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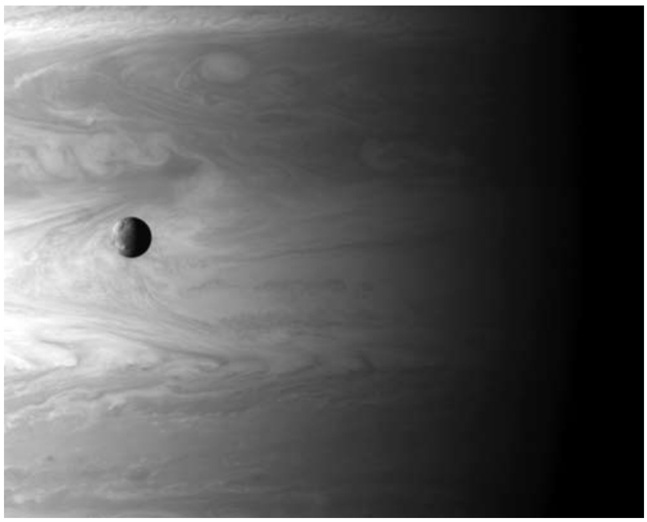
Amateur Radio Astronomy Projects — Radio Signals from Jupiter

You can receive signals directly from the planet Jupiter, possibly by using equipment you already own.



Jupiter and Io.

In 1955 mysterious signals from space were discovered by radio astronomers at the Carnegie Institution of Washington, DC. Some thought the signals were local interference, perhaps a noisy ignition system of a pickup truck whose driver was returning home from a late night date. However, analysis revealed that the planet Jupiter was in the beam of the Mills Cross antenna each time that signals were heard. Unlike many radio astronomy dish antennas, the huge Mills Cross comprised over 100 dipoles strung between wooden poles planted in a Maryland field. The dipoles were phased to produce a narrow, steerable, pencil-thin beam some 2.5º in width. That is an amazingly narrow beam considering the operating frequency was 22.2 MHz. Ever since this accidental discovery, researchers have aimed shortwave antennas at Jupiter as they attempted to understand the source of these powerful signals.

Giant Jupiter, some 500 million miles from Earth, is a huge ball of gas with a small core of solid hydrogen, a strong magnetic field, and a retinue of over 60 moons. The largest moons, Io, Europa, Ganymede and Callisto, were first viewed by Galileo over 400 years ago using his primitive telescope. Large enough to hold 1000 Earths, Jupiter rotates about its axis every 10 hours — a rotating speed demon compared to tiny Earth and its 24-hour day.

Signals Detected

The so-called *decametric* radio signals from Jupiter are not on the air all the time but seem to be linked to three longitude regions around the planet, cleverly named the A, B, and C source regions. If one of these source regions is facing Earth, we have an increased probability of receiving signals. If the Jovian moon Io is in the right place in its orbit, the probability of receiving signals is greatly enhanced. The moon Io happens to be within the tidal force's limit of Jupiter and it is literally being torn apart by gravitational forces with tides as large as 100 meters (about 300 feet!). Io crosses the magnetic field of Jupiter and is thus able to release charged particles into the field. These charges are accelerated to very high speed and spiral along magnetic field lines and generate synchrotron radiation, which manifests itself as the radio signals detected here on Earth. There is additional data that suggests that Ganymede and Europa may also contribute to the radio emissions. Earth's

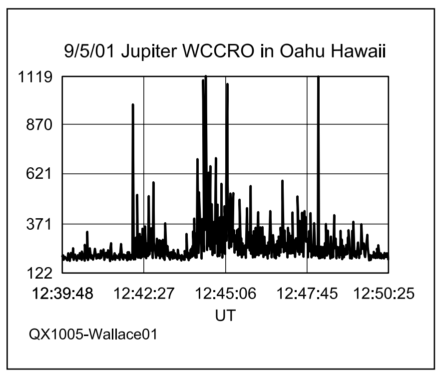


Figure 1 — Jupiter radio noise bursts received at 20.1 MHz using a Jove receiver and dual dipole antenna. Signals are displayed using *SkyPipe* software. The vertical axis is proportional to voltage.

