Exploring the dynamics of the Io plasma torus using a multi-dimensional physical chemistry model

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The Io plasma torus is an ideal space-based laboratory for testing our understanding of fundamental magnetosphere-ionosphere (MI) coupling processes. The ~1 TW of UV power radiated from the torus enables exceptional remote diagnostics ofplasma properties and composition to complementin situ spacecraft observations. Key properties of the torus giving clues to the nature of MI coupling are: (1) subcorotation, and (2) the existence of superthermal electrons modulated by the System III (magnetic coordinates) period, and by the puzzling System IV (subcorotating) period. To complicatematters, the time scale for outward radial plasma torus from Io to Europa is comparable to the subcorototating / System IV time scale and many of the physical chemistry time scales (all of the order of 30 days). To untangle the torus MI coupling problem, it is essential to model physical chemistry in combination with azimuthal (subcorotational) and radial transport.

Our results show that if a radially-dependent subcorotation profile is prescribed, consistent with observations [e.g., Brown, 1994; Thomas et al., 2001], then the model produces a radially-independent periodicity that is consistent with System IV. In addition, if volcanic events decrease the System IV period, as observed during the Cassini era (Steffl et al., 2006) and during the Hisaki era (Arakawa et al., 2017), then the model requires a modified subcorotion profile with the region near Io moving closer to rigid corotation. These observational/model results are contrary to the expectation of increased subcorotation for a more heavily mass loaded torus [Pontius and Hill, 1982]. In this talk we will discuss implications for MI coupling in the context of subcorotation, the System IV period, and superthermal electron abundance.

Keywords: Jupiter, magnetosphere, Io plasma torus, magnetosphere-ionosphere coupling

