# Injection Events in the Kronian magnetosphere

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## Injection Events

- hot plasma injections have been observed in the Earth's magnetosphere, at Jupiter and with the Cassini S/C at Saturn
- in the Earth's case they are generated by magnetospheric substorms
- in a rotationally dominated magnetosphere like in the Jovian and Kronian case, the plasma injections are caused by the interchange instability

➡ hot plasma is transported into the inner magnetosphere (see Fig. 1)

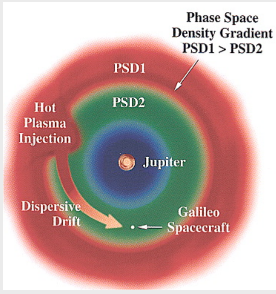
- the energetic particles experience the corotating ExB-drift (not energy dependent) as well as the magnetic gradient and curvature drift (energy and charge dependent)
- spiral pattern of energetic particles is formed (see Fig. 2)

➡ particles arrive at the S/C in a specific order

➡ injections are visible in energy spectrograms as energy-time-dispersed features (see Fig. 3)

- more than 800 dispersion profiles have been observed with MIMI/LEMMS during five years of mission
- since the measurements of injections for our study have to be made in the equatorial plane, we could use a subset of 52 events

Figure 1. Simple concept used by *Mauk et al. [1999]* to reproduce energy-time dispersed signatures of energetic particle injections at Jupiter.



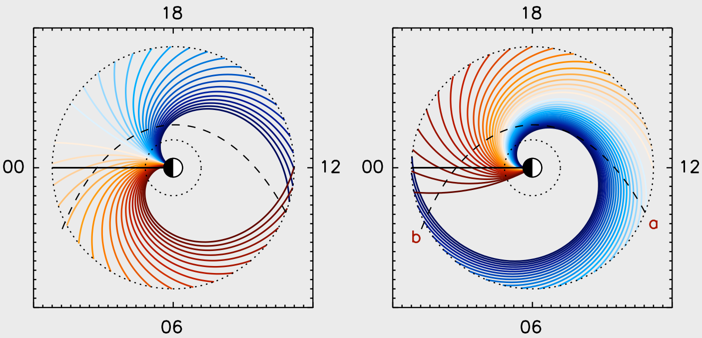




Figure 2. Top-view of the L-shell range up to 13 Rs. Drift angles of electron (blue) and ion (red) energies after an injection time of 10 h are displayed. 10 keV electrons are displayed in light blue, 200 keV electrons in dark blue with ΔE = 10 keV between two neighbouring lines. Ions span the same energy range from 10 keV (yellow) to 200 keV (dark red). Particles were injected along the line to local midnight. The Cassini S/C-trajectory of day 2005.302 is displayed as a dashed line and goes from point (a) to (b).

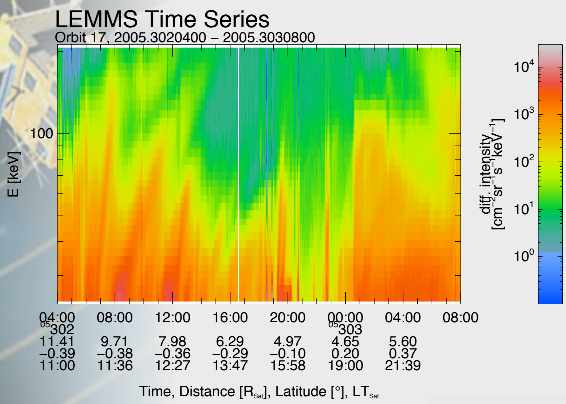



Figure 3. Example of an energy spetrogram for electrons in the inner Kronian magnetosphere as measured by the MIMI/LEMMS detector onboard Cassini on days 302/303 in 2005.

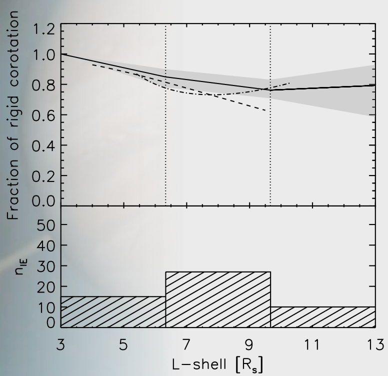



Figure 4. Top: Model of the azimuthal plasma ow in the Kronian magnetosphere, with error range included (grey). The dashed line represents the model by *Mauk et al. [2005]*, the dashed-dotted line is he result of the moment calculation made by *Wilson et al. [2008]*. Bottom: Distribution of observed injections inside different L-shell range bins.

## Azimuthal velocity and injection site

- the magnetosphere is clearly subcorotating with a minimum of 76 % of corotation at a distance of 9.6 $R_s$ (see Fig. 4)
- interaction of the energetic particles with the neutral cloud around Saturn is most probably the reason of the velocity drag *[Saur et al., 2004]*
- with knowledge of the azimuthal plasma velocity and the age of an individual injection event, we are able to trace back the events to the place where they have been injected in the inner magnetosphere
- injection site of the 52 injections are shown in Fig. 5
- due to the biased measurements by the S/C trajectory we had to statistically weighten the four different local time sectors
- the midnight (21 LT to 3 LT) and the morning sector (3 LT to 9 LT) are clearly preferred by injections, whereas in the noon sector from 15 LT to 21 LT just 10 % of the hot plasma was injected

## Applications to plasma flow profile

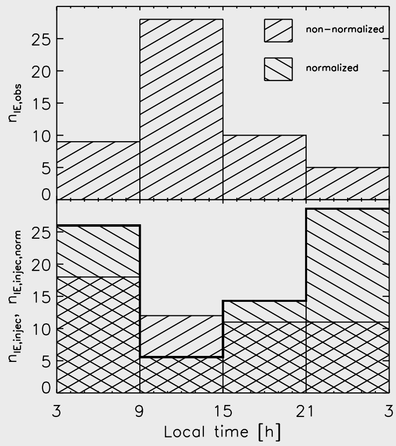
- the shape of the dispersion profiles depend on the age of an individual injection as well as on the azimuthal plasma flow in the Kronian magnetosphere
- after *Mauk et al. [2005]* the energy as a function of time can be written as:

$$\frac{\mathrm{d}E}{\mathrm{d}t} = \frac{(\Omega_{SC} - \Omega_0 - \Omega_d)}{(t - t_i)(\mathrm{d}\Omega_d/\mathrm{d}E)} - \frac{v_L[(\mathrm{d}\Omega_0/\mathrm{d}L) + (\mathrm{d}\Omega_d/\mathrm{d}L)]}{\mathrm{d}\Omega_d/\mathrm{d}E}$$

| | |
|---|---|
| $\Omega_{SC}, v_L$ | azimuthal and L-shell velocity of Cassini |
| $\Omega_0$ | azimuthal plasma velocity |
| $\Omega_d$ | particles' drift velocity |
| $(t - t_i) = T_A$ | age of injection event |

- by comparing observed $(E_{obs})$ and theoretically computed dispersion profiles $(E_{th})$ and by applying a least-mean-square-fit, we are able to estimate the Kronian magnetosphere's azimuthal velocity profile $\Omega_0$ and the age $T_A$
- for calculation of $E_{th}$ we assume a dipolar configuration and an instantanious population of energetic particles along a specific azimuth
- to characterize the flow profile, we separated the L-shell range between 3 $R_s$ and 13 $R_s$ into three different sectors and binned together the injections in each sector

Figure 5. Statistical distribution of the Kronian local time of measurement (top), and the injection site of the events (bottom) that we considered in our study.

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