Figure 2 — The Jove RJ1.1 direct conversion receiver is simplicity itself with only two controls – a POWER SWITCH/VOLUME CONTROL and a TUNING knob. Low level audio from the receiver is sent to a computer sound card and also may drive an amplified speaker. The receiver uses a J310 grounded gate RF amplifier followed by the traditional NE602 mixer/oscillator and high gain audio amplifiers. A varicap tunes the receiver over a 400 kHz range centered on 20.1 MHz.

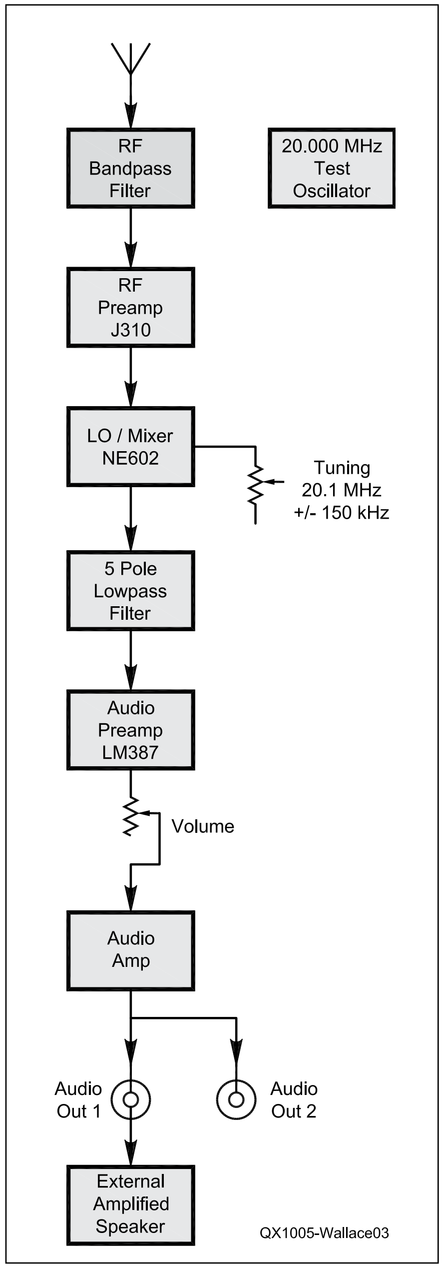


Figure 3 — Here is a block diagram of the Radio Jove receiver.

ionosphere limits ground based reception below about 15 MHz and Jupiter itself does not emit these signals above 39.5 MHz — an upper limit determined by the strength of the Jovian magnetic field.

So what do the signals sound like? There are two distinct types: *L-bursts* sound like ocean waves breaking up on a beach, and *S-bursts*, which can occur at rates of tens of bursts per second, sound like popcorn popping or a handful of gravel thrown onto a tin roof.

Have you heard them? Late at night is the best time, when the ionosphere has become transparent and most terrestrial signals have disappeared on the 15 meter band. The quiet hiss in your headphones comes mostly from relativistic electrons spiraling in the galactic magnetic field. L-bursts and S-bursts are heard above this background noise. A radio noise storm of L- or S-bursts can last from a few minutes to a couple of hours (Figure 1).

Do you need a giant antenna spread out over several acres? Fortunately not — a ham band Yagi will do very nicely. Even if Jupiter is 30º or 40º above your horizon, a low-mounted Yagi aimed toward the azimuth of Jupiter will probably have adequate gain. And you don't need a cryogenically-cooled front end either; your favorite ham-band receiver is plenty sensitive. Just be sure to turn the AGC off, as AGC can severely distort the Jovian noise bursts. Probably the best frequency range is between 18 and 22 MHz, so if you are using a ham-band only receiver, try the 15 or 17 meter bands. Either AM or SSB modes will work. Just tune for a quiet spot between the stations.

