

Observing Jovian Decametric Radio Emissions with a Software Defined Radio Telescope

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Table of Contents

Thesis Proposal.....	1
<i>D. Kirwan</i>	
Introduction.....	3
Scope	4
Research Questions	5
Potential Pitfalls	5
Methodology	6
Preliminary Literature Review.....	7
Contribution to Research Knowledge Anticipated	8
Description of the Experimental Design / Validation Methodology	9
Special Resources Required.....	10
Main Milestones Anticipated	11

Introduction

It was discovered in 1954 by Burke and Franklin [1955] that the planet Jupiter emits radio transmissions in the decameter range *10-100MHz*, and that the inner Jovian satellite Io appeared to have an effect on these emissions occurring [Belcher, 1987].

The Jovian satellite Io has a thin atmosphere made up of a number of neutral sodium, potassium, sulfur, and oxygen gasses which have been emitted through volcanic activity on the surface of the moon.

Talk about the Io Flux Tube, which is a "bundle Jovian of magnetic field lines" [Belcher, 1987]. Link Belchers diagram fig 1 in [Belcher, 1987]. A large portion of the decametric emissions come from the area where the IFT (get a glossary page going haha), meets the Jovian ionosphere.

Io itself orbits within a gas torus of ionized sulphur around Jupiter. Talk about where this gas torus comes from.. The local corotation speed of the flux torus is faster than the Keplerian orbit of the moon, and the plasma overtakes Io in its orbit at $57km\ s^{-1}$

As Io orbits within this flux torus it acts as a conductor, and Alfvén waves are regularly produced and carry the charge along the magnetic field lines between Jupiter and Io ?. These Alfvén waves reflect off Jupiters ionosphere at both north and south poles while following Io through its orbit, thereby acting as a standing wave. It appears the source of the DAM emissions are largely due to these reflections of these Alfvén waves.

Talk about the types of DAM emissions I'm interested in observing.

- S-Bursts, short millisecond wideband bursts
- L-Bursts, long second wideband bursts
- N-Bursts, narrowband bursts

[Queinnec and Zarka, 1998]

Scope

Students should identify whether the research outcomes are likely to have universal application or have a defined scope. This is important in gauging the extent to which the work is capable of independent replication.

Due to the latitude of Ireland being 53.3 degrees N, the telescope configuration will apply only to locations at this or a similar latitude, but will be universally applicable at this latitude without modification, and with relatively minor modifications can ensure the end solution can be used at all locations. Kivelson et al. [1996]

SDR Radio Telescope study Jupiter / Sun in the Decametric Band

- Study Jupiter in the decametric band 3MHz - 40MHz
- Jupiter emits strongly near 20Mhz
- Earths atmosphere is transparent at these frequencies during the night time
- Study Solar emissions during the day
- Solar emissions are strong enough to penetrate Earths atmosphere during the day
- Low cost to deploy
- Can be run by an Amateur observer
- Mechanism for sending data from listening site back to a network connection (Ardtweeno)
- Backhaul system for capturing, processing and storage of listening site data
- API for accessing data, and or integrating into another system
- Amateur listening sites can compliment larger telescope arrays around the world

Research Questions

A clear, precise definition of the problem is very important to focus on the research activity. great care should be used in devising the research questions. They define the structure of the investigation/innovation that will be used and an essential metric of the quality of the dissertation is the degree to which the research question has/have been answered.

- can I use this antenna to pick up signals from planetary bodies
- Signal Processing issues
- Can I address these natural signal noises
- Can I address these human signal noises

Potential Pitfalls

Predecisions on how I want to collect data, creating the research questions itself I might need to carefully look at this, because I've made some initial ideas on how I want to collect this data.

Its going to be lower cost than other methods, or its using something new compared to other devices

- Do amateur radio emissions adversely affect radio astronomy in the 15m band?
- What can be done using software defined radio to filter local radio interference from radio astronomy observations?
- How cheaply can a fully automated radio telescope listening station be built using current IOT technologies?

Methodology

This should outline the approach and methodology being proposed by the student to address the research question.

Preliminary Literature Review

This should contain a review of a number of books, journal articles and web references of relevance to the research area proposed. The literature should contain seminal and recent referenced research material that is categorised under a number of relevant sub-themes.

I've read about 15 papers already related to the background of the interactions between Jupiter and Io, and papers detailing results from similar telescopes to the design I intend to build. I've hit a paywall on some of the earliest seminal papers which were the first to detail the phenomenon of decametric emissions being emitted by the Jupiter-Io system. I will attempt to get a copy through the inter library loan system at WIT.

My literature review can be broken down into the following areas:

- What are the decametric radio emissions and what are they caused by
- Research journals detailing potential radio telescope designs which could be replicated in order to collect DAM emissions
- I need to look into journals involving signal processing and maybe some rudimentary filtering or AI for identifying spurious signals
- Something else

Contribution to Research Knowledge Anticipated

A dissertation is a work of scholarly investigation that is grounded in the research literature and differs from a report or a book. It is judged on a prescribed set of academic criteria. Although the likely outcomes are tentative at the start of the program, it is useful to incorporate them into the research proposal to help focus the work program.

Description of the Experimental Design / Validation Methodology

A dissertation must employ rigorous scientific argument. The experimental design and the validation methodology must be specified in great detail in the proposal. At this proposal stage you should define clear evaluation criteria.

- Identify data caused by lightning
- Identify data caused by human emissions
- Perform a site survey with the spectrum analyser
- Replicate the testbed at a second site

Special Resources Required

The research work may require access to specialised equipment, software, journals and so on.

Access to the HackRF or another similar SDR is required. Access to the RadioJove Prediction software

Main Milestones Anticipated

Students should agree a number of milestones and their likely delivery dates with their supervisor at the start of the progress.

- Design the testbed
- Build the telescope
- Perform a site survey with the spectrum analyser
- Replicate the testbed at a second site

Bibliography

- John W. Belcher. The jupiter-io connection: An alfvén engine in space. *Science*, 238(Oct 9):170–176, 1987.
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- M. G. Kivelson, K. K. Khurana, R. J. Walker, C. T. Russell, J. A. Linker, D. J. Southwood, and C. Polanskey. A magnetic signature at io: Initial report from the galileo magnetometer. *Science*, 273, July 1996.
- J. Queinnec and P. Zarka. Io-controlled decameter arcs and io-jupiter interaction. *Journal of Geophysical Research*, 103(A11):26649–26666, November 1998.

Appendix

Here is some content in the appendix

How I became inspired

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