Research Plan and Development Schedule

B. Cecconi, L. Lamy, C. Louis, P. Zarka
LESIA, Observatoire de Paris, Meudon, France

Research Topics

- Jupiter
  - Io-Jupiter interaction
  - other Galilean moon effect
  - SW impact
  - Modeling of Jupiter DAM emission visibility

- Saturn
  - SKR polarization and beaming pattern
  - SKR periodicities

- Exoplanets

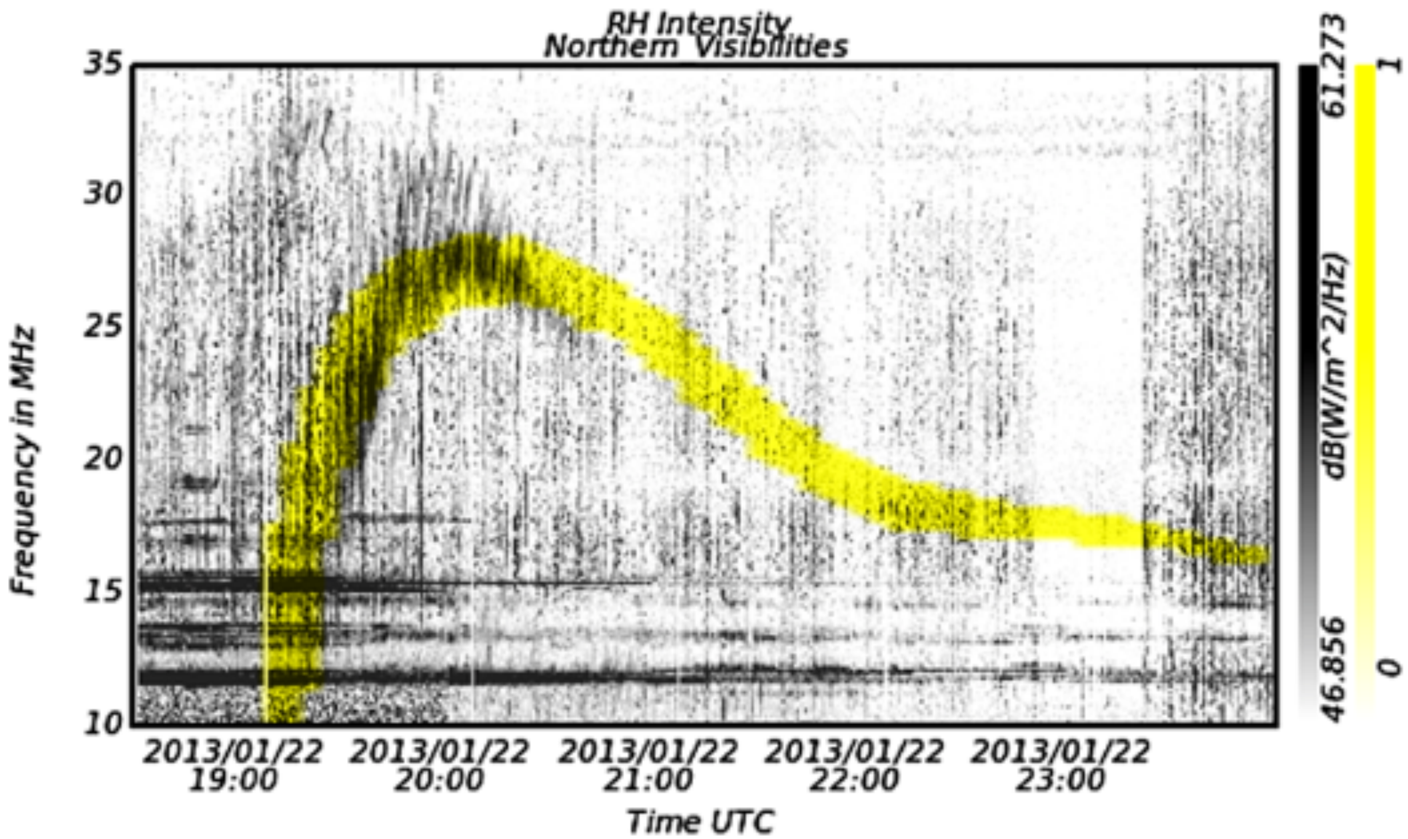
