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Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique
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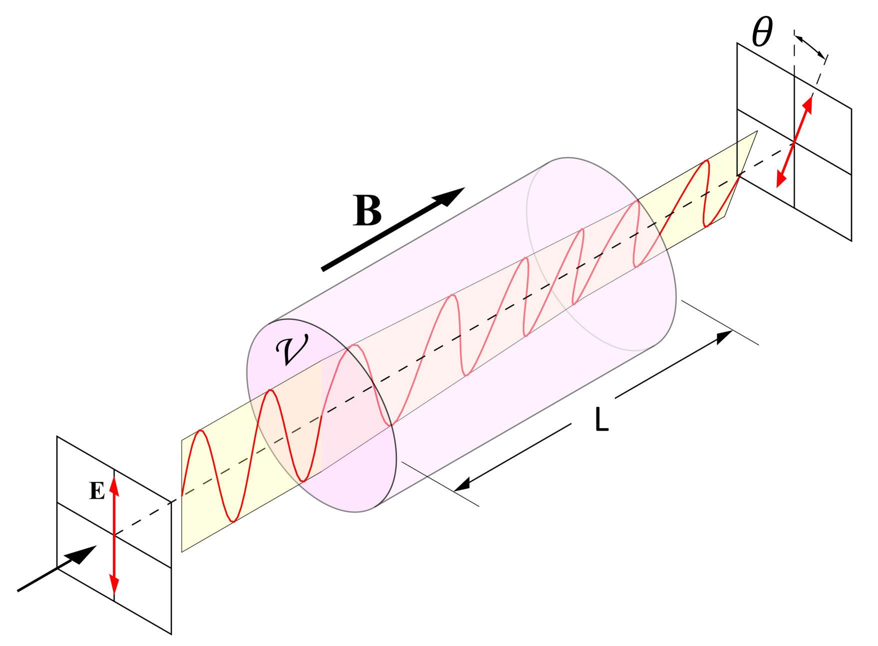
Effect of Faraday rotation on Jovian low-frequency radio-emissions.

E. Mauduit [1], P. Zarka[1,2], X. Zhang [1], L. Lamy[1], A. Loh [1], J.-M. Grießmeier[2,3], J. Turner [4,5] and the NenuFAR collaboration

Context and motivations

- Studying Jovian low-frequency magnetospheric radio-emissions (≤40 MHz) allows to remotely probe their generation mechanism (especially the electron Cyclotron Maser – ECM) and the acceleration processes of electrons that power it. Those emissions have different time scales : from milliseconds (fast drifting radio bursts, [1]) to hours, and are mainly polarized elliptically (both circular and linear polarization are present).
- While propagating through the plasmas between the source and the observer, those radio emissions are subject to Faraday rotation, producing spectral fringes in linear polarization. Studying these fringes allows to retrieve the Rotation Measure (RM) of the emission and remotely study the interplanetary medium, the terrestrial ionosphere and especially the Jovian magnetosphere in our case. In this work, we analyze the dependence of the measured RM to source-observer geometry and periodicities related to the Jovian magnetosphere.
- Finally, it has been convincingly argued that radio emissions from exoplanets and star-planet interactions are expected to have deep similarities with Jupiter's [2,3].

Faraday effect and rotation measure (RM) [3]



Polarisation rotation angle :

$$\theta = \lambda^2 * RM$$

$[rad]$ $[m^2]$ $[rad.m^{-2}]$

Rotation measure :

