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Examining Radial-Interchange in the Jovian Magnetosphere using JERICHO: a Kinetic-Ion, Fluid-Electron Hybrid Model

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The Jovian magnetosphere is loaded internally with material from the volcanic moon of Io, which is ionised and brought into co-rotation forming the Io plasma torus. Plasma is removed from the torus mainly via ejection as energetic neutrals and by bulk transport into sink regions in the outer magnetosphere.

There are two physical processes that are implicated in the bulk transport process, these are diffusion and the radial-interchange (RI) instability. The latter is analogous to the Rayleigh-Taylor instability, but with centrifugal force replacing gravity. This allows magnetic flux tubes containing hot, tenuous plasma to exchange places with tubes containing cool, dense plasma, moving material from the inner to outer magnetosphere whilst returning magnetic flux to the planet. Observational data does not currently provide strong evidence to favour either process and indeed they may be non-linearly coupled. Furthermore, current state-of-the-art simulations do not permit an understanding of non-linear phases of the instability nor the effect of magnetosphere-ionosphere coupling on small length scales.

In order to examine the bulk transport process we have developed a full hybrid kinetic ion, fluid-electron plasma model in 2.5-dimensions, JERICHO. The technique of hybrid modelling allows for probing of plasma motions from the scales of planetary-radii down to the ion-inertial length, considering constituent ion species kinetically as charged particles and forming the electrons into a single magnetised fluid continuum. This allows for insights into particle motions on spatial scales below the size of the magnetic flux tubes. We are particularly interested in exploring a) bulk transport on spatial scales not currently accessible with other state-of-the-art models; b) the relative contributions from diffusive motions against those from RI instabilities; and c) non-linear effects generated by RI instabilities and the impact of these on plasma transport from the inner to outer magnetosphere. In this presentation we will examine the latest simulation results from JERICHO, initialised with a range of Jovian parameters, examining the evolution of the RI instability on differing spatial and temporal scales.