Newcomers and Elmers Net: Amateur Radio Astronomy 05.21.17
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I never cease to be amazed at how many different areas of the radio hobby await to be explored! Perhaps more accurately, I never cease to be amazed at what can be heard on the various radio frequencies. When I think I have heard the most amazing things possible, I find yet another listening opportunity which can be enjoyed right in my own back yard. Like listening for Jupiter. The planet. Yeah, *that* Jupiter! Most of us already have the equipment we need to hear signals from Jupiter, so read on and we will look at how we can discover what Jupiter is saying over the radio!

Having watched the movie *Contact* a number of years ago and marveling at the huge linked antenna dish arrays, I could easily believe they could hear signals from whole galaxies away. Many years ago I used my computer to be a part of the SETI project as it processed data in the background while my computer sat idle. I never did discover anything in the chunks of data my computer analyzed, but that did not keep me from dreaming of being the one whose computer found extra-terrestrial life!

While I do not expect my monitoring radio signals from Jupiter to provide ground-breaking new information about the planet, I am thrilled with the idea of hearing radio signals from a planet roughly 500 million miles from Earth! (And if E.T. wants to phone home, who am I to stop him?!)

Signals from Jupiter are commonly found right in the sweet spot of HF radio, roughly between 15-40 MHz, utilizing antennas we already have or which we can easily build. More good news—typical amateur radios can be used for reception, and many folks already have the ability to record the signals they hear for later analysis.

A Little Background

Radio astronomy is a relatively new field, considering the age of radio itself. Signals from space were discovered back during the depression era when Bell Laboratories decided they wanted to see if HF bands could be used for reliable long-distance telephone communications. It was known signals could travel great distances in the ”useless” portion of the RF spectrum given to amateur radio operators, but the impact of storms and various other sources of interference was not known.

Karl Jansky began surveying the skies with an antenna which was roughly 100 feet in diameter and 20 feet high, and able to be rotated like a merry-go-round. Jansky identified three main types of static after surveying the sky at 20 MHz: strong storms, light storms, and an unidentifiable hiss which occurred every 23 hours and 56 minutes, the relationship of the Earth's rotation relative to the stars. By consulting astronomical maps he was able to determine the noise was coming from Sagittarius, roughly at the center of the Milky Way.

Jansky wanted to pursue these discoveries, but Bell Labs saw no financial gain to be had, so they abandoned the project (along with the idea of using HF signals to carry long-distance calls). Can you imagine the dropped calls that system would have had?!

Fortunately two other men found out about Jansky's work and decided to pursue it further. One was Grote Reber, a radio engineer who built a 32 foot parabolic radio telescope in his Illinois back yard in 1937 (shown here), allowing him to do the first systematic survey of astronomical radio waves. The entire assembly was mounted on a tilting stand, allowing it to be pointed in various directions, though not turned. His data, published as contour maps showing the brightness of the sky in radio wavelengths, revealed the existence of radio sources such as Cygnus A and Cassiopeia A for the first time.

The second was Prof. John D. Kraus, who started a radio observatory at Ohio State University and wrote a textbook on radio astronomy, long considered a standard by radio astronomers. Of course Kraus is known to amateur radio operators for his outstanding work *Antennas*, a classic reference in the field, and his development of the helical antenna.

Kraus also supervised the Ohio Sky Survey which cataloged over 19,000 radio sources, more than half of which were previously unknown, and later participated in the SETI survey conducted by Bob Dixon. One of the signals received at the "Big Ear" radio telescope of The Ohio State University, was the now-famous "Wow!" signal noted by astronomer Jerry Ehman in 1977. The 72-second signal was captured as a series of letters and numbers, indicating the signal's properties.

Ehman explains:

> The circled alphanumeric code "6EQUJ5" describes the intensity variation of the signal. Each character represents 12 seconds (by 10 kHz). A space denotes an intensity between 0 and 1, the numbers 1 to 9 denote the correspondingly numbered intensities (from 1.0 to 9.9),

and intensities of 10.0 and above are denoted by a letter ("A" corresponds to intensities between 10.0 and 11.0, "B" to 11.0 to 12.0, etc.). The value "U" (an intensity between 30.0 and 31.0) was the highest detected by the radio telescope; on a linear scale it was over 30 times louder than normal deep space. The intensity in this case is the unitless signal-to-noise ratio, where noise was averaged for that band over the previous few minutes. (The complete explanation given by Ehman may be found here.)

The signal is presumed by many to be an extraterrestrial signal because it was continuous during the 72-second window in which the telescope could listen, and its characteristics match what would be expected for such a signal. Unfortunately it has never been heard again.

