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Virtual Observatory tools and Amateur Radio Observations Supporting Scientific Analysis of Jupiter Radio Emissions

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Abstract

In the frame of the preparation of the NASA/JUNO and ESA/JUICE (Jupiter Icy Moon Explorer) missions, and the development of a planetary sciences virtual observatory (VO), we are proposing a new set of tools directed to data providers as well as users, in order to ease data sharing and discovery. We will focus on ground based planetary radio observations (thus mainly Jupiter radio emissions), trying for instance to enhance the temporal coverage of jovian decametric emission. The data service we will be using is EPN-TAP, a planetary science data access protocol developed by Europlanet-VESPA (Virtual European Solar and Planetary Access). This protocol is derived from IVOA (International Virtual Observatory Alliance) standards. The Jupiter Routine Observations from the Nancay Decameter Array are already shared on the planetary science VO using this protocol. Amateur radio data from the RadioJOVE project is also available. We will first introduce the VO tools and concepts of interest for the planetary radioastronomy community. We will then present the various data formats now used for such data services, as well as their associated metadata. We will finally show various prototypical tools that make use of this shared datasets. A preliminary study based on January-February 2014 data will also be presented.

1. Introduction

Radio-JOVE is an educational and public outreach project developed in the USA that introduces low frequency radioastronomy concepts to students and teachers, but also the amateur radio community as well as the general public. The participants are building their own radio telescope, using a kit sold by the Radio JOVE team. This instrument can observe the sky at frequencies around 20 and 30 MHz. The users can share their observations on an archive web site, and on a mailing list.

Radio-JOVE web site:
http://radiojove.gsfc.nasa.gov

Radio-JOVE data Archive:
http://radiojove.org/cgi-bin/calendar/calendar.cgi

We are proposing to set up a prototype interoperable service dedicated to the distribution of Radio-JOVE data in the Virtual Observatory (VO). This service shall:

- store the data sent by the users in a standard format,
- allow a data selection by the science team before putting the data online,
- share the data using VO standards, specifically EPN-TAP, but also those linked to the SPASE (Space Physics standards), or the HELIO project, for solar radio observations.

During this project, we test how amateur data can be shared to the scientific community, using the VO. We also want to consolidate the use of the EPN-TAP protocol, testing it with a new type a dataset, and a new type of data provider (distributed amateur community).

2. Scientific interest

In the Radio-JOVE frequency band, there are 2 main radio sources, wich canbe observed: the Sun and Jupiter. Other radio sources also contribute: the Galactic Background radiation, the radio counterpart of terrestrial lightnings, and local radio interferences. There are 2 large instruments in the world that routinely observe Jupiter in this frequency range: the Nançay Decameter Array in France, and the Iitate radio observatory in Japan. Other instruments can also observe Jupiter during dedicated observation campaigns, such as the UTR2 array at Kharkov in Ukraine, the LOFAR telescope in Europe, or the new LWA telescope in New Mexico, USA. These instruments do not provide a full time survey of Jovian radio emissions. Extending the temporal coverage is scientifically interesting, in particular, for the upcoming space missions that are going to explore the Jovian system (JUNO and JUICE), in which the LESIA at Observatoire de Paris in involved.

The Jovian radio emissions are appearing as "arc-shaped" structures in the time-frequency plane. This shape indicates how the observer is "beamed" by the radio source, which has a very anisotropic beaming pattern and is rotating around Jupiter, following its off-axis magnetic field. The study of these radio arcs is a powerful tool that can remotely probe the plasma is the radio emission regions. Their observed temporal variability is correlated to their intrinsic temporal variability, and the spatial variability of the emission medium. The short term variability requires a series of a radio observatories spread other the Earth, with simultaneous observations. The Radio-JOVE observer's network is the perfect candidate for such studies. The same kind of study could be done with solar radio emissions.

