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Exploring the Jupiter's and Saturn's radiation belts with LOFAR

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Since its detection in the mid-fifties, the decimeter synchrotron radiation (DIM), originating from the radiation belts of Jupiter, has been extensively observed over a wide spectrum (from >300 MHz to 22 GHz) by various radio instruments (VLA, ATCA, WSRT, Cassini…). They provided accurate flux measurements as well as resolved maps of the emission that revealed spatial, temporal and spectral variabilities. The strong magnetic field (∼4.2 G at the equator) is responsible for the radio emission generated by relativistic electrons. The emission varies at different time scales (short-time variations of hours to long-term variation over decades) due to the combination of visibility configuration (fast rotating "dipole" magnetic field, beamed radio emission) and intrinsic local variations (interaction between relativistic electrons and satellites/dust, delayed effect of the solar wind ram pressure, impacts events) (e.g. de Pater & Klein, 1989; de Pater & Dunn, 2003; Bagenal (ed.) et al., 2004; Santos-Costa, 2009, 2011). A complete framework is necessary to fully understand the source, loss and transport processes of the electrons populating the inner magnetosphere over a wide frequency range. The low frequencies are associated with electron of lower energies situated in weaker magnetic field regions.

LOFAR, the LOw Frequency ARray (LOFAR) (van Haarlem et al., 2012), the last generation of versatile and digital ground-based radio interferometer operates in the [30-250] MHz bandwidth. It brings very high time (∼μsec), frequency (∼kHz) and angular (∼asec) resolutions and huge sensitivities (∼mJy). In November 2011, a single 10-hour track enabled to cover an entire planetary rotation and led to image, for the first time, the radiation belts between 127-172 MHz (Girard et al. 2012, 2013). In Feb 2013, an 11-hour joint LOFAR/WSRT observing campaign seized the dyname state of the radiation belts from 45 MHz up to 5 GHz. We will present the current study of the radiation belts' dynamic with this broadband observation and the advances on the open questions that remained in the inner magnetosphere of Jupiter.

In parallel, Saturn has also been observed with LOFAR in the 110-190 MHz band. It was used as an atmospheric probe to measure the thermal emission from the planetary disk (Hofstadter & Butler, 2003; Gulkis & Hofstadter, 2012; Nettelman, in prep; Girard, in prep), originating from the H_2O/NH_3 layers at the kbar level inside the deep atmosphere. Because of a much weaker magnetic field (∼0.2 G at the equator) and the interaction of energetic electrons with the rings, the processes taking place in the inner magnetic field are likely to be of much weaker intensity. By piggybacking on this 20-hour observation, we are trying to detect (or put an upper limit on) radio signals predicted at the sub-mJy level (from ∼0.14 to ∼0.4 mJy, Lorenzato, 2012). This emission, if detected, will give a new opportunity to carry out comparative studies of inner magnetospheres in the Solar System.