During a good storm, Jovian signals can be easily heard, often several dB above the background noise. Of course, the bigger your antenna the stronger the signals. The 640-dipole, 26.3 MHz, phased array antenna at the University of Florida would yield signals well over 20 dB above the background.

Radio Jove

Ten years ago a group of (mostly) University of Florida graduates working at NASA conceived an educational outreach program known as Radio Jove. The idea was to build an inexpensive radio telescope kit suitable for detecting signals from Jupiter. The Jove receiver (Figure 2) is a simple direct-conversion design operating over a few hundred kilohertz range centered at 20.1 MHz. The block diagram is shown in

Sources for Jupiter Radio Supplies and Information

Radio Jove Web site: **http://radiojove.gsfc.nasa.gov/**

Jim Sky's Radio Jupiter Central site: **www.radiosky.com/rjcentral.html**

Jim Sky's Radio Sun Central site: **www.radiosky.com/suncentral.html**

The Society of Amateur Radio Astronomy (SARA): **www.radio-astronomy.org/**

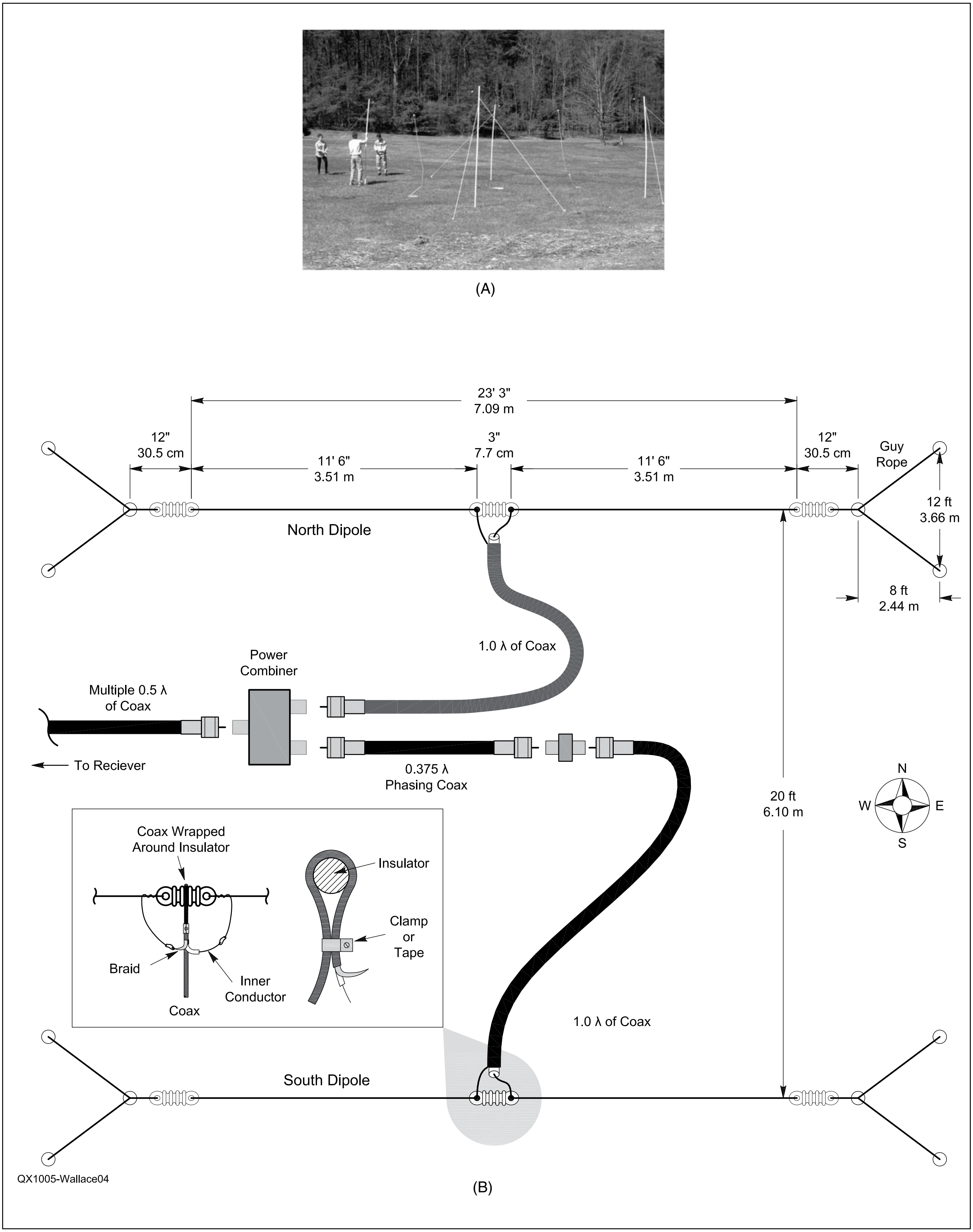


Figure 4 — The Jove dual dipole array. Dipoles are suspended between PVC masts. Signals from the dipoles go to a power combiner and then to the receiver.

