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Magnetosphere-Ionosphere-Thermosphere Coupling at Jupiter: a study based on multi-instrument data analysis of Juno's First 30 Orbits and Modelling Tools

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Abstract

The dynamics of the Jovian magnetosphere is controlled by a complex interplay between the planet's conducting upper atmosphere, its moons and the solar wind:

1- anchoring of planetary magnetic field lines into the conducting layers of the thermosphere drags them into corotation with the planet;
2- interactions with the solar wind superimpose on corotation a Dungey-type system of convection cells, likely significant at very high latitudes;
3- finally, centrifugal forces acting on outward flow of Iogenic plasma induce partial sub-corotation and are believed to drive a second circulation cell, i.e. the Vasyliunas cycle, connecting the middle magnetosphere to the magnetotail and magnetospheric boundaries.

Exchanges of particles, momentum and energy between the planet, its moons and its magnetosphere resulting from the competition between these three elementary transport cycles are mediated by Magnetosphere-Ionosphere-Thermosphere (MIT) coupling processes which display both similarities and differences with their Earth and Saturn counterpart.

At the ionospheric level, these processes can be characterized by a set of key parameters: ionospheric conductances, field-aligned and ionospheric currents, ionospheric electric fields, electrons precipitation fluxes, momentum and energy deposition rates into the upper atmosphere. Determination of these key parameters in turn makes it possible to estimate the net deposition/extraction of momentum and energy into/out of the Jovian upper atmosphere induced by its coupling with the equatorial magnetosphere.

We will describe a method to retrieve these key parameters along the Juno magnetic footprint. Based on a combined use of NASA's Juno mission multi-instrument data from the MAG, JADE, JEDI, UVS, JIRAM and WAVES instruments and three modelling tools, it was first developed by Wang et al. (2021) for analysis of the first nine Juno orbits, and then extended to Juno's first 30 orbits by Al Saati et al (2022). We will show how this method makes it possible to characterize the dynamical coupling of the southern and northern main auroral emission regions to the equatorial magnetosphere, and to test the degree to which sub-corotation or super-corotation of the plasma results from the coupling between large-scale magnetospheric motions and planetary rotation at Jupiter. We will discuss the potential application of this same method to the Saturn case using Cassini observations, and possibly to multi-instrument observations from future orbiters of the Ice Giants Uranus and Neptune.