Tools and Databases

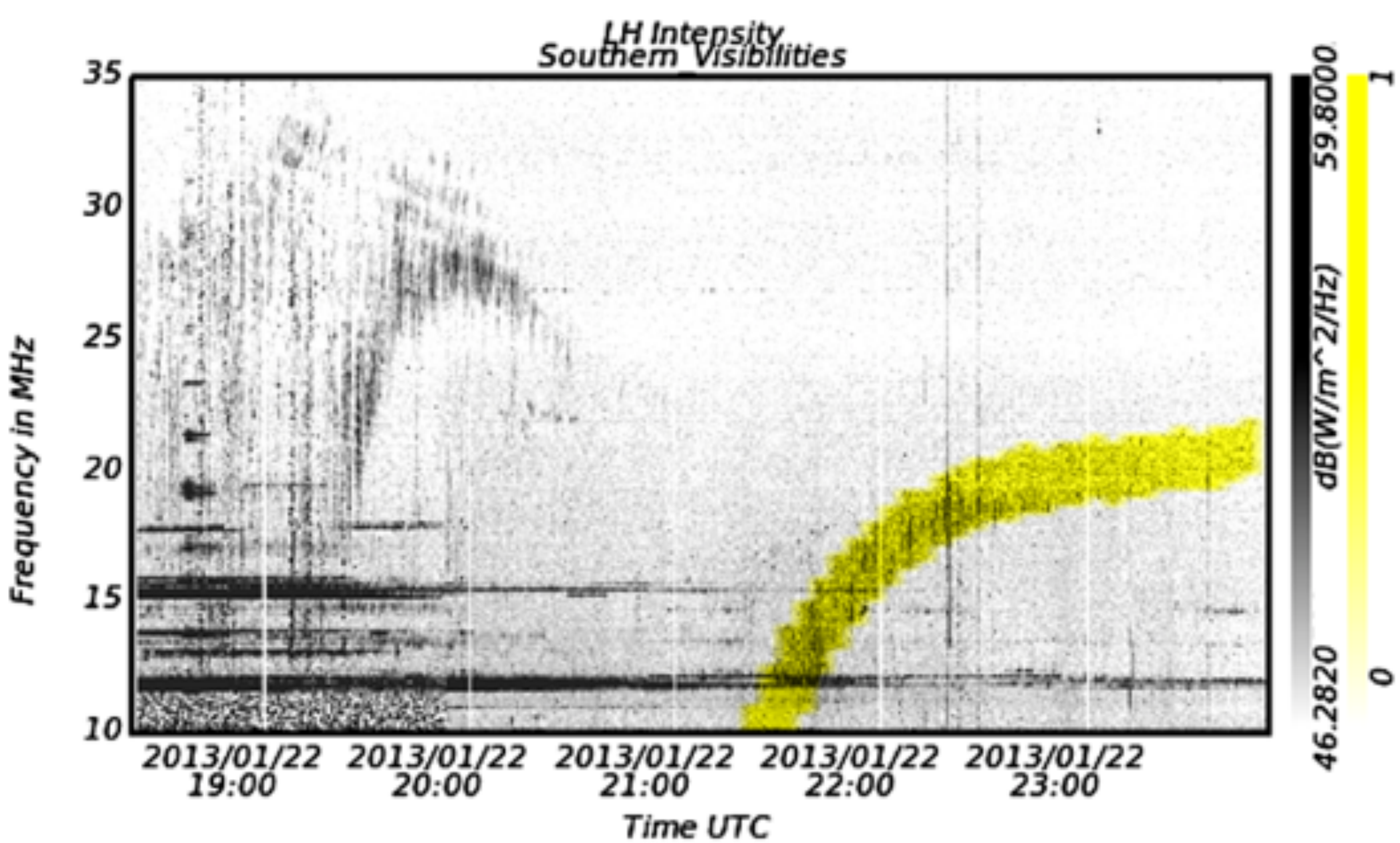
- Tools and databases:
  http://maser.lesia.obspm.fr

- Datasets:
  - Cassini/RPWS
  http://lesia.obspm.fr/kronos
  - Voyager/PRA
  - Ulysses/URAP
  - WIND/Waves
  - STEREO/Waves
  - Nançay/NDA

- Tools:
  - ExPRES
  - VESPA
  - JUNO-Ground-Radio
  https://voparis-juno.obspm.fr
  - RadioJOVE archive