By the 1960s Radio Astronomy research took off and continues today. Fortunately for those of us not able to participate in studies using large antenna dishes, there are projects we can build to experience Radio Astronomy on a smaller scale, as well as using equipment and antennas we have already.

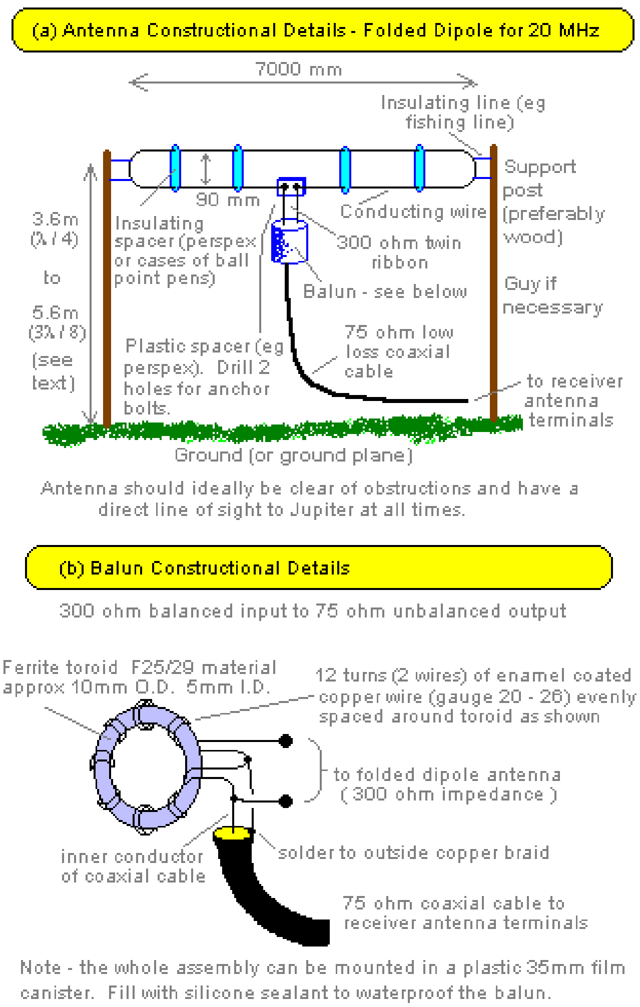
Jupiter is Our Friend

In 1955 signals from Jupiter were accidentally discovered at Carnegie Institution in Washington D.C. using a phased antenna array consisting of a network of 100 dipoles listening on 22.2 MHz. These signals are referred to as *decametric* radio signals (wavelengths in the tens of meters), and they seem to be linked to three main longitudinal positions around Jupiter. As they do not face Earth all the time, software may be used to calculate when they will be in the proper position. Also Jupiter's moons seem to have an impact on what may be heard, as well as other local factors.

The moon Io is within the tidal force's limit of Jupiter and it crosses the magnetic field of Jupiter, releasing charged particles into the field. These charges are accelerated to very high speed and spiral along magnetic field lines, generating synchrotron radiation. These are the radio signals we detect here on Earth. Ganymede and Europa may also help to contribute to the radio signals. (Image is from NASA's Cassini spacecraft showing Io's shadow cast on Jupiter.)

Signals not related to Io are referred to as Non-Io-B or Non-Io-A, while signals generated by Io are referred to as Io-B or Io-A. The most intense source for amateur observation is the Io-dependent source Io-B, and it is also the most predictable. There are two different types of radiation typically observed--short bursts of 1 to 10 milliseconds, and long bursts 0.5 to 5 seconds or longer. Some sources seem to produce only long bursts while others, such as Io-B and Io-C, radiate a combination of long and short bursts. During a typical observing session many bursts of both types can be observed, and the complete event is called a *noise storm*. The duration of these storms varies from only a few seconds to several hours.

A Simple Antenna Design



Antenna design and image curtesy of by Mal Wilkinson and John Kennewell and the Australian Space Academy

Wilkinson and Kennewell note:

> The signals from Io-B are quite intense in comparison to most radio-astronomical sources. When the Earth and Jupiter are near inferior conjunction, even a simple dipole will deliver around 1 μV peak to the antenna terminals of a receiver. The dipole should be folded to

maximize its bandwidth, and elevated above the ground (or a suitable reflecting surface such as a metal roof) at a distance of between 1/4 and 3/8 of a wavelength. Small irregularities such as corrugations in this surface will not affect performance unless they exceed a depth of approximately 1/10 of a wavelength at the observing frequency. The exact height of the dipole does affect the response pattern of the antenna, and use can be made of this fact to maximize the antenna gain in the direction of the planet.