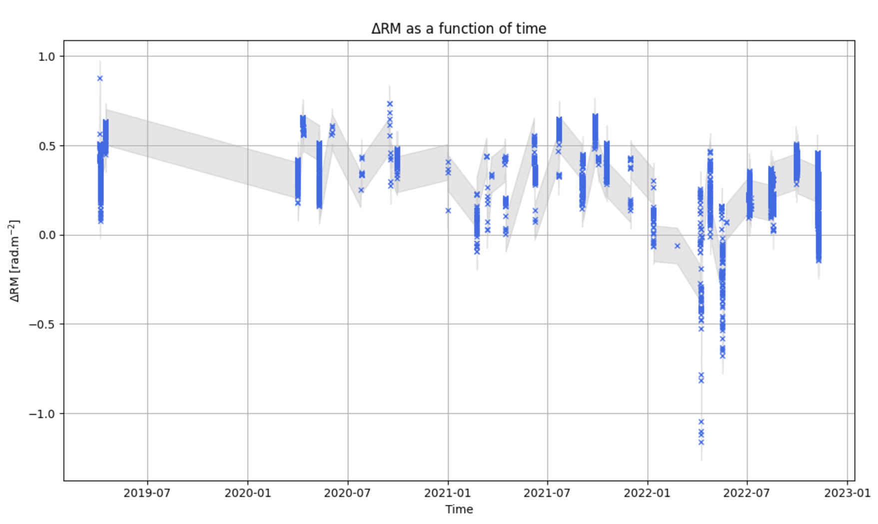
$$RM = 0.8 \int^L N_e B_{\parallel} \, dL$$

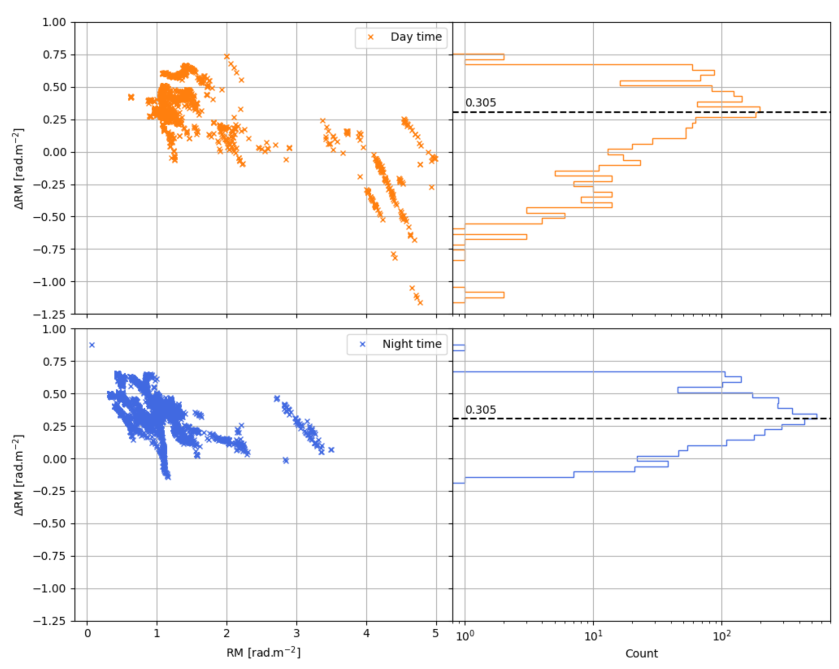
$[rad.m^{-2}]$ $[cm^{-3}]\,[\mu G]\,[pc]$

