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The role of Io in the dynamics of Jupiter's magnetosphere: A sandpile modelling approach.

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Abstract

Jupiter's magnetosphere is thought to be largely internally driven, by the combination of the loading of ~500 kg/s of plasma into the system by the volcanic moon Io, and the rapid rotation of the planet itself. Since we do not see a continuously expanding torus and magnetosphere, we would expect a long-term balance between the inflow of mass, primarily from Io, and the outflow of mass, via plasmoid release.

Simple calculations, which attempt to match the mass-loading rate from Io with the amount of mass lost via large-scale tail reconnection events, indicate a significant mass imbalance at Jupiter. This mass imbalance may be due to several reasons, including visibility issues linked to single spacecraft observations.

This is where modelling can be a powerful tool. A single spacecraft can only expect to observe a global 'systemwide' event, where energy is redistributed across the entire system, with any certainty. While 'internal' events, with a more local redistribution of energy, are likely to be missed. Using computational modeling we are able to 'observe' an entire system at any time. Cellular automata (CA) based on robust physical parameters and rules can allow us to manipulate the inputs and drivers of magnetotail physics, and to explore the response of the system over a range of temporal and spatial scales. Here we examine the variability of the mass-loading and the response of our CA sandpile model to an analogous driving. We explore whether Jupiter's magnetospheric dynamics can be explained purely in terms of Io mass-loading. In particular we examine the difference between the small local events ("internal" avalanches) and larger global events ("systemwide" avalanches), and what this can tell us about the fate of mass in Jupiter's magnetosphere.