Building a radio telescope with which to observe radio emissions from Jupiter in the form of S- and L-bursts

Lucy Todd, University of York, England UK Mentor: Fran Bagenal, LASP, Boulder CO

1. History

The 'Mills Cross Array' used by Burke and Franklin to detect radio emissions from Jupiter [1].

- Radio emissions from Jupiter were discovered in 1955 by Bernard Burke and Kenneth Franklin in Washington D.C. [1]
- Patterns in the emission were observed by James Warwick and George Dulk in 1960s Boulder, Colorado. These patterns were later confirmed by NASA's Voyager missions [2].
- Jupiter's magnetosphere it creates "radio lasers" of high speed magnetised plasma that produce the bursts of radio emissions that Burke and Franklin observed.
- Bursts correspond with Jupiter's rotation & come in either long bursts (L) or short bursts (S).

2. Background

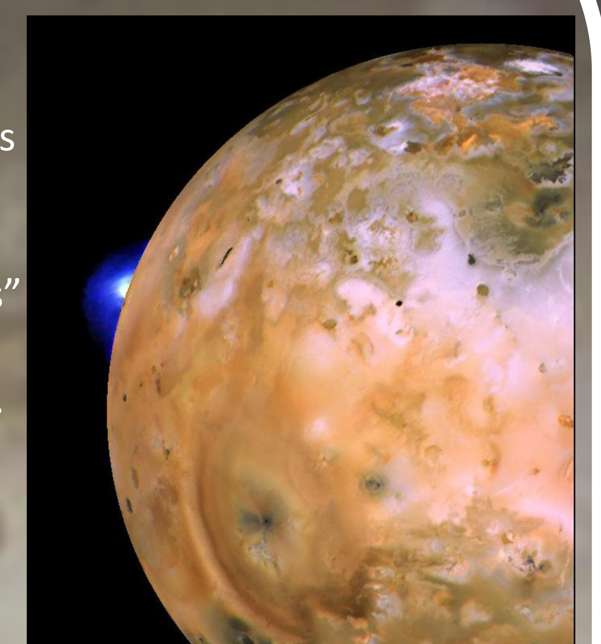
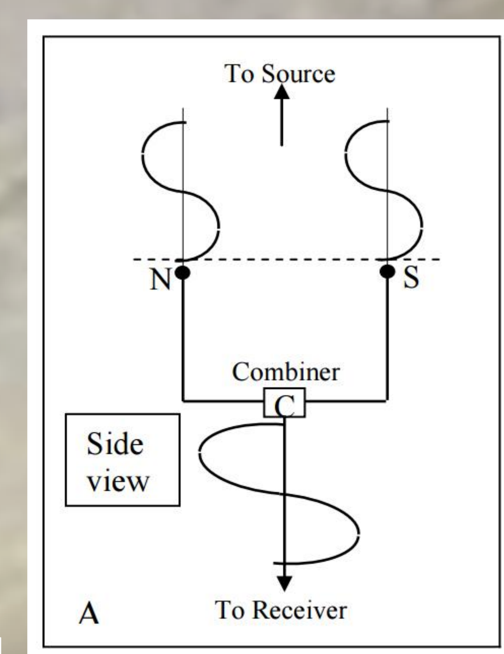


Image of Io from Voyager showing active plume of volcano Loki [3].

- Jupiter's orientation and thermal emissions influences character of its radio emissions, but Jupiter's moon Io is most important.
- Io's volcanoes create the "Io torus" (electrically conducting ring of electrons, sulphur & oxygen ions).
- Movement of Io through the Io torus creates a high electrical current between Io and Jupiter.
- Disturbance of Jupiter's magnetic field triggers emission of Deca- -meter radio waves.
- Decametric waves can be detected in L- or S-bursts via a simple radio telescope with two dipoles in a dual array.
- Each burst type has a distinct sound (L-bursts like breaking ocean waves, S-bursts like popping corn).
- Emission patterns observed from a Jupiter radio storm can be compared with predictions based on Io's phase.
- Can also be analysed against data from other radio telescopes across the globe or even spacecraft such as the Juno.



Simple Dual Dipole [4].

3. Receiver Construction

The receiver was built using a kit provided by NASA's Radio JOVE Project (more details can be found at website: http://radiojove.gsfc.nasa.gov/).

- Receiver was soldered in 9.5 hours and works by radio signal passing from antenna to a bandpass filter to reject strong interference.
- Signal then amplified by Junction Field Effect transistor (provides additional filtering and amplification by a factor of 10.
- A local oscillator & mixer convert the desired radio frequency to a range of audio frequencies.
- Local Oscillator generates a sinusoidal voltage wave form at frequency 20.1 MHz. This signal and the amplified signal from antenna feed into the mixer to create new signal.

- A low pass filter is then used to eliminate interfering radio stations at nearby frequencies (creates narrow window that Jupiter signals can enter) getting rid of any unwanted signals outside the desired range.
- This creates channels that are "clear" for the receiver to be tuned to. Audio amplifiers are used to amplify the final signal enough for it to driver either headphones or speakers.