Comparison with ionospheric contribution predictions

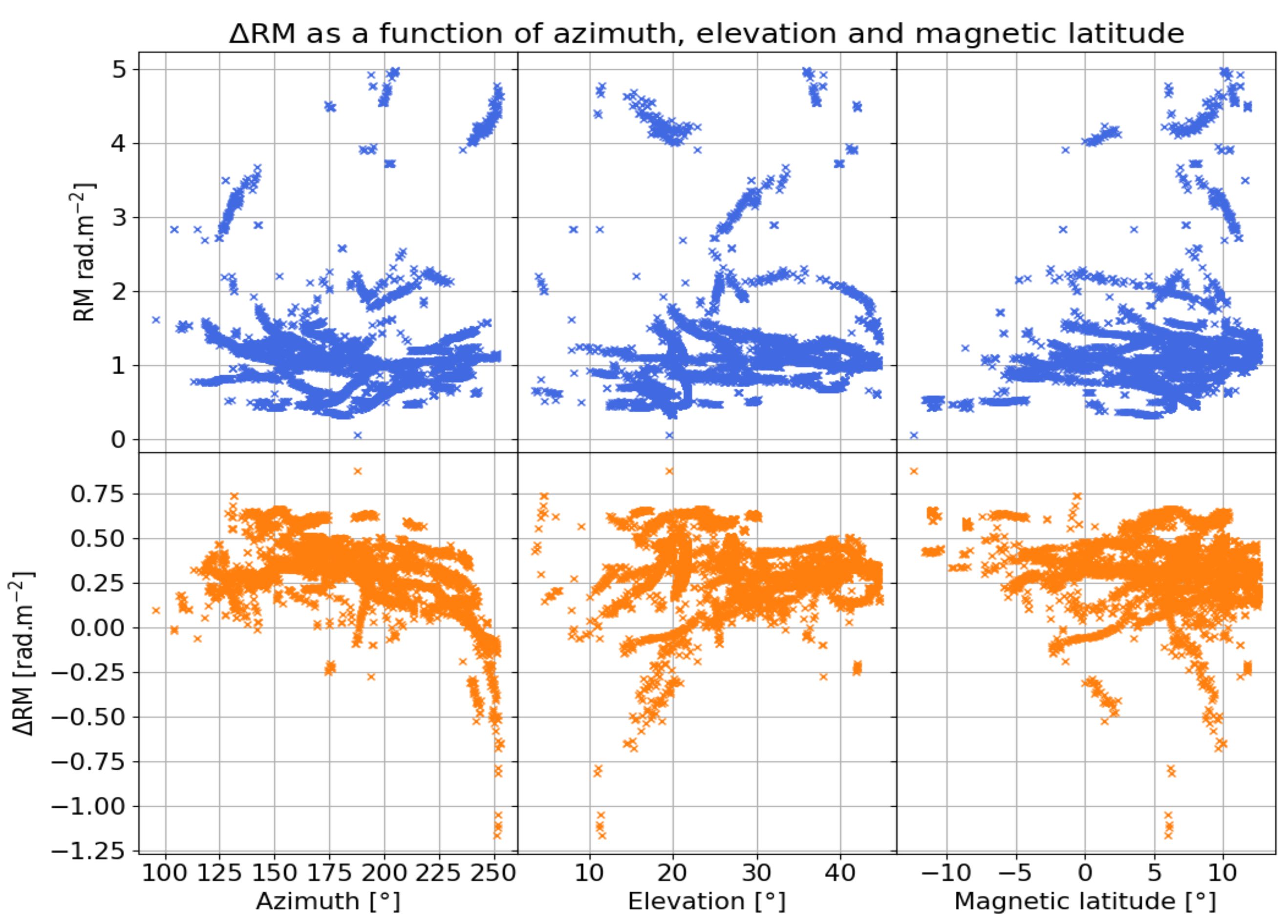
RM_{iono} is obtained with the RM_extract code [5], and we define ΔRM as follows :

$$\Delta RM = RM_{iono} - RM_{measured}$$





⇒ RM_{iono} seems to be over-estimated most of the time, especially at night time.

