tonight the moon would occult the Pleiades, and you could watch the stars wink out one at a time, her reply would be "That's nice. Tell me about it in the morning."

But if there was work to be done, she was always willing. In the days when *SkyWAAtch* was printed on paper and mailed to each and every member, the collating crew would gather, often around our dining room table, to sort, fold and stuff. When the last envelope was sealed and the last stamp affixed, Vivian would bring out coffee, tea and home-baked cookies to send the crew homeward-bound, refreshed.

Vivian will be missed—by our club and especially by me, our daughter Karen, son-in-law Rob, granddaughters Logan and Kira, and all her many friends.

She will always remain our bright and shining star.

-Doug Towers

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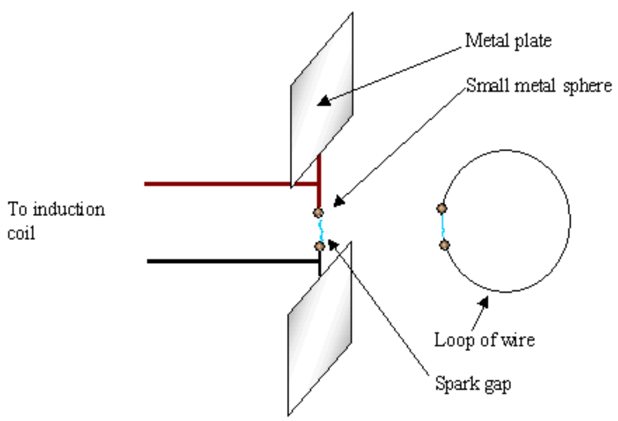
Bob Kelly took this photo of the Moon and Venus next to a skyscraper under construction. He used 250mm zoom lens on a Canon XS at f/11, ISO-400, 1/640 seconds exposure, auto brightened and contrast enhanced in Microsoft Office Picture Manager.

The Radio Sky
Larry Faltz

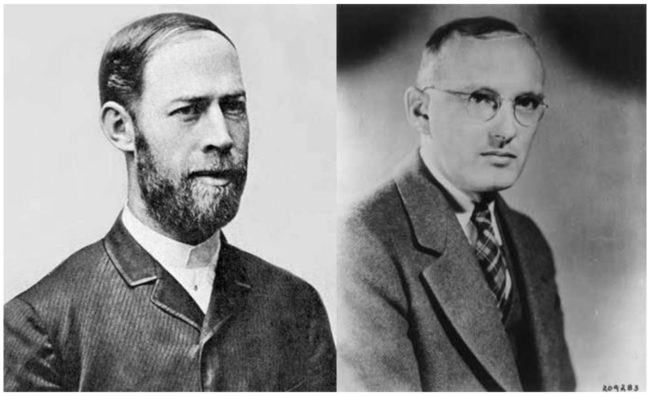
From ancient times until 1932, human beings observed the heavens with their own eyes. While Galileo's telescope opened new vistas, the spectral response of the human retina still delineated the objects that could be observed. William Herschel discovered invisible "infrared" wavelengths when he noticed, quite by accident, that a thermometer placed outside of the red end of a spectrum of the sun registered a temperature above ambient. German physicist Johann Wilhelm Ritter extended the spectrum to the other side of the visible range in 1801 when he exposed silver chloride-impregnated paper to a spectrum and found that the area beyond the violet was darkened more than the area under the violet rays. But these discoveries did not translate into new observational methods. The solutions to Maxwell's equations of electromagnetism, published in 1865, show that electromagnetic radiation can exist in a vast, almost limitless range of wavelengths, all moving at the speed of light. We perceive only a tiny zone of that span. In 1886, Heinrich Hertz detected radio waves by inducing a spark across a gap in a circle of copper wire. The source of the waves was an oscillating high-voltage spark from an induction coil and a capacitor.



