Radio Astronomy Intro

Intro RT home

Why Radio?

A Brief History

Light is Light

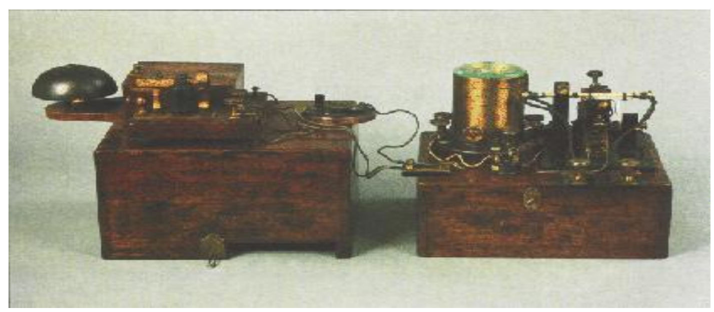
A Pixel is a Pixel

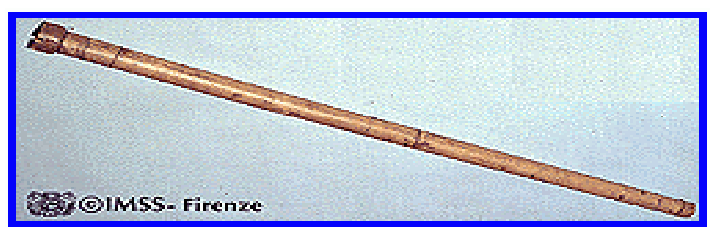
Projects

Astronomy & Radio

Today, the fields of Astronomy & Radio are tightly linked. From the time of Galileo (1609) people have peered into the heavens looking through **glass**. In 1897 Marconi sent his first ‘wireless (radio) telegram’ message.

Who would have thought that a mere 37 years later (1934) these two disciplines would stumble across each other and create the most powerful tool with which to understand our very existence and place in the expanding universe.





Galileo Galilei – Although not the discoverer of the telescope – he was the first to perfect it. Galileo discovered the four major moons of Jupiter (which has many) using a crude telescope like the one above.
Today, on a clear day, you can see the ‘Galilean’ moons with an average pair of binoculars.

ASRAS Home Page

Intro RT home

Why Radio ?

A Brief History

Light is Light

A Pixel is a Pixel

Projects

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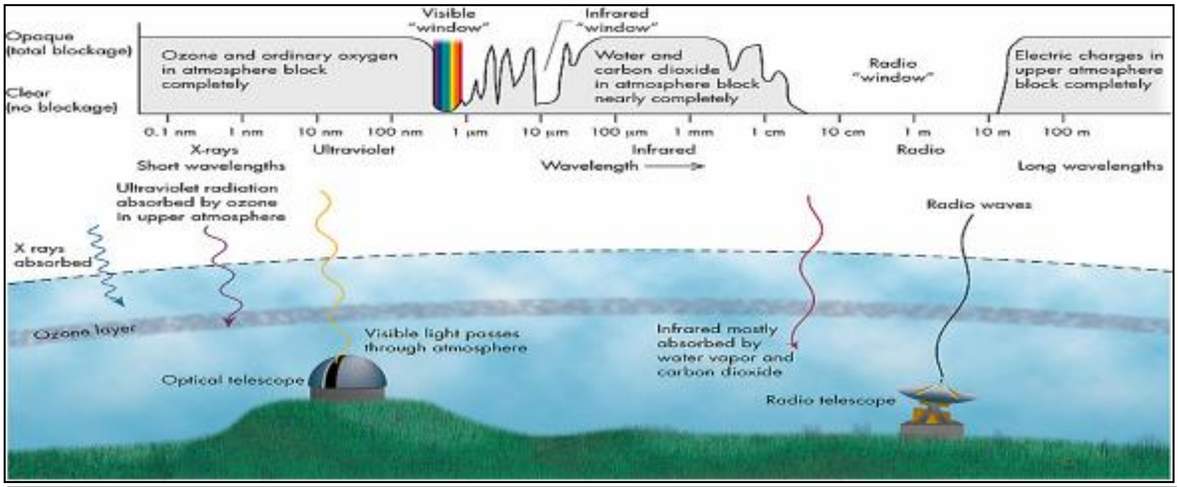


Why Radio?

- Atmospheric Absorption

Only **visible** and **radio waves** make it to the ground,
X-rays, UV, IR etc. get absorbed by our atmosphere.