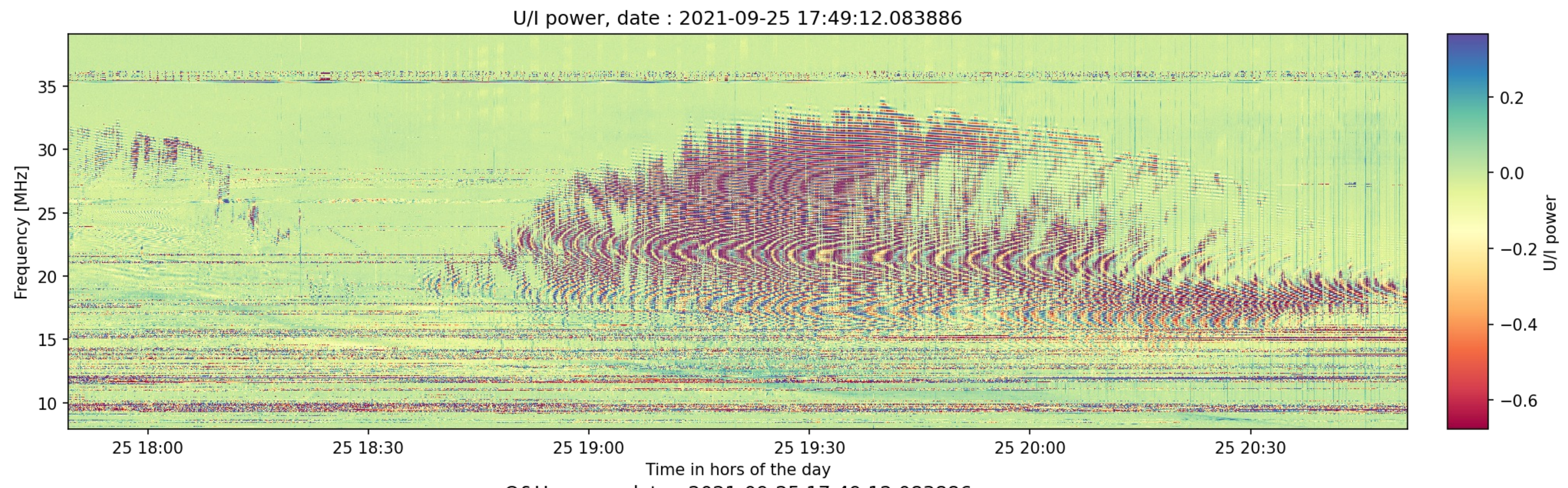


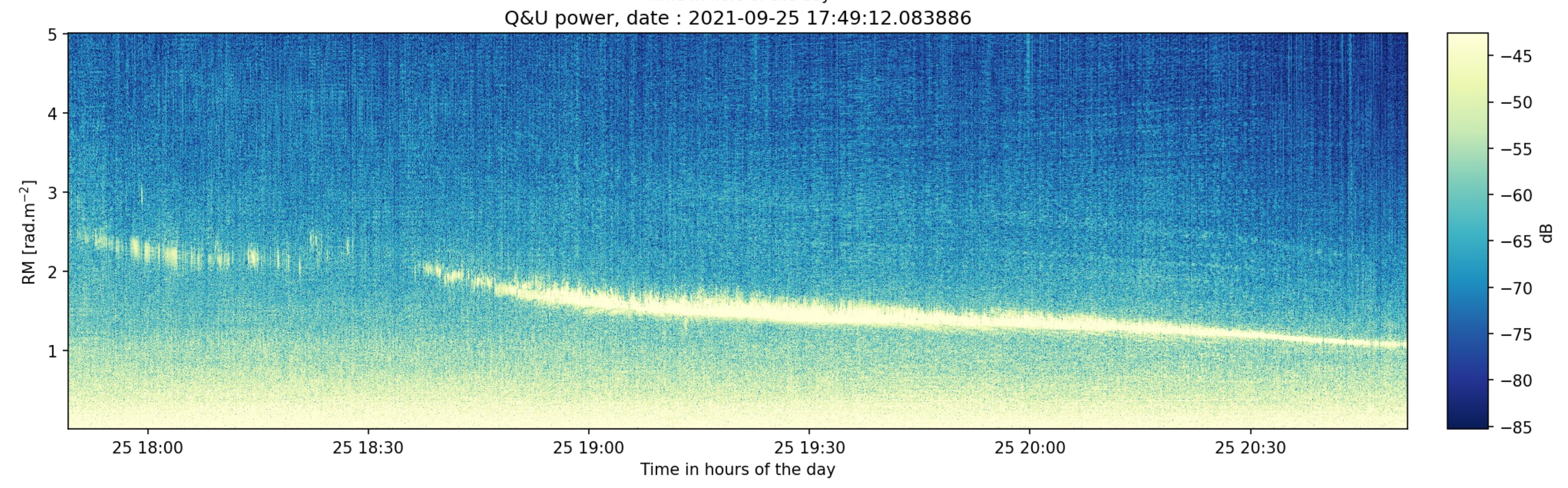
⇒ RM_{iono} seems to be under-estimated for low elevations and high azimuth angles.

