EPSC Abstracts
Vol. 11, EPSC2017-63, 2017
European Planetary Science Congress 2017

Juno-Ground-Radio Observation Support Tools

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Abstract

In the frame of the NASA/Juno mission, an international support activity with observations in the low frequency radio range has been set up. We are proposing a new set of tools directed to data providers as well as users, in order to ease data sharing and discovery. 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. Data from all major decametric radio instruments will contribute: Nançay Decameter Array (France), LOFAR (France, Sweden, Poland), URAN (Ukraine), LWA (USA), Iitate Radio Observatory (Japan), etc. 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 tools that make use of this shared datasets. This activity also supports the development of the ESA/JUICE (Jupiter Icy Moon Explorer) mission, and that of the planetary sciences virtual observatory.

1. Introduction

The Jovian radio emissions have been discovered in 1955 by Burke and Franklin (1). They are observed from ground in the decameter wavelength range (10 MHz to 40 MHz). They have been studied and monitored since the Voyager fly-bys in the 70's. Several ground observatories have dedicated operations for Jovian radio emission monitoring, e.g., the Nançay Decameter Array (NDA), at Station de Radioastronomie de Nançay (SRN), in France; the Iitate Radio Observation, in Japan; or the Ukrainian T-shaped Radiotelescope mark 2 (UTR-2), at Kharkiv in Ukraine. These intense radio emissions are also observed from space with, e.g., the Cassini/RPWS (2), Wind/Waves (3) and STEREO/Waves (4) instruments. Ground-based and space-borne observations are complementary. Ground-based observatories are more sensitive due to their larger antenna and are not limited in data volume by the space telemetry downlink rate. On the other hand, space-borne instruments can observe at all times. The exploration of the Jovian radio emissions from space was mainly conducted during the Voyager 1, Voyager 2, Ulysses and Cassini flybys around Jupiter (see, e.g., (5)), as well as during the Galileo mission. It is noticeable that the Ulysses/URAP (6) instrument was the first to observe the Jovian radio emissions out from the ecliptic plane (7).

The Jovian radio emissions result from the auroral precipitation of relativistic electrons in the Jovian auroral regions (8). The two main drivers for the Jovian radio emissions are the interaction with the Galilean moons (mainly Io (9; 10), but also Europa and Ganymede (11; 12)) and with the Solar Wind (13; 14; 15). The radio sources are located above the Jovian auroral regions, on magnetic field lines connected to the Jovian aurora or magnetic footprints of Galilean moons (8). The radio emission mechanism is the Cyclotron Maser Instability (16; 17; 18), which is predicting an anisotropic beaming pattern of the radio emission with the shape of a hollow cone. This radio source visibility can be modeled (10; 19). The radio emission shape in the time-frequency domain is interpreted in terms of radio source physical parameters (20; 21).

The Juno mission is a NASA flagship mission dedicated to the study of Jupiter. Several instruments are dedicated to the study of the Jovian internal magnetic field and its inner magnetosphere (22). The spacecraft started its prime mission phase in July 2016 after a successful insertion in Jupiter's gravitational system. The polar orbit of the spacecraft is very well adapted to study the Jovian auroral regions. The Juno/Waves instrument will observe the Jovian electromagnetic emissions from 24 Hz to 41 MHz. Juno will provide an entirely new view on the Jovian radio emission: the polar orbit provides systematic observations out of the ecliptic plane; and the low altitude perijove allows radio sources region in-situ exploration. However, since most of the Jovian radio emissions studies were conducted with observers in the ecliptic plane, an observation support within the ecliptic plane will allow to link Juno's observations to previous studies. This is the goal of the Juno-Ground-Radio observation support group.

In order to ease the discovery and sharing of low frequency radio astronomy data products from various sources, we propose to use new tools developed in the planetary science virtual observatory (VO). These tools are directed towards both data providers and scientists. The data providers are using EPN-TAP (23), a planetary science data access protocol developed by Europlanet-H2020-RI/VESPA (Virtual European Solar and Planetary Access) for data sharing (24). This protocol is derived from IVOA (International Virtual Observatory Alliance) standards. All services are using the same interface, so that users can query all services the same way (e.g., using the VESPA main query portal (25)).

2. Participating Observatories

The main low frequency radio observatories in the world are participating to the Juno-Ground-Radio observation support team:

- Nançay Decameter Array (NDA), at Station de Radioastronomie de Nançay (SRN), Nançay, France;
- Ukrainian T-shaped Radiotelescope mark 2 (UTR2), Kharkhiv, Ukraine;
- Iitate Log-periodic Radio Antenna, Iitate, Fukushima Pref., Japan;
- Long Wavelength Array 1 (LWA1), New Mexico, USA.

Teams from the Low Frequency Array (LOFAR) are also setting up plans for participation (with French, Polish and Swedish stations). The RadioJOVE citizen science project (26) is providing data from its "Spectrograph User Group" (SUG), which is composed of several semi-professional observers providing the community with high quality amateur data.

3. Juno-Ground-Radio Team

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Acknowledgements

The *Europlanet H2020 Research Infrastructure* project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208. The *Europlanet Research Infrastructure* was supported by the European Commission's 7th Framework Program, grant agreement No 228319, as part of the Capacities Specific Programme/Research Infrastructures.

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