With Lake Ontario just to our north, Rochester easily makes the top ten cloudiest cities in the US at # 6. But don't feel too bad, Lake Erie makes our neighbor to the west, Buffalo, comes in at # 3. ☹

You cannot use an optical telescope when it's cloudy, so…..

Switch to a longer wavelength ☺

The longer radio waves go right through clouds & moisture.

A Brief History

1928: Karl Jansky—Bell Laboratories

In 1928 Karl Jansky started working on a long wire antenna for Bell Laboratories to create a transatlantic Radio Telephone Service to Europe using the 20.5 Mhz radio band.

Results were erratic as they encountered a 'hiss' that repeated exactly every 23 hrs. & 56 min. (**NOT 24 hrs.**). Furthermore, the baseline noise level repeated & tracked each month in every year.

Unknowingly, they were receiving celestial radio emissions from planets, the Sun, stars, galaxies, etc. The reason for the 23 hr. 56 min. repeat was that's exactly how long it takes for the Earth to make one complete revolution on its axis (not 24 hrs.).

Additionally, the baseline repeat each month of the year was that their antenna was pointed to a different deep sky location (for the same reason you don't see the constellation Orion in the summer & Scorpius in the winter), and they were receiving synchrotron radiation from the cosmic ray background (CMB) .

A bright grad student and avid ham radio operator, Grote Reber wanted to join this team to continue this work. But alas, the project was canned and he was not hired.

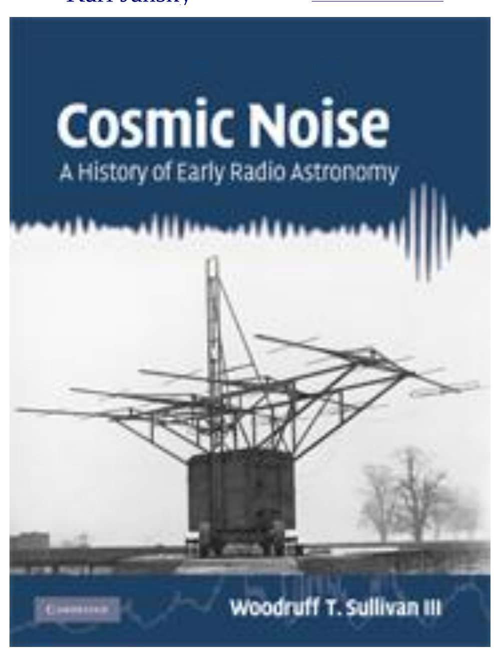
Undaunted, Grote built a dish antenna in his mother's back yard in suburban Chicago. Then he added a chart recorder to give him a hardcopy record of his experiments. He had to switch to evening work, as there was too much interference during the day from car ignitions, and industry. I'm sure he raised some suspicions from the neighbors and government, as the year was 1943! But it helped to put Ham Radio research on the map during and after WW II.

1943: Grote Reber - Chart Record & Survey

Karl Jansky

Grote Reber
1911—2002

Grote Reber



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Intro RT home

Why Radio ?