Application to Jupiter observations with NenuFAR

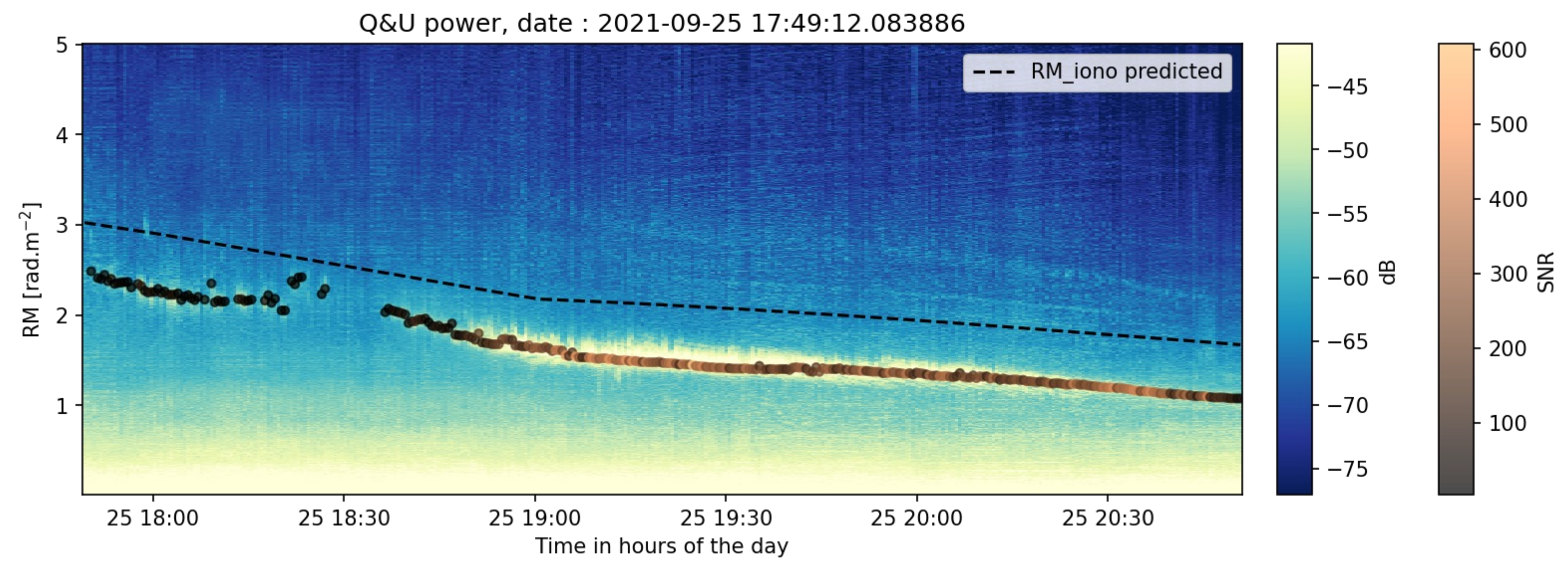
Going from the frequency space to the RM space :

$$\Delta f = af^3 \quad \text{with :} \quad a \approx \frac{\Delta\theta}{10^7\, RM} \quad (\Delta\theta = 180° \text{ between two fringes})$$