3. RadioJOVE Data Distribution

The Radio-JOVE kit is sold with the "Radio Sky Pipe" software, which drives the Radio-JOVE instrument and proposes to: save data into files or stream data to connected users. A limited series of metadata is attached to each observer. The Radio-JOVE data are distributed both ways: either using emails on the RadioJOVE-data mailing list, or on the Radio-JOVE online archive. The data format is most usually a screenshot (PNG or GIF files), as well as WAV files. A few events are shared using the native Radio Sky Pipe format.

At the occasion of the annual meeting of SARA (Society of Amateur Radio Astronomer), on July 2014, in Green Bank, USA, we have contacted the Radio-JOVE team and the Radio Sky Pipe developer. It has been decided to study the possibility of using CDF (Common Data Format) files for data distribution. The choice of the CDF as an standard format is rather natural:

- It is developed and maintained by NASA for Space Physics dataset.
- It is used as an archive format for Space Physics data at NASA (including space borne radio observation).
- It is now accepted as an archive format by NASA for planetary data.
- It has a recommended configuration and metadata description (ISTP standard and PDS guidelines).
- It has been recently added as an input format in TOPCAT.

The Radio Sky Pipe will study how to implement CDF output in his software, using the software library distributed by NASA/GSFC. We have studied the CDF file formatting, for the various Radio-JOVE data products.

5. Conclusion

The CDF format as a data distribution format for Radio-JOVE data is well adapted, if we except the compression aspects. The foundation of the data and metadata structures has now been drafted. The next step is to implement the CDF generation support into the Radio Sky Pipe software. The server part of the study is not finished yet, and we will go on working on this direction to propose a prototype as soon as possible. The current plans for the longer term are to deliver the server to the Radio-JOVE team in the US, once it is working and they have found a sustainable hosting solution for the server. They are also looking for a data storage solution for the data files. With the NASA/PDS compliance, a possibility could be to submit the data files to that archive facility.

Finally, the collaboration with the Radio-JOVE team has been very fruitful, and we are very happy to continue this project that links a very involved amateur community with a scientific community. We hope that this collaboration will enable new studies on solar and planetary radio emissions.

Acknowledgements

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Online Resources

CDF at NASA/GSFC: http://cdf.gsfc.nasa.gov
CDF archiving for PDS:
http://ppi.pds.nasa.gov/doc/cdf/PDS4-Archiving-of-CDF-Files-v3.pdf
CDF ISTP guidelines:
http://spdf.gsfc.nasa.gov/istp_guide/istp_guide.html

Radio-JOVE web site: http://radiojove.gsfc.nasa.gov
Radio-JOVE Archive site: http://radiojove.org/archive.html
Radio Sky Pipe software:
http://www.radiosky.com/skypipeishere.html

VOParis Europlanet web resources:
http://voparis-europlanetobspm.fr
TOPCAT: http://www.star.bris.ac.uk/~mbt/topcat/
AutoPlot: http://autoplot.org
UCD standard:
http://www.ivoa.net/documents/latest/UCD.html

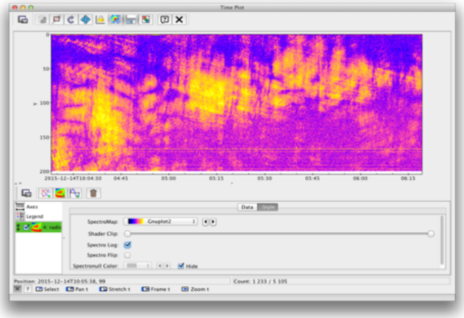

Figure 1: Radio-JOVE SP1 data from D. Typinski displayed in TOPCAT after conversion in CDF.

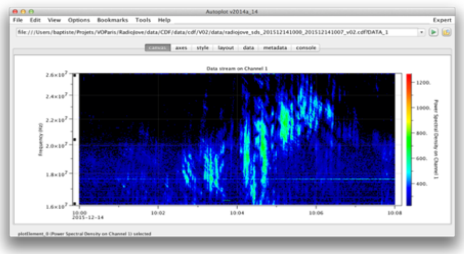

Figure 2: Radio-JOVE SP1 data from D. Typinski displayed in Autoplot after conversion in CDF.