ExPRES





Astronomy & Astrophysics manuscript no. article'serpe
April 25, 2016

ExPRES: a tool to simulate planetary and exoplanetary radio emissions

S. L. G. Hess[1], P. Zarka[2], B. Cecconi[2], L. Lamy[2], and C. Louis[2]

[1] ONERA-The French Aerospace Lab, FR-31055 Toulouse, France e-mail: sebastien.hess@onera.fr
[2] LESIA, Observatoire de Paris CNRS, UPMC, Univ. Paris 7, France,

Preprint online version: April 25, 2016

ABSTRACT

Context. All magnetized planets are known to produce intense nonthermal radio emissions through a mechanism known as Cyclotron Maser Instability (CMI), that requires the presence of accelerated electrons generally arising from magnetospheric current systems. In return, radio emissions are a good probe of these current systems and acceleration processes. But the CMI generates highly anisotropic emissions, and thus leads to important visibility effects in the observations, which have to be taken into account when interpreting the data. Several studies have been previously performed that showed that modeling the radio source anisotropy effect can reveal a wealth of physical information about the planetary or exoplanetary magnetospheres that produce the radio emissions.
Aims. We present a numerical tool, called ExPRES (Exoplanetary and Planetary Radio Emission Simulator), which is able to reproduce the observations of planetary and exoplanetary CMI-generated radio emissions in the time-frequency plane. Special attention is given to the computation of the radio emission beaming at and near its source.
Methods. We explain what physical information about the system can be drawn from such radio observations, and how it can be obtained. Depending on the system studied, this information may include the location and dynamics of the radiosources in the magnetosphere, the type of current system leading to electron acceleration, the energy of accelerated electrons and, for exoplanetary systems, the magnetic field strength and the rotation period of the emitting body (planet or star – the latter corresponds to emissions induced by the planet in the stellar magnetic field), the planetary orbital period, the inclination of its orbit, and – if emission comes from the planet – the tilt of the planetary magnetic field relative to the rotation axis and its offset relative to the center of the planet. Most of these parameters can be measured only via radio observations.
Results. Our results should provide the proper framework of analysis and interpretation for past (Voyager, Galileo…), present (Cassini, ground-based radiotelescopes) and future (Juno, Juice) observations of solar system planetary radio emissions, as well as for future detections of radio emissions from exoplanetary systems (or from magnetic white dwarf-planet or white dwarf-brown dwarf systems). Such detections are expected to occur soon as the outcome of large observation programs carried on with giant radiotelescopes such as LOFAR, UTR2 or the GMRT. Our methodology can be easily adapted to simulate specific observations, once effective detection is achieved.

Key words. <Planets and satellites: aurorae - Radio continuum: Planetary systems - Planet-star interactions>

1. Introduction

1.1. Planetary radio Emissions

All planets in our solar system that possess an internal magnetic field are known to emit low frequency radio emissions, in wavelength domains extending from kilometer (below ∼100 kHz) up to decameter (a few 10s MHz – in the case of Jupiter only). The frequency domain corresponds to the electron cyclotron frequencies (f_{ce}) close to the planet, revealing that the emission process is related to the electron gyration along the planet's magnetic field lines. Theoretical work and in-situ observations of the terrestrial radio sources permitted to elucidate the physical process at the origin of the radio emissions : the Cyclotron-Maser Instability (CMI), which occurs when an elliptically polarized wave resonates with the gyration motion of accelerated electrons (see reviews by Wu 1985; Louarn 1992; Zarka 1998; Treumann 2006). Under some circonstances – notably a positive gradient of the perpendicular velocity distribution of the electrons – the CMI mainly amplifies the wave on the extraordinary mode, which can escape the source and propagate in free space as a radio wave.

