EPSC Abstracts
Vol. 13, EPSC-DPS2019-1583-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Investigating the Morphology and Evolution of Hot Ion Injection Events in Saturn's Inner Magnetosphere

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Abstract

We examine the energy-dependent drift of hot (>1 keV) ions through Saturn's inner magnetosphere after they have been injected by Rayleigh-Taylor like interchange instability motion. We calculate the drift of these energetic ions to investigate the morphology and evolution of hot plasma injections.

1. Introduction

In Saturn's magnetosphere, hot (> 1 keV) plasma is injected inward from a reservoir at ~12-15 R_S as cold (< 1 keV) plasma from the Enceladus torus moves outward in a Rayleigh-Taylor-like instability, commonly called interchange injections. Figure 1 shows Cassini data with several such injection signatures, seen in multiple instrument data sets. Several studies have quantified the location and features of these injections [1, 2, 3, 4, 5, 6, 7, 8]. Most recently, Azari et al. [1, 2] used the Cassini CHEMS data set to quantify "fresh" injections of hot plasma inside of 11 R_S, examining the relationship as a function of local time, radial distance, and Saturn longitude system.

Several questions still remain about these injection events. One such unresolved issue is this: what is the morphology of the injections? Morphologies of injections can be related to the stages of linear, non-linear, and turbulent type Rayleigh-Taylor instabilities. This is very difficult to assess with the single-spacecraft data set from the Cassini mission. However, Saturn's fast rotation period of <11 h, with ions experiencing a gradient-curvature drift in the same direction as corotation, mean that injections can drift around the planet and potentially be seen by Cassini later in the same periapse interval through the inner magnetosphere. Therefore, one way to examine this issue is using an observed injection as an initial condition for a numerical simulation and then comparing the results with Cassini's observations an appropriate time later.

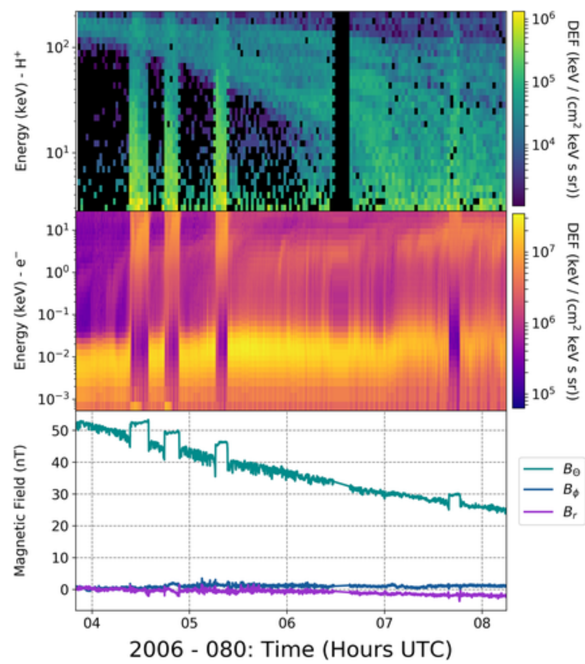

Figure 1: Series of interchange injections on 2006 day of year 080. The top plot is the differential energy flux of H+ as measured by CHEMS between 3 and 220 keV, followed by the CAPS ELS differential energy flux for electrons from Anode 4, and finally the magnetic field in KRTP (Kronocentric body-fixed, J2000 spherical coordinates). From [1].

2. Investigating Injection Morphology

Using the list of injection events from [1], we conduct calculations for a large number of such events to assess whether the dispersed ion signatures various morphologies with different radial extensions. The example calculation in Figure 2 shows the numerical approach with a thin radially-aligned injection morphology. From the timing of when Cassini encounters the drifting particles, a spectrogram can be constructed for direct comparison to the CHEMS observations at this later time.