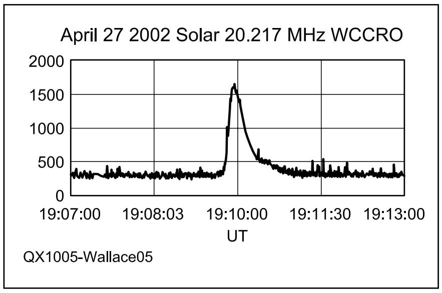


Figure 5 — A single shark fin shaped solar burst. Activity has been sparse during the long solar minimum but as we head toward maximum there will be many opportunities to hear solar bursts. On occasion, following a strong burst the background noise will decrease, indicating increased absorption in the earth's ionosphere due to enhanced solar X-ray and UV flux.

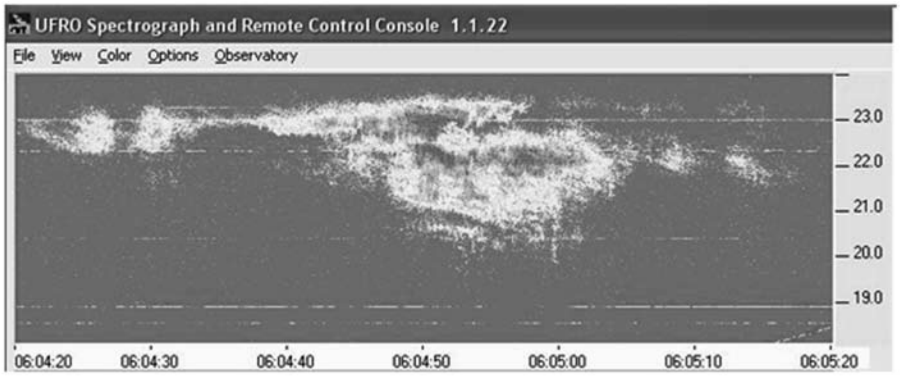


Figure 6 — Radio spectrogram of Jupiter radio noise storm activity. Horizontal lines are weak stations while Jovian signals are seen as the enhanced region between 20.2 and 23.5 MHz. Any resemblance between this emission region and the shape of the starship *Enterprise* is purely coincidental.

Figure 3. The antenna is a dual dipole array (Figure 4). Audio signals from the receiver are sent to a computer sound card where they are processed and displayed as a strip-chart record using *SkyPipe* software. In addition to simply displaying signal strength, *SkyPipe* will stream your data over the Internet to other observers who can then display your results in real time on their computer screens.

