MASER (Measuring Analyzing & Simulating Emissions in Radio frequencies), a Toolbox for Low Frequency Radio Astronomy

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Abstract

The MASER (Measuring, Analysing and Simulating Radio Emissions) project provides a comprehensive infrastructure dedicated to low frequency radio emissions (typically < 50 to 100 MHz). The four main radio sources observed in this frequency are the Earth, the Sun, Jupiter and Saturn. They are observed either from ground (down to 10 MHz) or from space (down to a few kHz). Ground observatories are more sensitive than space observatories and capture high resolution data streams (up to a few TB per day for modern instruments). Conversely, space-borne instruments can observe below the ionospheric cut-off (10 MHz) and can be placed closer to the studied object. Several tools have been developed in the last decade for sharing space physics data. Data visualization tools developed by the CDPP (http://cdpp.eu, Centre de Données de la Physique des Plasmas, in Toulouse, France) and the University of Iowa (Autoplot, http://autoplot.org) are available to display and analyse space physics time series and spectrograms. A planetary radio emission simulation software is developed in LESIA (ExPRES: Exoplanetary and Planetary Radio Emission Simulator). The VESPA (Virtual European Solar and Planetary Access) provides a search interface that allows to discover data of interest for scientific users, and is based on IVOA standards (astronomical International Virtual Observatory Alliance). The University of Iowa also develops Das2server that allows to distribute data with adjustable temporal resolution. MASER is making use of all these tools and standards to distribute datasets from space and ground radio instruments available from the Observatoire de Paris, the Station de Radioastronomie de Nançay and the CDPP deep archive. These datasets include Cassini/RPWS, STEREO/Waves, WIND/Waves, Ulysses/URAP, ISEE3/SBH, Voyager/PRA, Nançay Decameter Array (Routine, NewRoutine, JunoN), RadioJove archive, swedish Viking mission, Interball/POLRAD... MASER
also includes a Python software library for reading raw data. This work is supported by CDPP, CNES, PADC and Europlanet-2020-RI. The Europlanet 2020 Research Infrastructure project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 654208.
What Data?

- Low Frequency radio data: up to ~100 MHz
- Mostly spectrograms (time-frequency)
- Ground observatories and Space platforms
- Catalogues of events
- Raw and derived data
- Standard formats (CDF) and metadata
- Virtual Observatory (Interoperable) interfaces using VOSI protocols, through VESPA (Virtual European Solar and Planetary Access)
- Network of databases with same data discovery interface, that can be queried simultaneously
- Databases from all fields in Solar System (Sun, Space Physics, Planetary... ) are connected.

Main Tools and Software

- Maser-py (Python 3.5+) software library
  - https://github.com/maserlib/maser-py (open source)
- ARTEMIS-P (ray tracing code for planetary radio emissions) [available soon]
- Das2 servers (Currently under test): Meudon and Nançay

* Project interfaces: Juno-Ground Radio, RadioJOVE

Open Source Library

- Maser-py library
  - Data reader classes for LF radio data collections, Unit tests built-in
  - https://github.com/maserlib/maser-py
- Das2 Tools and software for LF radio astronomy
- Ground segment software for Solar-Orbit/RFW, CDF file building helper tools

2019 Deployment Plan

- Maserpy library
  - CDF building tools
- Codes
  - https://github.com/maserlib/maser-py

‘Member of the Hello-Python working group

Interoperability: - ODINA: http://odina.data.org
- IPDA: http://data.ipp.dwd.de
- VOSI: http://vosi.org

Link with SPASE under study

- NumericalData and Data Discovery: GIS, SPASE, Data, Data
- Datasets (das2 + VESPA + HAPI)

- ExoPla, Cluster, ISEE3…
- RadioJOVE: NDA-Routine, NDA-NewRoutine, NenuFAR…