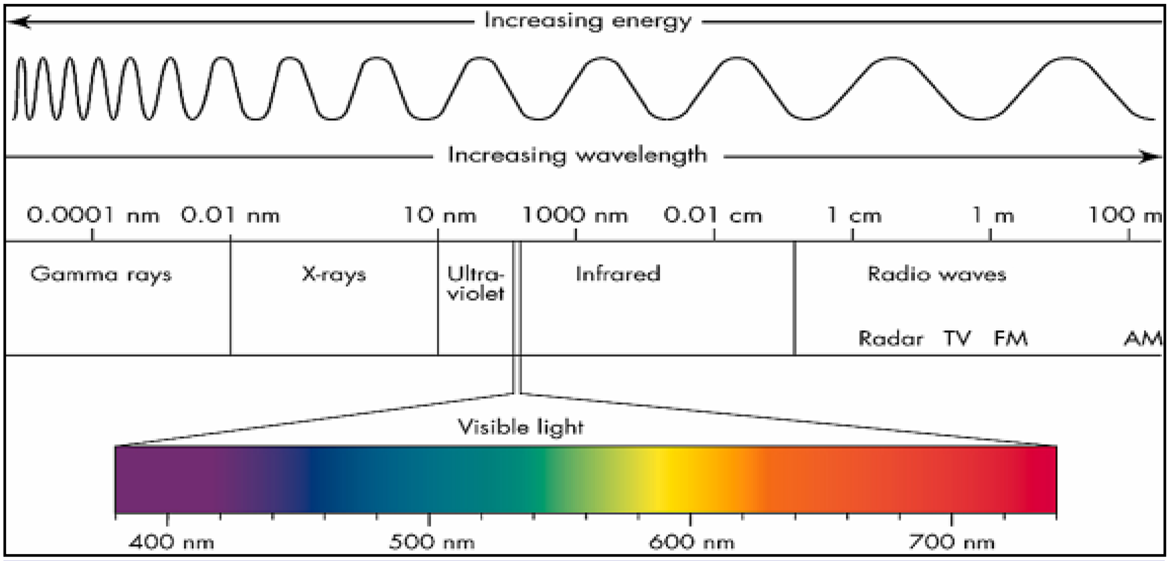
A Brief History

Light is Light

A Pixel is a Pixel

Projects

ASRAS Home Page



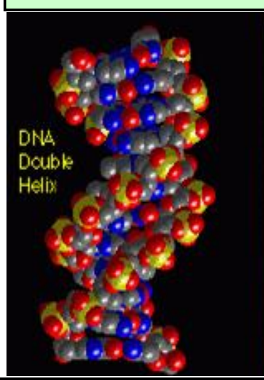
A light wave is a light wave no matter how long

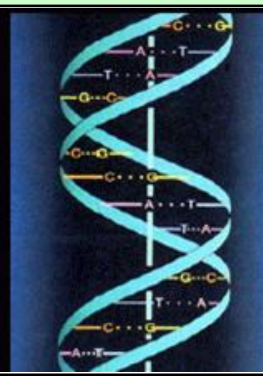
Light, X-Rays, Radio, etc. are all part of the Electro-Magnetic (EM) Spectrum of energy. Light has two major properties, particles (photons) and wavelength (like waves crashing periodically on a beach).

The radio that you listen to, the microwave that cooks your dinner, the color of a red rose, even the X-Rays used in the hospital when you break a leg are all the SAME, they only vary in wavelength. Your eyes then are really **tiny radio receivers**.

Regardless of wavelength all EM waves travel at the same speed **300 x 10^6 Meters/sec** or **186,000 miles per second**! How many seconds in a year (31,536,000) x 186,000 = 1 light year (1 Ly).

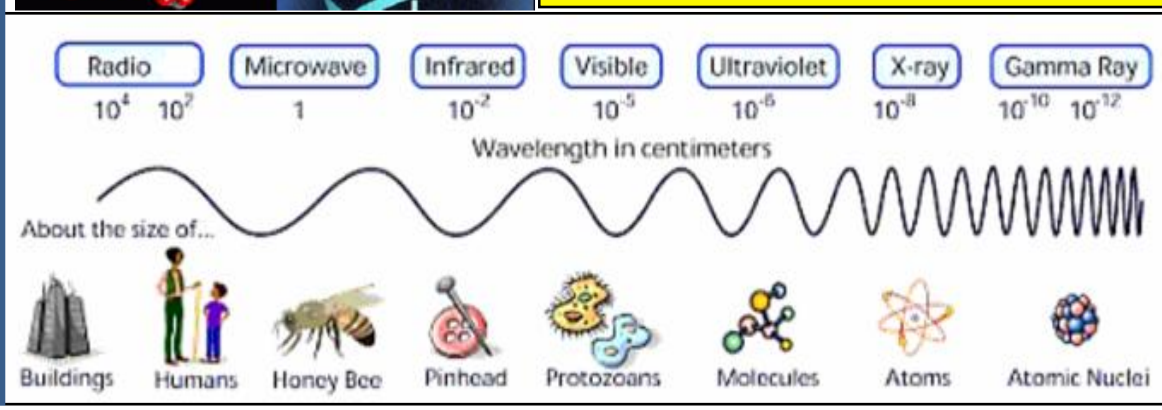
Our nearest neighbor *(left)*, the ***Andromeda Galaxy*** is a mere **2.54 million** Ly away.





Complicated molecules and compounds like proteins, sugars, phosphates, and 22 Amino Acids (all those things that go into your RNA & DNA) have been found in deep space with a Radio Telescope!