Hertz's setup for detecting radio waves

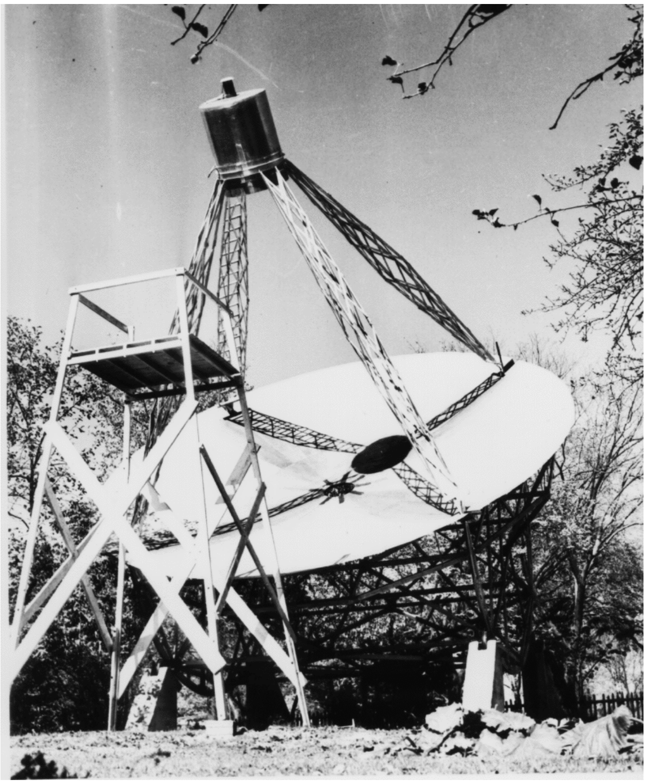
In later experiments Hertz demonstrated a wide range of frequencies for these waves and showed that they behaved exactly like light waves, undergoing diffraction, refraction and polarization. In the mid-1890's, Guglielmo Marconi invented a practical method of using radio waves for communication.

Although it was speculated that radio waves could arise from extraterrestrial sources, the discovery of the ionosphere in 1902 convinced physicists that any radio waves that might arise from extraterrestrial sources would be bounced back into space and thus blocked from detection on the Earth's surface. It wasn't until 1932 that celestial radio waves were detected. Karl Jansky, an engineer for Bell Laboratories, was investigating whether "short waves" with wavelengths of 10-20 meters could be used for transatlantic communications. His directional antenna in Holmdel, NJ, picked up two sources of interference: thunderstorms and a faint steady hiss that seemed to vary with 24-hour periodicity. Studying the hiss for a year, he refined its phase to exactly 23 hours 56 minutes, the length of a sidereal day, proving that the hiss was not solar in origin but came from outer space. He ultimately determined that it came from the Milky Way and was strongest in the direction of Sagittarius, where we now know the center of our galaxy is located.



Heinrich Hertz (L) & Karl Jansky (R)

The first dedicated radio telescope was made by Grote Reber in 1937 in his backyard in Wheaton, Illinois. His neighbors must have been a little put out to wake up one day to see a 31.4-foot diameter dish of sheet metal with a receiver perched on struts 20 feet above the reflecting surface. The parabolic surface allowed wavelengths of every dimension to come to focus at the same point, just like a parabolic mirror on an optical reflecting telescope (which is why reflectors don't have chromatic aberration). The telescope permitted Reber to examine specific locations in the sky in a variety of wavelengths. He was unable to detect signals at 3300 megahertz (90 millimeters) but was successful at 160 megahertz (1.875 meters). At this frequency he was able to create contour maps of the radiation flux.

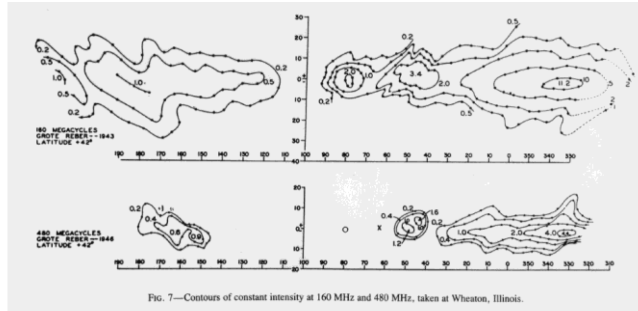


Reber's radio telescope. It's since been reassembled as a historic artifact at the National Radio Astronomy Observatory in Green Bank, West Virginia

Reber's instrument had to be large (albeit a dwarf compared to today's radio telescopes) because the angular resolution of any parabolic reflector depends on the wavelength of the energy it receives according to the formula