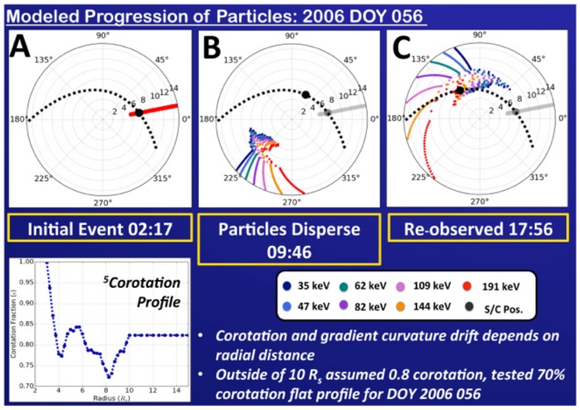

Figure 2: Beginning with a particles (colored dots) arranged in a radially outward line from the injection observation (in A), they are forward-modeled (B) with a particular corotation profile (lower left) and gradient-curvature drift assumption until they encounter the spacecraft again (C), as it moves along its trajectory (black dotted line).

3. Summary

In this study, we calculate the drift of energetic ions through Saturn's inner magnetosphere to investigate the morphology and evolution of hot plasma injections. We include adiabatic acceleration and inward drift speeds during the injection, as well as velocity-dependent drift and charge exchange attenuation after injection.

Acknowledgements

The authors would like to thank NASA and NSF for funding of this work. The data are available at the Planetary Plasma Interactions node of the Planetary Data System

References

[1] Azari, A. R., Liemohn, M. W., Jia, X., Thomsen, M. F., Mitchell, D. G., Sergis, N., et al. (2018). Interchange injections at Saturn: Statistical survey of energetic H^+ sudden flux intensifications. Journal of Geophysical Research: Space Physics, 123, 4692–4711. https://doi.org/10.1029/2018JA025391

[2] Azari, A., X. Jia, M. W. Liemohn, G. B. Hospodarsky, G. Provan, S.-Y. Ye, S. W. H. Cowley, C. Paranicas, N. Sergis, A. Rymer, M. F. Thomsen, and D. G. Mitchell (2018). Are Saturn's interchange injections organized by rotational longitude? *Journal of Geophysical Research - Space Physics*, 124, https://doi.org/10.1029/2018JA026196.

[3] Chen, Y., & Hill, T. W. (2008). Statistical analysis of injection/dispersion events in Saturn's inner magnetosphere. *Journal of Geophysical Research, 113*, A07215. https://doi.org/10.1029/2008JA013166

[4] Kennelly, T. J., Leisner, J. S., Hospodarsky, G. B., & Gurnett, D. A. (2013). Ordering of injection events within Saturnian SLS longitude and local time. *Journal of Geophysical Research: Space Physics, 118*, 832–838. https://doi.org/10.1002/jgra.50152

[5] Lai, H. R., Russell, C. T., Jia, Y. D., Wei, H. Y., & Dougherty, M. K. (2016). Transport of magnetic flux and mass in Saturn's inner magnetosphere. *Journal of Geophysical Research: Space Physics, 121,* 3050–3057. https://doi.org/10.1002/2016JA022436

[6] Mitchell, D. G., Brandt, P. C., Carbary, J. F., Kurth, W. S., Krimigis, S. M., Paranicas, C., et al. (2015). *Injection, interchange, and reconnection. Magnetotails in the Solar System*, 2004, 327–343. https://doi.org/10.1002/9781118842324.ch19

[7] Paranicas, C., Thomsen, M. F., Achilleos, N., Andriopoulou, M., Badman, S. V., Hospodarsky, G., et al. (2016). Effects of radial motion on interchange injections at Saturn. *Icarus, 264*, 342–351.

[8] Rymer, A. M., Mauk, B. H., Hill, T. W., André, N., Mitchell, D. G., Paranicas, C., et al. (2009). Cassini evidence for rapid interchange transport at Saturn. *Planetary and Space Science, 57*(14–15), 1779–1784. https://doi.org/10.1016/j.pss.2009.04.010