Life (as we know it) depends on water and it's all over outer space (the water molecule resonates at 22 G Hz.) **found** with a Radio Telescope! **We are made of Star stuff !!**



Radio 'Image' Data

Intro RT home
Why Radio ?
A Brief History
Light is Light
A Pixel is a Pixel
Projects

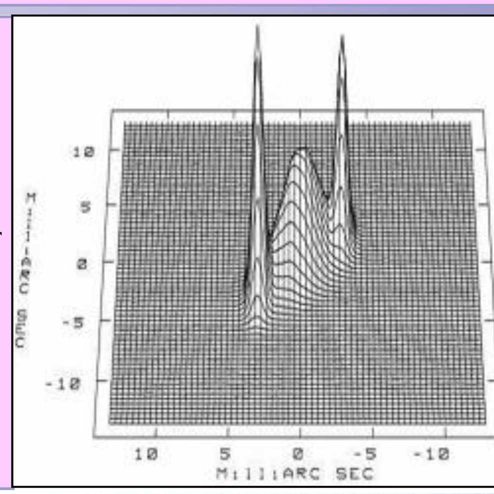
A Pixel is a Pixel

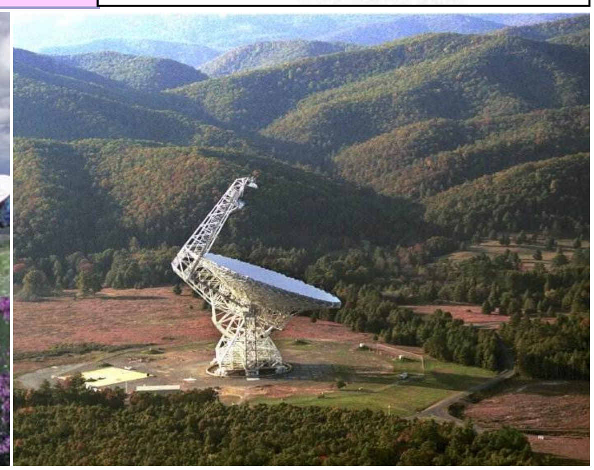
— Except, when you don't have enough of them!

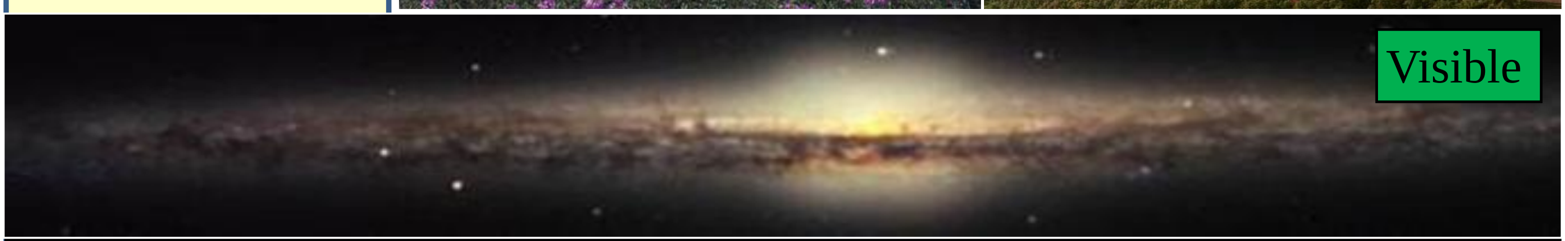
A pixel is the smallest piece of a digital photo describing the picture you're looking at. A typical digital camera has 7 to 20 Mega (million) Pixels. We've all been disappointed by a grainy photo. This is also what drives HD video television having finer detail (720, 1080, 4K, etc.).

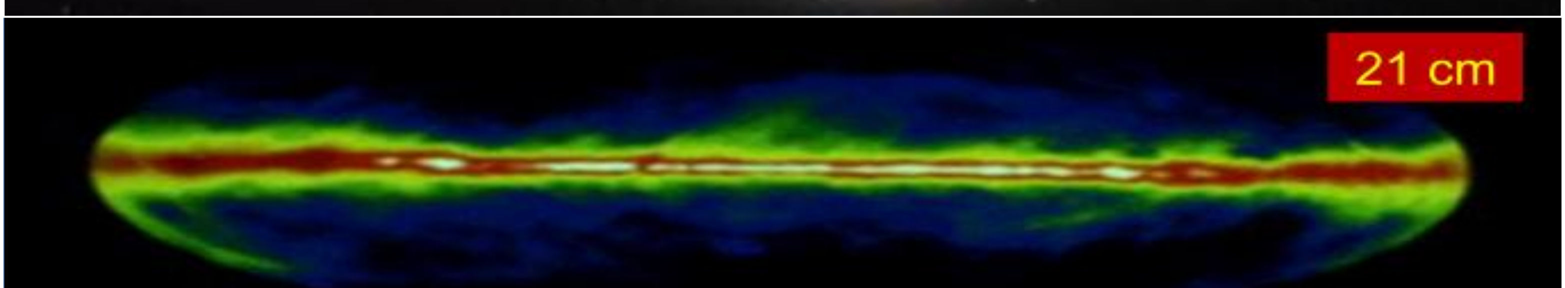
A radio astronomer takes a 'picture' of the 'radio sky' **<u>1 pixel at a time</u>**, then re-assembles them in a computer to create an 'image'. The example shown (at right) is a 'wire frame' model of two peaks with a shallower one in between.