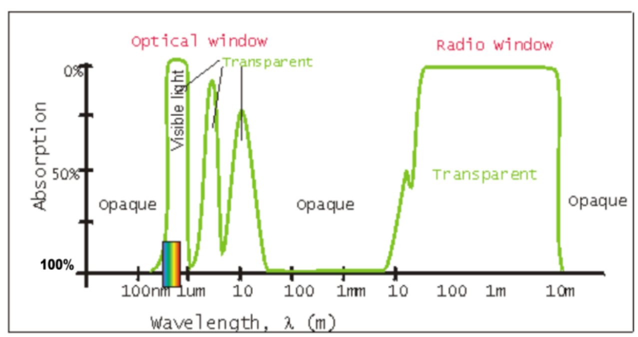
$$\theta = 1.220\frac{\lambda}{D}$$

where λ is the wavelength and D the diameter of the parabola. Radio waves have long wavelengths. Imagine the resolution of an 80 mm optical refractor for the greenish-blue light of the Dumbbell Nebula at 500.7 nanometers. The calculation comes out to be 1.57 arc-secs. If you made a radio telescope of this diameter and searched for 1.875 meter signals, the instrument's angular resolution would be greater than 360 degrees, which means of course you couldn't resolve them at all. And that actually makes sense, because a wave 1.875 meters across can't fit into an 80 mm aperture. Reber's telescope had an angular resolution of just 13 degrees. Shorter wavelengths provide higher resolution, and some of the most important radio astronomy work has been done with 21-cm signals from neutral hydrogen. Had Reber built electronics to detect that wavelength, he would have been able to resolve down to 55 arc-seconds.



Reber's contour maps of the Milky Way, published in *Sky & Telescope* in 1949

But you can't just detect any radio wave (or other wavelengths, for that matter) you want. There are discrete ranges of electromagnetic wavelengths that are able to penetrate the atmosphere. Waves between the far infrared and short radio wavelengths are absorbed. Fortunately for life on Earth, energetic far ultraviolet, X-ray and gamma ray wavelengths are also stopped. Wavelengths longer than about 10 meters reflect off the ionosphere. Extraterrestrial signals of this dimension are lost to us, but long-wave terrestrial transmissions can "bounce" around the circumference of the Earth. That's why you can listen to distant radio stations, particularly at night in the AM band, when there is no local station for your receiver to lock onto. Nowadays these stations transmit their signals over the Internet, and the hobby of "dx-ing", as it was called, is not much practiced anymore. But I found it useful in late October in Florida when I wanted to listen to the World Series but no local station seemed to be broadcasting it. I was able to pick up a St. Petersburg station while driving in Boca Raton, nearly 200 miles away.



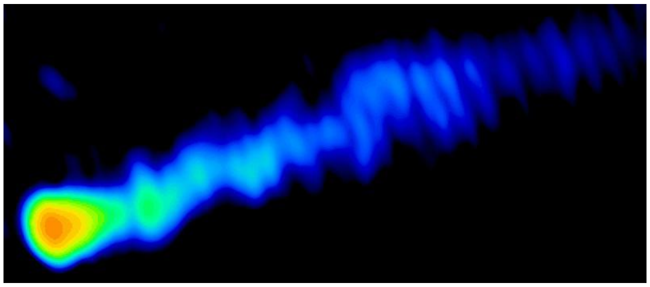
Transparency of the Earth's atmosphere to electromagnetic wavelengths.

Reber noticed that the power spectrum of radio waves from space is lower at higher frequencies, the opposite of what occurs with thermal radiation such as the visible light from stars. In the 1950's, Russian physicist V.L. Ginzburg showed that radio waves are emitted by electrons moving in magnetic fields, via the process known as synchrotron radiation. There are some radio waves that have thermal origin, such as the cosmic microwave background, but these started out as infrared light and are in the radio band only because cosmic expansion and the red shift. Millimeter-length waves arise from cold molecules in molecular clouds, influenced by local magnetic fields. In our solar system, the Sun and Jupiter, both with significant magnetic fields, have copious radio emissions.

Radio waves are inherently low energy, which is why we can have lots of them pass through our bodies without evident harm. The energy of any photon (the quantum of the electromagnetic field such as a radio wave) is given by Planck's formula

$$E = h\nu = \frac{hc}{\lambda}$$

where h is Planck's constant 6.626×10^{-34} Joule-seconds, c is the speed of light (299,792 km/sec), λ is the wavelength and ν the frequency. High frequency signals like gamma rays have very short wavelengths on the order of 10^{-12} meters and frequencies of greater than 10^{19} Hz (10 exahertz), while radio waves span a wide range of wavelengths beyond the far infrared with wavelengths longer than 1 mm. For example, AM radio wavelengths run from 556 meters (540 KHz) to 185 meters (1620 KHz) while FM radio wavelengths are close to 3 meters (88.1 to 107.9 MHz). The FM band sits around channel 6 on the broadcast television spectrum (54-216 MHz). Ham radio operators are familiar with "shortwave" bands of 6, 19, 25, 31 and 49 meters, among others. Individual stations have specific frequencies, and therefore specific wavelengths within those bands. Sitting between high-energy gamma and X-radiation and low-energy radio waves, visible light has wavelengths of 400-700 nanometers (10^{-9} meters) and frequencies in the 425-750 terahertz (10^{12} Hz) range.