Radio Jupiter Pro (RJP) software carries out the fairly complex calculations necessary to predict when a radio noise storm is likely, taking into account the longitude of Jupiter facing the Earth, the position of Io in its orbit, and where Jupiter is in your local sky.

Many observers are also using the Jove equipment to monitor radio noise bursts from the Sun. Some solar bursts can be very strong (over 25 dB above the background) and can easily be received with a single dipole. Individual solar bursts often start abruptly, and then trail off in intensity over tens of seconds (Figure 5). On a strip-chart record they sometimes look like a shark fin. Since you will be receiving during the daytime, the ionosphere can be an issue (as discussed in previous articles) and you need to tune between stations to avoid false signals.

Solar radio bursts are classified as follows (from **www.radiosky.com/suncentral.html**):

Type I Short, narrow band events that usually occur in great numbers together with a broader band continuum. May last for hours or days.

Type II Slow drift from high to low frequencies. Often show fundamental and second harmonic frequency structure.

Type III Rapidly drift from high to low frequencies. May exhibit harmonics. Often accompany the flash phase of large flares.

Type IV Flare-related broad-band continua.

Type V Broad-band continua that may appear with Type III bursts. Last 1 to 2 minutes, with duration increasing as frequency decreases.

The Jove program operates two radio spectrographs. These instruments normally sweep through 200 channels between 18 and 28 MHz and produce a visual display of signal strength at different frequencies. Spectrograms are streamed to observers in real-time and are useful in seeing what frequencies are currently active (**http://radiojove.gsfc.nasa.gov/software/index.html**). Jupiter noise storms often drift up and down the spectrum, and the spectrograms help observers confirm their signals at 20.1 MHz (Figure 6).

To date over 1400 Radio Jove kits have been sold to enthusiastic observers all over the world. The kit has been successfully assembled by middle school and high school students, giving them a lesson in electronics and the opportunity to participate in scientific studies.

Radio Jove offers a great opportunity for ham radio operators to become involved, perhaps with local schools, helping them to get on the air and make observations. The radio telescope kit costs under $200 and includes the receiver kit, most of the antenna hardware, as well as *SkyPipe* and *RJP* software. To learn more about the program visit the Jove Web site at **http://radiojove.gsfc.nasa.gov**.

Jon Wallace has been a high school science teacher in Meriden, Connecticut for over 28 years. He is past president of the Connecticut Association of Physics Teachers and was an instructor in Wesleyan University's Project ASTRO program. He has managed the Naugatuck Valley Community College observatory and run many astronomy classes and training sessions throughout Connecticut. Jon has had an interest in 'non-visual' astronomy for over twenty-five years and has built or purchased various receivers as well as building over 30 demonstration devices for class use and public displays. He is currently on the Board of the Society of Amateur Radio Astronomers (SARA) and developed teaching materials for SARA and the National Radio Astronomy Observatory (NRAO) for use with their Itty-Bitty radio Telescope (IBT) educational project. Other interests include collecting meteorites, raising arthropods ("bugs") and insectivorous plants. Jon has a BS in Geology from the University of Connecticut; a Master's Degree in Environmental Education from Southern Connecticut State University and a Certificate of Advanced Study (Sixth Year) in Science from Wesleyan University. He has been a member of ARRL for many years but is not a licensed Amateur Radio operator.

Richard Flagg has an educational background in physics, astronomy, and electrical engineering. He spent many years at the University of Florida studying radio emissions from the planet Jupiter and has worked as a telemetry engineer on the Eastern Test Range, developing and testing antennas and low noise receiving systems. Richard was also the principal engineer for the State of Hawaii commercial spaceport development project. For the last decade he has been involved with the NASA radio Jove educational outreach project. As AH6NM he has participated in over 75 SAREX and ARISS telebridge contacts and enjoys satellite tracking and chasing DX – mostly on 20 meter CW.

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