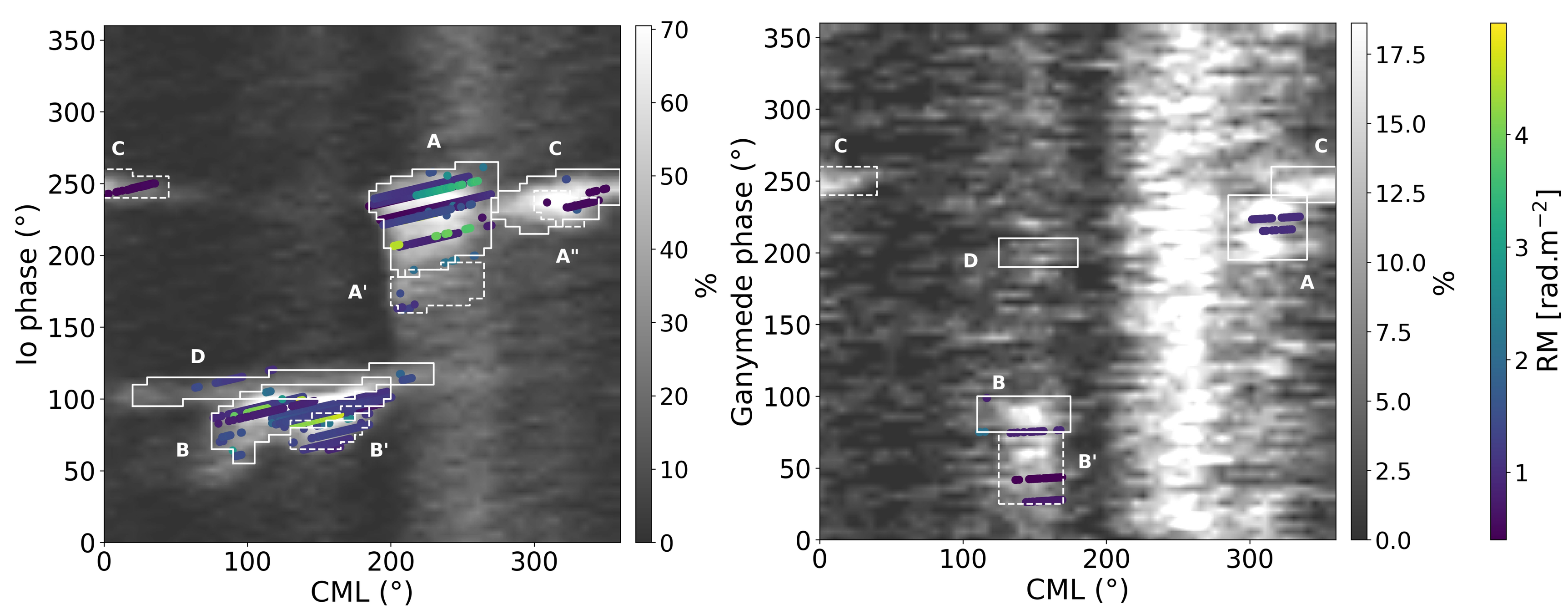




Detection of RM peaks :



Relation with satellite phases



Discussion and perspectives

- Accordingly to recent work by the team working on the RMextract code [5], the code tends to over-estimate the contribution of the ionosphere, thus the difference with what we observe may mainly come from that. This makes it more difficult to identify a contribution from the magnestophere of Jupiter for example.
- It seems there is no evident relation between RM values and the position of Jupiter.
- We want to do a Lomb-Scargle periodogram of all the detections in order to see if we can find a peridicity corresponding to Jupiter's rotation period.
- The next step of this study will be to evaluate the application of this detection method to exoplanets by conducting 'Jupiter as an exoplanet' studies with data from the NenuFAR radiotelescope [6]. Combined with other tools, such as predictions on the exoplanetary magnetic field or Zeeman-Doppler Imaging (ZDI) observations, this will allow us to remotely study the interstellar medium and exoplanetary magnetospheres [3,7].

References

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[5] - Mevius, M. (2018) RMextract, Astrophysics Source Code Library, record [ascl:1806.024]
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