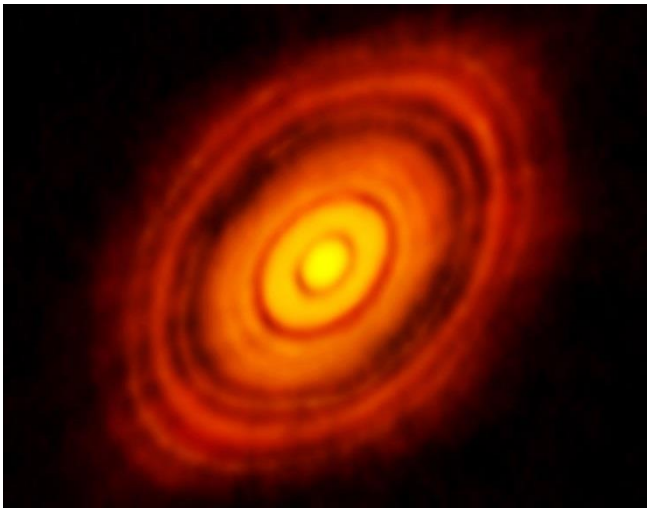
The jet of M87 imaged by the Very Large Array at a wavelength of 2 cm

Although the energy of radio waves is low, the signals can arise from very high energy processes in the universe when electrons are accelerated by cosmic objects. A good example is the radio signal from the jet of M87, the large elliptical galaxy in Virgo. There is solid evidence that a spinning supermassive black hole of at least $3.8\text{x}10^9$ solar masses generates an enormous magnetic field that accelerates electrons from the black hole's accretion disk away from the galaxy. As they spiral in the collimated jet, they emit synchrotron radiation in the radio band which is detected on Earth.

Radio telescopes have evolved from steerable single-dish instruments like Reber's backyard instrument and the 300-foot telescope at the National Radio Astronomy Observatory in Green Bank, WV (which collapsed in 1988 but has been replaced with a slightly larger, more sophisticated instrument) to the 1,000-foot diameter fixed Arecibo dish in Puerto Rico, to interferometric instruments (using "aperture synthesis") such as the Very Large Array near Magdalena, New Mexico. The VLA is composed of twenty seven 82-foot dishes on railroad tracks arranged in a Y-formation that can be as wide as 22 miles across, giving an effective aperture of 22 miles with a sensitivity of a dish 422 feet across. Resolution is bought at the expense of signal intensity.

The Very Large Array from a Google Earth image. The instrument was in its narrowest ("D") configuration when this satellite image was captured in 2013.

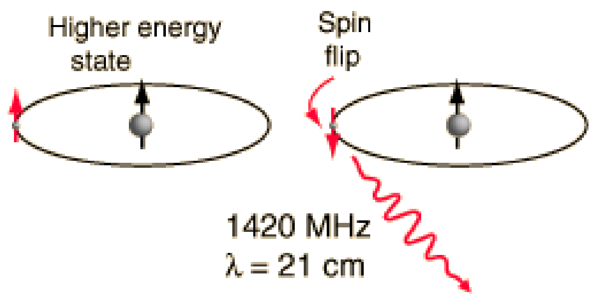
The new Atacama Large Millimeter/submillimeter Array (ALMA) works similarly, but detects shorter wavelengths and therefore has higher resolution. Situated in the high desert in northern Chile, sixty-six 12-meter (39 ft.), and 7-meter (23 ft.) diameter radio telescopes observe millimeter wavelengths that would be attenuated by water vapor in the thicker atmosphere encountered at lower elevations. Aperture synthesis makes the telescope the equivalent of a 16-kilometer dish. A good example of the capabilities of this telescope is an image of the protoplanetary disc surrounding the 15^{th} magnitude star HL Tauri, which is about 450 light years from Earth.