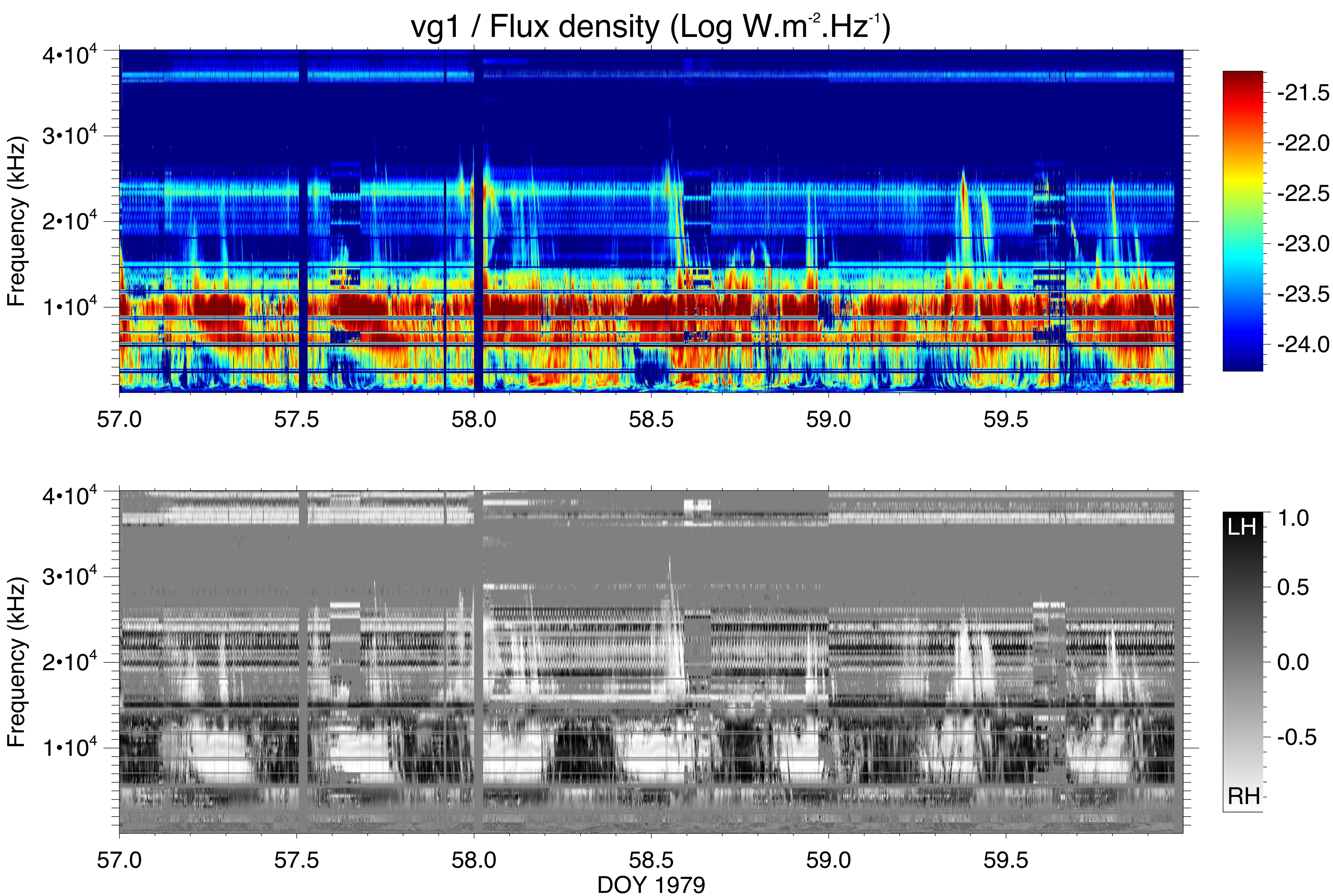
The interest for planetary low-frequency radio emissions is driven by their relation with accelerated electrons. Those are also responsible for auroral emissions on top of the planet's atmosphere (over a broad spectral domains extending from Infrared to X-rays) and reveal the presence of field-aligned currents coupling the magnetosphere to the planet's ionosphere. Contrary to the other auroral emissions, radio emissions are not emitted on top the planet's atmosphere but along a larger altitude range extending from the top of the ionosphere up to a few planet radii (see review in Zarka 1998). The emission frequency is close to f_{ce} in the source, itself proportional to the local magnetic field strength which decreases with altitude. Hence, the radio source altitude can be deduced from the frequency at which it emits. This property can be used to probe large altitude ranges above the aurorae and to reveal, for example, the presence of acceleration regions

Submitted to A&A

More info: http://maser.lesia.obspm.fr

Voyager/PRA

Voyager 1&2 PRA data at high resolution (6s)
Flux + polarization information
Jupiter and Saturn flybys (still looking for Uranus and Neptune)



Saturn SKR periodicities

See Laurent's presentation (1)

Io-Jupiter interactions with Cassini

See Laurent's presentation (2)

Possible collaborations

Hisaki Io-Torus observations + Nançay + ExPRES