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Auroral-like radio emissions as a diagnostic tool for planetary and exoplanetary magnetospheric processes

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Abstract

A comparative review of planetary high-latitude radio emissions (auroral and satellite-induced) is presented. Emphasis is put on the diagnostic capabilities that they provide for studying the magnetospheric processes. Extrapolation to radio emissions from exoplanets and exoplanet-star plasma interactions are presented, as well as prospects for their detection.

1. Introduction

Auroral emissions are a well-known diagnostic tool of magnetospheric processes, as they reflect the magnetospheric structure and dynamics (large scale plasma flows, acceleration regions) projected on and above the high latitude atmosphe along magnetic field lines. Among those, low-frequency radio emissions present the inconvenient of providing little angular resolution (and hence a difficulty to locate accurately the sources of the observed emissions), but the advantage of having a particularly rich time-frequency information content, that can be observed with very high resolutions from space or from the ground. Also auroral radio emissions are non-thermal and intense enough to compete wih the radio output of the planet's parent star. As a consequence, they may be a good diagnostic tool for discovering and characterizing exoplanetary magnetospheres and exoplanet-star plasma interactions [1].

2. Planetary Radio Emissions

We summarize the relevant characteristics of solar system planets' radio emissions, derived from remote space- and ground-based observations, as well as from direct in-situ measurements. We will discuss the EXPReS software that allows to model their dynamic spectra [2,3]. Then we will identify the planetary and magnetosperic processes on which they can shed light (internal planetary rotation, unipolar inductor interaction, energy budgets, etc.).

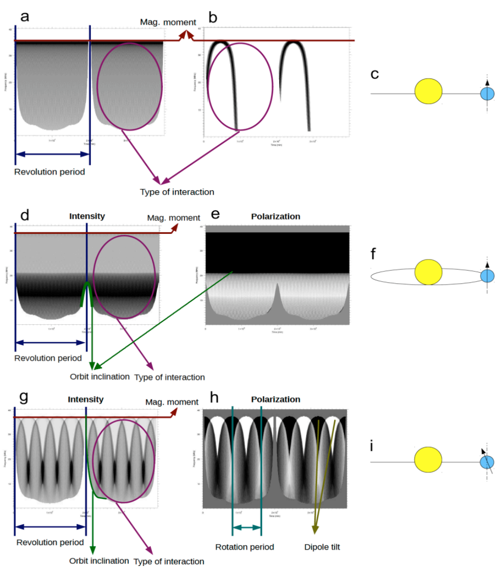

Figure 1: Relation between dynamic spectral features and star-planet parameters: a-c) Planetary magnetic field tilted by 0° relative to its rotation axis and orbit inclination of 0°, for (a) a full active auroral oval or (b) an auroral active sector fixed in local time. d-f) Planetary magnetic field tilted by 0° relative to its rotation axis and orbit inclination of 15°, for a full active auroral oval. g-i) Planetary magnetic field tilted by 15° and orbit inclination of 15°, for a full active auroral oval (from [4]).

3. Exoplanetary Radio Emissions

As a second step, we will discuss the case of exoplanetary radio emissions (predictions, observations, and modelling [1,4]). Figure 1 displays the dynamic spectra in intensity and polarization that should be observed for various star-planet plasma interactions, depending on the planetary field magnitude, tilt and offset, planetary rotation period and orbital inclination. It illustrates how the comparison with model predictions should allow to determine such parameters not accessible to other detection methods, and consequently how detection of magnetospheric radio emission from exoplanets should broaden the field of comparative magnetospheric physics to star-planet plasma interactions at large.

4. Perspectives

The most difficult step to overcome is the radio detection of an exoplanetary signal. Establishing its planetary origin should be relatively easy, based on emission polarization (highly circular/elliptical for all solar system planetary radio emissions only) and periodicity (orbital, especially). Observational searches are ongoing using all large ground-based low-frequency radiotelescopes [5]. Strong expectations are in particular carried by the new giant european low-frequency array LOFAR (*www.lofar.org*).

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