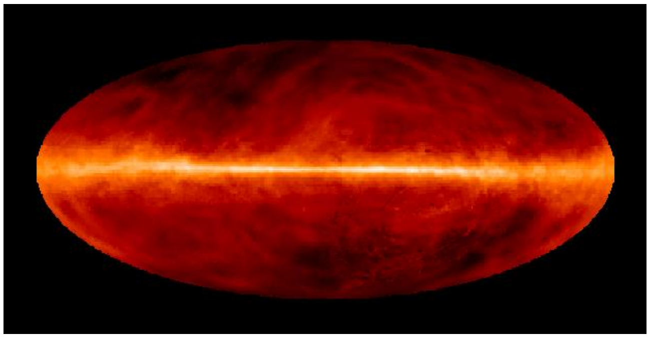
ALMA image of HL Tauri at a wavelength of 1.3 mm (233 GHz. The resolution is 35 milliarc-seconds, just 5 AU at the star's distance.

The technique of aperture synthesis via interferometry can be scaled up to continental proportions. The Very Long Baseline Array uses ten 25-meter telescopes stretching from Hawaii to the Virgin Islands, an aperture synthesis of over 8,000 km. In attempt to visualize the black hole at the center of the Milky Way, the Event Horizon Telescope will link radio telescopes across the entire Western Hemisphere and observe at higher frequencies (shorter wavelengths) to achieve the resolution necessary to image Sagittarius A*. The observing team is hoping for Nobel Prize-worthy images within the next decade.

One of the most important signals in the radio spectrum is the 21-cm line from neutral hydrogen, known as the HI line (HII would be singly ionized hydrogen, in other words a proton. Why it isn't H0 and H1 is beyond me). This has a frequency of exactly 1420.405751786 MHz, corresponding to a wavelength of 21.10611405413 cm, in the microwave region to which the atmosphere and, conveniently, cosmic dust are transparent. The radiation was first predicted by Hendrik van de Hulst in 1944. It is due to the quantum-mechanical properties of the hydrogen atom, which consists of a positively charged proton and a negatively charged electron surrounding it in a spherical shell in its ground state (although it's usually portrayed as a circular orbit, which is how Niels Bohr originally thought of it). The two particles each have an intrinsic magnetic moment, and quantum mechanics says that their angular momentum, known as "spin," can only take one of two configurations: parallel and antiparallel. The parallel configuration has a higher energy and can decay to the antiparallel configuration with the release of a photon of $5.9x10^{-6}$ electron volts, which corresponds to the 21-cm wavelength. This "hyperfine transition" is actually highly forbidden, with a reaction time of about 10 million years. Nevertheless, there is so much hydrogen in the universe that whatever direction you look in, you will encounter photons from the hyperfine transition, with signal strength in proportion to the amount of hydrogen along that line of sight. And since the wavelength and frequency are known to such precision, measurement of the line's Doppler shift provides information on the the velocity of the hydrogen from which it originates.



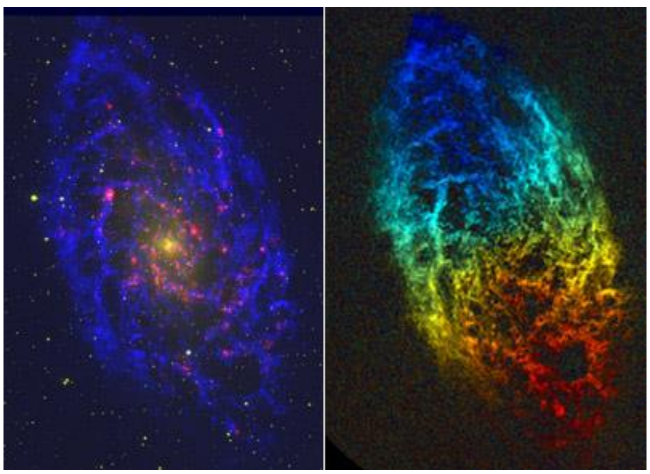
Radio observations of this line and its Doppler shifted signals have been used to map the structure of the Milky Way and determine its rotation. The Milky Way has about 3 billion solar masses of neutral hydrogen in interstellar space, which by my calculation means that there are about $3.6x10^{66}$ hydrogen atoms available to undergo the hyperfine transition. Perhaps only 3 out of 10^{15} of these atoms will undergo the transition each second, but that means that every second over 10^{51} hydrogen atoms in the Milky Way are flipping and sending out 1420 MHz photons. Similarly, the structure of distant galaxies can be determined from their HI regions, and more concentrated molecular clouds in our galaxy can be discerned and mapped.



21-cm image of the whole sky

When combined with data taken in other wavelengths, some truly spectacular images can result.