If Jupiter has an elevation angle of less than 50° when it crosses the meridian at the observing site, a dipole height of 3/8 of a wavelength is appropriate. For elevation angles exceeding 50°, the height should be 1/4 of a wavelength. The dipole should generally be mounted in an east-west direction, and as clear of obstructions as possible. If the observing latitude is such that Jupiter crosses the meridian within about 20° of the zenith, a north-south orientation might give a better coverage. Either way, it should certainly have a direct line of sight to the planet. When the planet is at elevation angles below 30° use of a typical radio amateur 21 MHz beam antenna (if available) may be appropriate.

The antenna is connected to the receiver via a length of 75 Ω (ohm) coaxial cable. This requires a balun (4:1 impedance ratio) to match the antenna impedance of 300 Ω to the 75 Ω coaxial line.

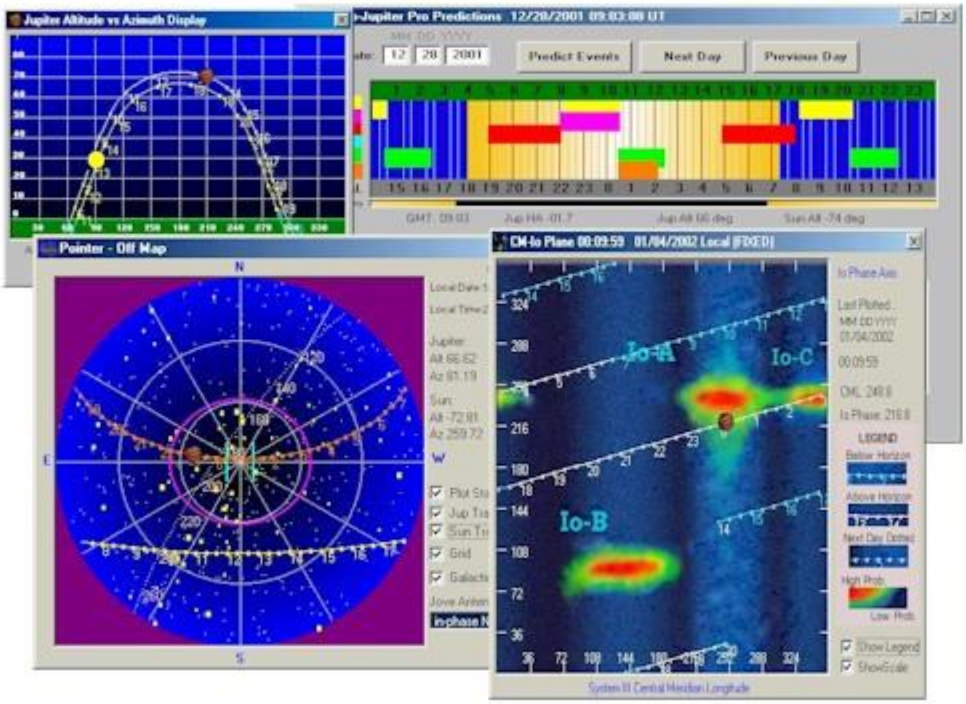
Finding the Signals

Signals are strongest when Earth and Jupiter are the closest, and when the longitudinal sources are pointed toward Earth. The easiest way to find these times is to use one of several Jupiter monitoring software programs designed for this purpose. Radio-SkyPipe II has both a stand-alone feature for local use and an Internet-enabled feature allowed shared resources, data sharing, and real-time chat/data sharing with multiple users.

Another program is Radio-Jupiter Pro 3 which allows for prediction passes based on one’s location. A few of the features are listed here:

- Predictions and positional information customized to your location.
- Quick Look prediction chart helps you spot the best storms easily. Click on a noise storm and update other views such as the sky map to show you more about Jupiter's position or other parameters for that storm.
- Customizable prediction reports simplify long range planning.
- See when Jupiter season is coming with the yearly visibility chart.

• Real time sky map helps you see where Jupiter is in your antenna beam. Plots the Sun, stars, and even the galactic plane.