The computer can then apply a 'false color' to the data to make it appear as a 'visual image'. The image (below) is shown in the visible spectrum (upper), then the 21 cm (1.42 G Hz.) radio spectrum of a **H**ydrogen atom (lower) emission. **H** is the most abundant element in the universe.









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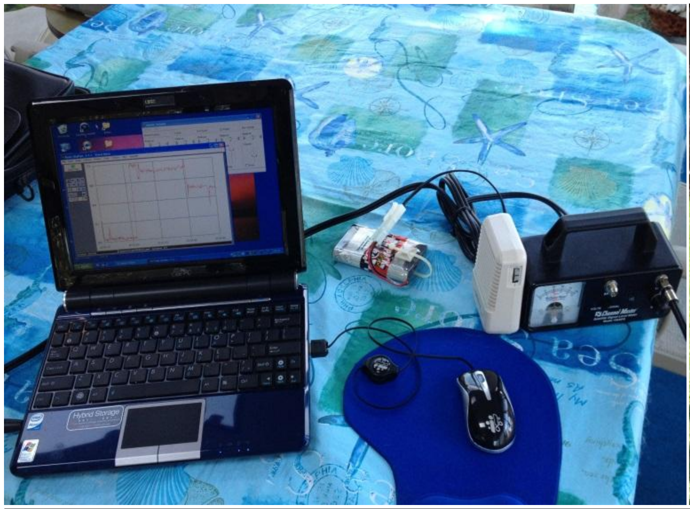
Notice the radio waves (21 cm, bottom) 'see' right through the dark 'dust' lanes that block the visible light. This is another advantage of radio, it can penetrate otherwise dirt and dust obscured celestial structures.

Intro RT home
Why Radio ?
A Brief History
Light is Light
A Pixel is a Pixel
Projects

Project List

Below is a list of some of our projects.
They are operational or in their final completion stages at our site in Ionia.
We have more coming, but unfortunately right now, they are only in our dreams. ☺

IBT – Itty Bitty Telescope




All things made up of atoms (and above absolute zero -273 °K) give off some amount of heat, and radio waves, like living things; plants, trees, people, etc.

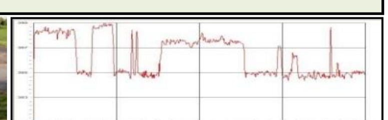
This project consists of using a surplus satellite dish to measure this energy (below). It can even find geo-synchronous satellites (lower right), like your Direct TV.

Not only can we show satellites but also record the heat & radio emissions from your body. We successfully demonstrated this project at the (national) NEAF 2014. It's a great outreach tool that can be built for scouts, science fairs, etc. by middle & high school students and teachers.

A Society of Amateur Radio Astronomy **(SARA) grant** is available for this project as the **Itty Bitty Telescope**.

We'll be hosting the Science Teachers Association of New York State (STANYS), Nov 5th for a Radio Astro Field Trip.



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ASRAS Home Page

Project List con't.

Intro RT home
Why Radio ?
A Brief History
Light is Light
A Pixel is a Pixel
Projects

Callisto Solar_RT – Solar Spectrograph

➢ **Demonstrated Autonomous Tracking of the Sun Regardless of the Weather - Clouds, Rain, Snow**

This is a Radio Telescope to study the RF emissions of Sunspots, Prominences, and CMEs on our Sun. Its purpose is to add to our knowledge of solar disturbances. It operates in the DTV band (45 – 890 M Hz.), and is a 2 meter dish, that can autonomously track the sun regardless of weather, with **NO** human intervention.