M51 images in optical and 21-cm wavelengths (red) combined (NRAO)



M33 in Triangulum. (L) Superimposed optical (red) and 21-cm neutral hydrogen (blue) images. (R) Doppler image at 21-cm. red receding, blue approaching. The rotation of the galaxy is clearly seen. (VLA)

There's another important reason to listen to the radio sky around 21 centimeters. Let's assume someone out there wants to announce their presence to the rest of the universe by sending a radio signal. They would want to broadcast on a frequency that someone else would be monitoring. There's no point broadcasting on channel 2 if everyone is tuned to channel 7. In fact there is no *a priori* reason to think that any specific frequency among the billions in the radio band should be favored, except one: the 21 cm hydrogen line. There is neutral hydrogen everywhere in the universe, and any species intelligent enough to develop radio astronomy will have discovered the hyperfine splitting of hydrogen and its 21 centimeter signal. This frequency was first suggested by Giuseppe Cocconi and Philip Morrison in a seminal paper published in 1959 (Cocconi, G, Morrison, P, Searching for Interstellar Communications, *Nature* 1959: 184:844-846). The authors write:

> At what frequency shall we look? A long spectrum search for a weak signal of unknown frequency is difficult. But, just in the most favored radio region there lies a unique, objective standard of frequency, which must be known to every observer in the universe: the outstanding radio emission line at 1,420 Mc/s. (21 centimeter wavelength) of neutral hydrogen. It is reasonable to expect that sensitive receivers for this frequency will be made at an early stage of the development of radio-astronomy. That would be the expectation of the operators of the assumed source, and the present state of terrestrial instruments indeed justifies the expectation. Therefore we think it most promising to search in the neighborhood of 1,420 Mc/s.

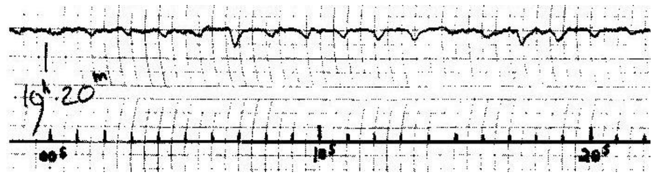
So it's reasonable to start the hunt for ET by tuning in at 1420.405751786 MHz. What would we listen for? Any signal with a non-random variation would be a candidate. As an undergraduate, Frank Drake attended a series of lectures at Cornell by the astronomer Otto Struve, who discussed measuring stellar rotation using the Doppler shift. In a series of deductions, Drake came to the conclusion that there may very well be a large number of stars with planets, on some of these, intelligent life may have evolved, and that intelligent life would have found the hyperfine line and perhaps sent out some signals on the frequency. In 1956, while making observations of the Pleiades at 21 cm with the Harvard's 60-foot Agassiz Station radio telescope, he thought he caught a regular signal, but it persisted when the telescope was slewed to another location, meaning it had a terrestrial origin. Drake's Project Ozma, using the 85-foot dish at Green Bank, was the first organized SETI (Search for Extraterrestrial Intelligence) effort. On April 8, 1960 Drake listened to signals from the star Tau Ceti, a magnitude 3.5 G-type star (similar to the Sun) about 11 LY distant from Earth. Nothing was heard. The next night he pointed the telescope at Epsilon Eridani (mag 3.75, type K, 10.5 LY) and captured a regular signal, but this too turned out to be terrestrial.

We can't be sure that ET is broadcasting on the 21-cm wavelength. Other possibilities include multiples of the basic frequency. In the movie *Contact*, the aliens' signal is detected at 4.4623 GHz, and Jodie Foster mutters "hydrogen times pi," which it is exactly (the comment is made *sotto voce*, undoubtedly intended only for radio astronomy cognoscenti since it's not further explained). Perhaps ET is concerned that the signal may get lost among all the other radio sources, or he doesn't want to disturb the research projects of radio astronomers on his planet or elsewhere in the galaxy. We didn't even broadcast on that wavelength the first time we sought out our compatriots in the stars. When the Arecibo Radio Telescope was recommissioned after an upgrade in 1974, a binary signal designed by Frank Drake and Carl Sagan was sent to the M13 star cluster. The message was broadcast on a frequency of 2.380 GHz (12 centimeters) with a 1,000 kW transmitter. Drake himself reasoned in 1981 that that since narrow-band signals centered on 21-cm get broadened as they encounter the intervening material in the universe, they might be hard to detect as the energy splays out along surrounding frequencies. He suggested that a more optimal frequency would be around 70 GHz (4.3 millimeters) where scattering is minimal. The only problem is that our atmosphere isn't transparent to this radiation, so radio telescopes would have to be in space. It's not likely that a 300-foot dish is going to be launched any time soon. We are going to need to scan a wide range of frequencies on Earth, albeit in possibly suboptimal wavebands, to be sure we are giving ourselves any chance of detecting signals from other intelligent life forms.