4. Antenna Construction

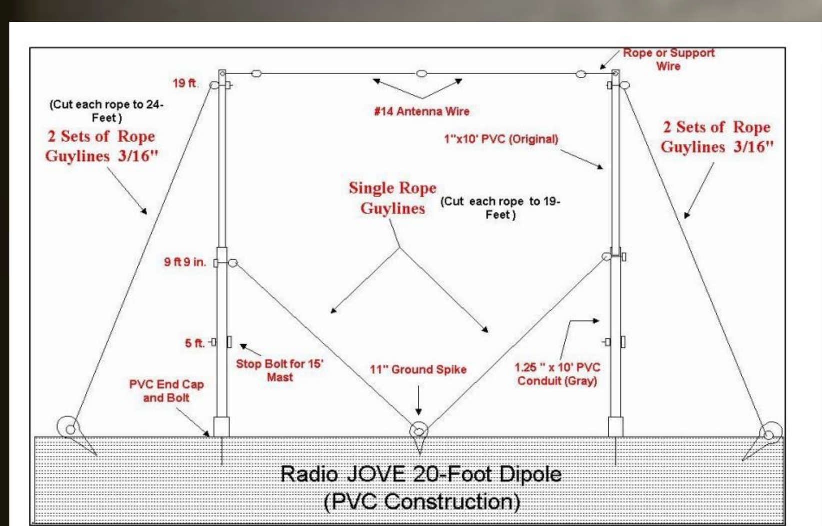


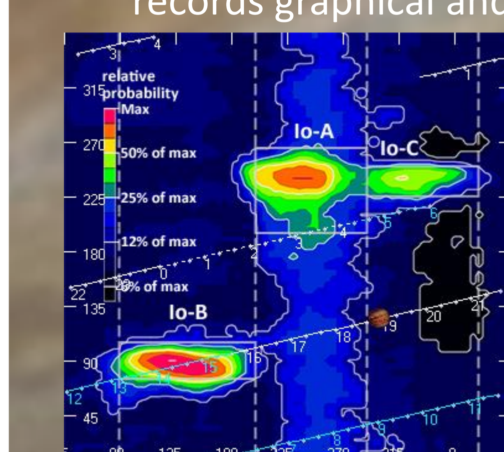
Diagram of dipole arrangement take from Radio JOVE manual.

- Antenna was constructed from 20ft high PVC masts on a ground area of 30ft N-S and 45ft E-W and situated away from power lines to avoid electrical interference.
- PVC was chosen to avoid conduction & each dipole consisted of two 12ft copper wires, 3 inductors, one 32.31ft coaxial cable and 2 lengths of 2ft nylon rope.
- Length (λ_{cable}) of the coaxial was important - relates to operating centre frequency (20.1MHz) of receiver. Derived from: $\lambda_{cable} = V_f \times \lambda_{free\ space}$

  where V_f is the velocity factor (0.66) of the coaxial cable and $\lambda_{free\ space}$ is 14.925m (speed of light 'c' over centre frequency).

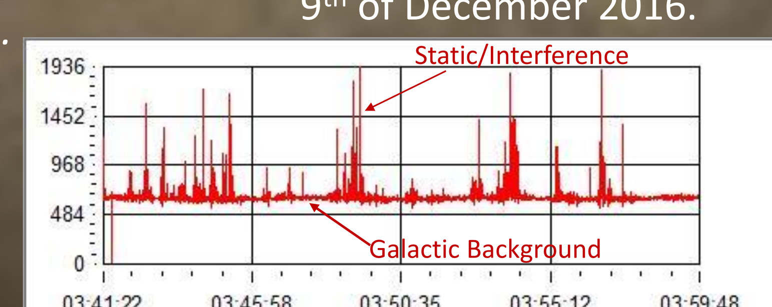
5. Making Observations

- Radio-Jupiter Pro 3 software uses observer latitude to predict Jupiter's radio noise storms & Radio-SkyPipe II software, records graphical and audio data.



An example of a CML Io Phase Chart from Radio-Jupiter Pro 3.

- As the Sun ionises the upper layers of Earth's atmosphere (leading to attenuation and reflection of signals from Jupiter) observations were done after sundown.
- However, as the last Jupiter Observing Season ended on June 3rd emissions can't be observed until the 9th of December 2016.



A Radio JOVE output chart obtained during observations on 07/18/16

6. Future Work

During Juno's planned 2 year mission, 37 close approaches will occur. It is likely that the next Jupiter Observing Seasons will overlap with these approaches. Therefore, it will be of interest to gather data from Radio JOVE at the same time as Juno and compare observations to see if the emission patterns are consistent with what Juno sees.

7. Acknowledgements

This project was funded by the Juno mission grant. Help with the construction of the telescope was provided by the researchers, graduates, undergraduates and associates of the LASP Magnetospheres of the Outer Planets Group listed below: Evan Sidrow, Kaleb Bodisch, Logan Dougherty, Eddie Nerney, Frederick Thaye, Drake and Emily Ranquist, David Malaspina and Vaughn Hoxie.

The Radio Jove kit was sold and distributed by the Radio JOVE Project Inc.

More details on the construction process can be found at: http://lasp.colorado.edu/home/mop/missions/juno/radio-jove-at-lasp/radio-jove-blog/

8. References

[1] http://radiojove.gsfc.nasa.gov/library/sci_briefs/discovery.html

[2] 'Listening to Jupiter' by Dick Flagg

[3] Image provided by NASA: http://www.jpl.nasa.gov/spaceimages/

[4] Image provided by Radio JOVE Manual

Background image: Taken by "Astronomy Photographer of the Year competition 2011" Damian Peach.