Radio Spectrograph is a program to see signals from online sources as an example of what can be heard, described here by the developers:

> This software allows you to view signals from special frequency-sweeping receivers at the Windward Community College Radio Observatory (WCCRO) and the University of Florida Radio Observatory (UFRO). These receivers, called spectrographs, allow you to see how radio signals are distributed across a 10 MHz wide swath of radio spectrum. The receivers were designed and built by Richard Flagg to be sensitive and fast enough to detect changes which occur in the radio emissions of the Sun and Jupiter. This software, produced by Radio-Sky Publishing , will run on most modern Windows based computers with an internet connection speed of 56K or more. There is no charge for use of the software for non-commercial users. Download it from http://jupiter.wcc.hawaii.edu/spectrograph_software.htm

More information and software may be found from NASA here.

A popular receiver is available at this location called the Radio Jove Project. This kit is in use in many schools as well as individual locations, and is useful for listening to Jupiter, the Sun, and signals from across the Galaxy.

The radio telescope kit contains:

1. All components for the JOVE receiver;
2. Complete step-by-step instructions for assembly;
3. Antenna parts for two dipoles including cable, wire, and connectors;
4. Complete step-by-step instructions for antenna assembly and setup;
5. CD ROM with SkyPipe software and general information.

For amateurs with shortwave radios already this kit would only be of interest for a project as most commercial gear will likely out-perform it, but as a project to stimulate and immerse interest, it seems quite useful.

Listening for Signals

The equipment and antenna are, in a sense, the easy part. Listening for signals from Jupiter is a challenge, but one worth exploring. The challenge comes from learning to identify what is an actual signal versus what is atmospheric noise, local interference, or internal receiver noise. This can be learned over time with experience, and there are many audio samples available online which can help train the ear for what to hear.

More difficult is our old friend propagation. As amateurs we are well aware of its vagaries, but even more so as we try to distinguish the wheat od Jupiter from the chaff of our local interference. An audio recording device hooked to the radio or computer will be a good addition as it will allow for recordings of entire listening sessions and then later analysis.

Likewise an SDR-capable radio which can record a band spread of one or two megahertz or more will also be quite useful for later analysis. The audio can be piped through the computer for filtering and adjustments using a program such as *Audacity*, which might allow for a bit of signal cleanup.

Beyond the strong signal bursts produced by Io in relationship to Jupiter, the weaker signals are harder to copy. Just as with weak signal work in amateur radio, the first thought might be to add an amplifier to boost signal reception. However, just as with weak terrestrial stations, boosting the receive signal of the desired signal also increases the noise received. The problem is not the volume, but rather the signal-to-noise ratio.

The best way to improve the system performance is to increase the antenna gain in the direction of Jupiter. A narrower antenna beam-width will increase the ratio of Jovian storm noise to cosmic noise, allowing weaker, non-Io bursts to be monitored. Recommended higher gain antennas are a 2, 3 or 4 element Yagi, a cubical quad, a corner reflector, or an array of several dipoles. Because of their narrower beam-width these antennas will need to be steerable.

As a general rule some of the best times for hearing Jupiter is like the best times for astronomy itself—winter nights when the atmosphere is clean and quiet, and the ionization of the atmosphere is at its lowest. Not only will this improve signals around 20 MHz, but it will also allow for better low-frequency reception down around 8 MHz which is otherwise easily absorbed by the D and E layers of the atmosphere.

Wrap-up
While the Radio Jove project is great for encouraging a budding interest in Radio Astronomy, I find the whole idea of receiving signals from Jupiter, the Sun, and our own Milky Way galaxy to be quite intriguing, and I hope you will give this a try. As amateurs we have most if not all of the equipment we need, and the software is reasonably priced for most folks.

This is an area which was really brought about and nurtured by amateur radio folks, and for a long time, we were the only ones doing it. Even now a good portion of the serious research being done in the field is being done by scientists who also have their amateur radio license, so we are in good company!

Additional information provided by Justin, Ke8COY
One more thing. If you are still compiling the notes from the net and want to put this in here is the description of the album Dark Matter by Lustmord:

"This project is derived from an audio library of cosmological activity collected between 1993 and 2003. It was gathered from various sources including NASA (Cape Canaveral, Ames, The Jet Propulsion Laboratory and Arecibo), The Very Large Array, The National Radio Astronomy Observatory and various educational institutions and private contributors throughout the USA. While space is a virtual vacuum, it does not mean there is no sound in space. It exists in space as naturally occurring electromagnetic vibrations, many well within the range of human hearing, while others operate at different regions of the electromagnetic spectrum and these can be adjusted with software to bring them within our audio range. The recordings of these interactions in space come from several different environments including radio, ultra violet, microwave and x-ray data and within these spectra a wide range of sources including interstellar plasma and molecules, radio galaxies, pulsars masers and quasars, charged particle interactions and emissions, radiation, exotic astrophysical objects, cosmic jets and flares from magnetars"