In case you are wondering about the "first time" comment, it turns out that there has been at least one other attempt to signal our presence. The "Cosmic Call" was sent from a radio telescope in the Crimea by an outfit called Team Encounter, a Texas-based technology company that's no longer around (just what could their business plan have been? Getting the aliens to pay to watch ESPN?) Digital messages were sent to a number of stars in 1999 and in 2003 using a 150 kW transmitter at 5.01 GHz (59.9 millimeters).

In both the Arecibo and Cosmic Call cases, the messages were transient (Arecibo lasted 3 minutes). Obviously it would be astonishingly serendipitous for another civilization to pick it up at all, and they would be scratching their heads (or whatever they have) not only to decode it but to verify its source, since no further transmissions would be coming. So anyone wanting to communicate would have to be transmitting pretty consistently.

In 1967, graduate student Jocelyn Bell was surveying the sky at 81 MHz (3.7 meters) and detected a regular signal. The signal was named "LGM-1" for "little green men," more as a joke since a natural cause for such phenomena in the form of a rapidly rotating neutron star had already been predicted. Famously, it was not Bell but her mentor Anthony Hewish who was awarded the Nobel Prize for the discovery of pulsars.



Jocelyn Bell's pulsar (top line is signal, bottom line is timing)

Contact posits that aliens picked up early television transmissions from Earth and beamed them back to us as modulations on a carrier wave that was clearly not natural in origin. That's not going to happen. It turns out that the strength of routine terrestrial broadcast signals isn't very high and they become indistinguishable from the radio background at fairly small cosmic distances. ET wouldn't be watching "I Love Lucy": he'd be seeing static.

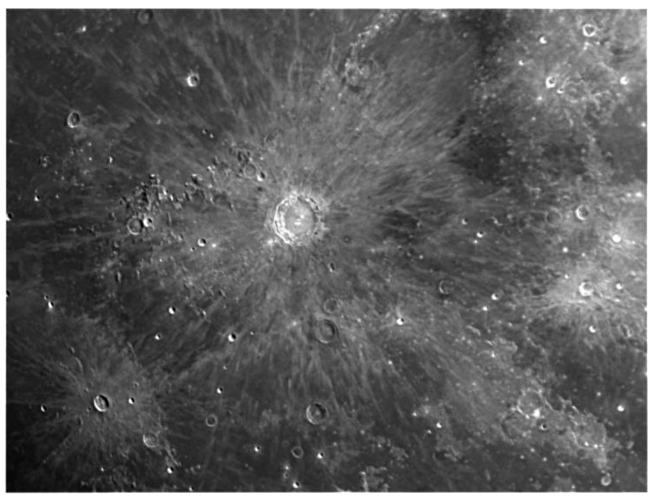
The history of SETI, the search for extraterrestrial intelligence, has advanced from Drake's early experiments at one frequency to detectors that can scan millions of frequencies. The evolution of SETI has been covered in a number of books, but an excellent review of the early days of the field is in David E. Fisher and Marshall Jon Fisher's *Strangers in the Night* (1998). Frank Drake's own story is detailed in his book with Dava Sobel, *Is Anyone Out There?* (1992).

With a dearth of public funding, in the last two decades SETI has to rely on private support. The SETI Institute's Allen Array in California is the main active project, funded initially by the philanthropic Microsoft billionaire Paul Allen. Using commercially-made 6.1-meter dishes, the assemblage will ultimately include 350 antennas with sophisticated detectors and computer software. It will scan millions of frequencies between 1,000 and 15,000 MHz. But even this doesn't guarantee success. The detection strategy depends on checking narrow frequency ranges in tiny areas of the sky, one after another, and being there just at the right time. In their outstanding essay "If You Want to Talk to ET" in *Frontiers of Astrobiology* (2012), Jill Tarter and Chris Impey note that "the fraction of nine-dimensional volume [3 spatial coordinates, time, two polarizations, frequency, modulation, sensitivity] searched to date [has] a geometric mean of $2.5x10^{-22}$. The Earth's oceans hold $1.4x10^{18}$ m^3 of water, or $6x10^{21}$ eight-ounce glasses… So our search of the cosmic ocean to date is equivalent to sampling about 1.6 glasses of water from the Earth's oceans. Not much." ■

Kepler

The 32 km wide Kepler is one of the more prominent craters on the moon, located on the western side of the Mare Insularum about 500 km west of Copernicus. Its floor over 2500 meters lower than its rim. It is surrounded by a prominent ray system but one that is dwarfed by that of Copernicus. Below Kepler is the 30 km wide Encke, only 750 meters deep. To the east near the right side of the image at the same level of Encke is the 10 km wide crater Hortensius, and just barely visible above it are several lunar lava domes. Stellarvue SVR-105 triplet refractor, 2x Barlow giving 1470 mm focal length, QHY-5L-II monochrome camera, best 300 of 3000 frames. Seeing 4/10. October 23, 2013, Larchmont, NY.