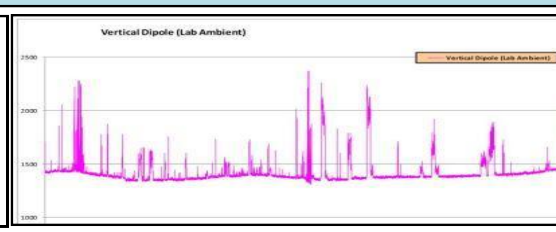
Our 'proof of concept' model has even characterized the local RF interference (below), and can mathematically remove it from the raw data.

This hardware was designed and built by a senior design team at RIT College, and demonstrated there at the **Imagine Fair** in May '15.

This coming school year (2016 – 17) our goal is to be fully operational, installed in Ionia, NY, with 'first light' in May '17. Data will be sent to central servers in Zurich, SZ, as part of the eCallisto network.

By far this is our most complicated project (yet).

P15571 SUNTRACKER



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Project List con't.

NASA - Radio Jove

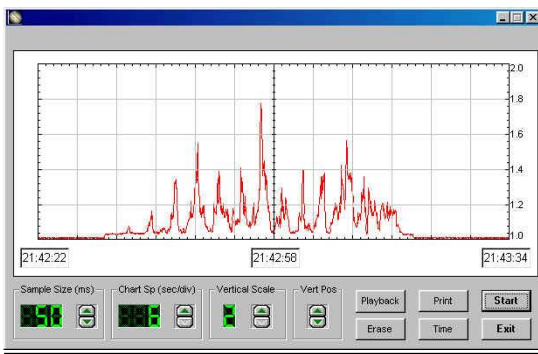
Most people think they have to have a 50 foot dish in the backyard to do any Radio Astronomy. A simple AM receiver and long wire antenna, in the 15 to 40 MHz band will do quite nicely.

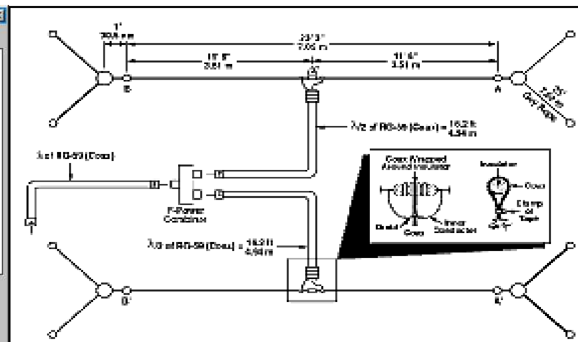
Everyone has seen colorful visual pictures from Hubble of deep space Galaxies. But many don't realize that deep sky objects have strong RF emissions, as well. Even some objects in our own Solar System give off radio waves in various frequency bands. The Sun and Jupiter are two of those objects in particular.

A stout RF emitter is the planet **Jupiter** (*see* NASA Radio Jove, *below*). The radio noise storms of interest can be heard from about 15 MHz up to a practical limit of about 38 MHz, the consensus seems to be that 18 MHz up to about 28 MHz is a good place to listen. Many 'hams' have inadvertently heard this and assumed it was just background noise & hiss (*audio file, below*).

The very conditions that cause the ionosphere to get charged and yield a good DX bounce at times, are one's that 'shield' us from hearing these signals. When the DXing - (Ham Radio Listening) is good, the Jupiter signals are rather weak, since they can't penetrate the same strong ionospheric 'shell' that's around the Earth. Conversely, when the DXing is bad the Radio Jove signals can be good, they can actually complement regular Ham Radio listening.

The RF generator of these signals is an interaction of some of Jupiter's Moons (*typically* **IO**), and the planet's strong magnetic field. These signals can be directional and don't always point at the Earth.





A simple direct conversion receiver and external antenna (*right & upper*) for the above band(s) can be used to monitor these signals (*upper left*), and the audio output can even be sent to a laptop to make a strip chart record. Here's an **audio** **S-burst** (slowed down).

For further reading check out some of the following links;

- Radio Jupiter Central - http://www.radiosky.com/rjcentral.html
- NASA Radio Jove - http://radiojove.gsfc.nasa.gov/library/newsletters/toc.htm
- SARA Radio Jupiter - http://www.radio-astronomy.org/pdf/qex/radio-jove-proof.pdf

We have TWO Radio Jove Kits from NASA and are actively looking for a Science Teacher and two Students to build these kits, get them running, and present their data; Contact M. J. Pepe !!

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Placeholder – Future Projects

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