The ray system of Kepler can easily be compared to that of Copernicus when the moon is near full, as in the second image of a 12.6-day moon using a red filter to bring out the contrast on the lunar surface. Copernicus is the large crater, and Kepler is to the lower left.



May 11, 2014. Orion 127 mm Maksutov, Wratten 25A filter, Skyris 445 monochrome camera.

--Larry Faltz

President's Report
Larry Faltz

I am happy to report that Westchester Amateur Astronomers continues to flourish and represents the best in the astronomy community.

In 2015 our membership continued to grow, and we now have nearly 180 members from every part of Westchester and also from New York City, Long Island, Connecticut and even Virginia.

In addition to our regular club lecture meetings and star parties, we did a lot of outreach in 2015. Members gave freely of their time, expertise, equipment and enthusiasm. We made many new friends for the club and introduced hundreds of people to the wonders of the skies. The roster of events included (I may have missed one or two)

- Scarsdale schools 3rd grade at Quaker Ridge
- Wainwright House, Rye
- White Plains Ethical Culture School
- Scouts at Yorktown Grange
- Somers Library
- Camp Ramah
- Bedford Town Community Family Campout
- Bell Middle School STEM Fair, Chappaqua
- Sidewalk Astronomy in Mamaroneck
- Sidewalk Solar Astronomy in Larchmont
- World Science Fair

We had terrific member participation in NEAF in 2015 and we will again take a table at the 2016 event, which will take place at Rockland Community College on April 9-10. I'll be recruiting participants via email in January.

Our newsletter, which we think is the best in the astronomy club world, continues to go out to over 200 email addresses.

In 2015 we created an Advisory Board to assist the officers in carrying out club responsibilities and to create a pathway to future leadership. The current Board will continue for another year, but we will identify new leaders for 2017. It's important for a volunteer organization to circulate responsibilities among its members. It's gratifying to put in effort to see something we value grow and flourish, and the amount of effort is really not all that much! If you are interested in joining the Advisory Board, please let me know.

The club's fiscal situation is excellent: we have more than 3 years' operating funds in reserve and as a result we have kept dues to just $25 per year. Because we are in good fiscal shape, we made an important decision to refurbish the club's 20-inch Obsession reflector. Under the leadership of Paul Alimena and with participation from Mike Newell, Darryl Ciucci, Mike Cefola, Mike Virsinger and others, new hardware for the mirror cell, collimation tools, a new observing ladder and aluminum loading ramps were purchased. In 2016 we will finish the upgrade with new truss tube hardware and an Argo Navis computer. When the scope is completed, we will dedicate it to the memory of Bob Davidson, who was so instrumental in organizing the club and fostering its success.

All of us at WAA owe thanks to Matt Ganis and Pace University for allowing us to use their excellent lecture rooms and AV equipment for our meetings, and to Jeff Main, Ward Pound Ridge Reservation and the Westchester Country Parks Department for their enthusiastic permission to let us hold our star parties after regular park hours.

On a personal level, I want to thank my colleagues on the Board for everything they do for the club, the new Advisory Board members for their participation, and all of the members of the club for their enthusiasm and love of astronomy. I've met many wonderful new friends in the past few years, and I look forward to meeting many more.

2016 Officers (Board)

- President: Larry Faltz
- Senior Vice President: Charlie Gibson
- Treasurer: Doug Baum
- VP for Membership: Paul Alimena
- VP for Programs: Pat Mahon
- VP for Field Events: Bob Kelly
- Newsletter Editor: Tom Boustead
- Webmaster: Dave Parmet
- Assistant VP: Claudia Parrington

Advisory Board

Karen Seiter	Margaret Brewer-LaPorta
Jeffrey Jacobs	Darryl Ciucci
Olivier Prache	Mike Lomsky
Dede Raver	Robert Novak
Jim Cobb	Tim Holden
Satya Nitta	Hans Minnich