Mass Release at Jupiter –

Substorm-like Processes in the Jovian Magnetotail

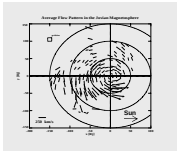
Kronberg, E. A. [a];

Woch, J.[a]; Krupp, N.[a]; Lagg, A.[a]; Glassmeier, K.-H.[b]

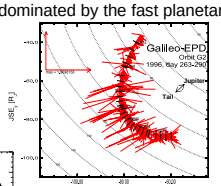
[a] Max-Planck Institut für Sonnensystemforschung; [b] Institut für Geophysik und Metereologie,TU Braunschweig

Summary The Jupiter orbiting spacecraft Galileo has provided evidence that the jovian magnetotail is subject to a periodic process with typical timescales of several days by which the Jovian system is presumably releasing its excess iogenic mass. The mass release process resembles a terrestrial substorm in the sense of a global reconfiguration of the magnetotail. During the initial "loading" phase the plasma convection is at a moderate speed in the corotation direction, and the jovian plasmasheet appears to be in a stable configuration. In the release phase reconnection through a thinned current sheet leads to radially inward and outward plasma flows and the ejection of plasmoids. Storage of magnetic energy in the lobe region seems not to be the prime driver of the reconfiguration process. Therefore the role of the solar wind as energy source is of less importance than for terrestrial substorms. Instead, it can be envisaged that plasma loading of fast rotating magnetic flux tubes and the associated centrifugal forces drive the reconfiguration process.

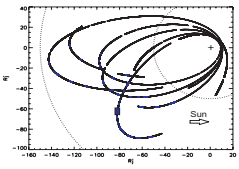
Introduction



➢ The plasma flow in the jovian magnetosphere is generally dominated by the fast planetary rotation.

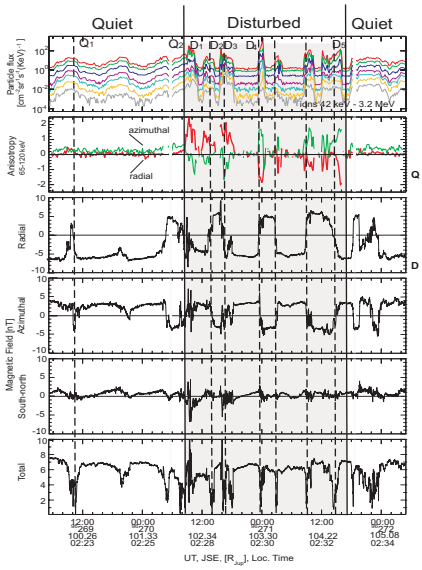


➢ However, in the magnetotail the corotational flow is often disrupted by radially outward and inward flow bursts.



➢ We analyzed 34 of the most prominent flow burst events by using energetic particle data from the EPD (Energetic Particles Detector) instrument in combination with magnetic field observations.

Mass-release event

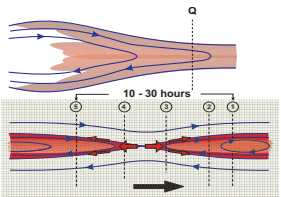


Quiet state

➢ Thick plasma sheet

➢ Plasma flow in corotational direction

➢ Undisturbed magnetic field



Disturbed state

➢ Thin plasma sheet

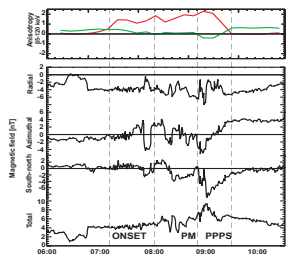
➢ Plasma flow first radially outward then radially inward

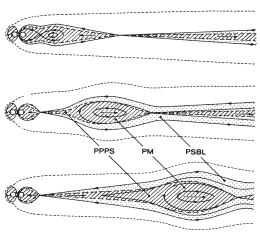
➢ Magnetic field strongly variable with bipolar signatures in the bz component

➢ particle intensities increase

➢ increase of wave activity

Reconfiguration events in details - similarities to the Earth's case





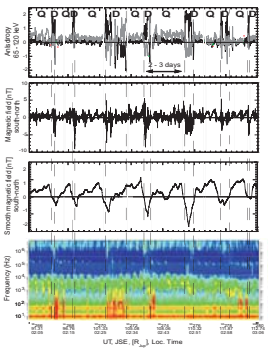
➢ Onset fluctuations ~ 45 min (at Earth ~3 min)

➢ Plasmoid formation

➢ Post Plasmoid Plasma Sheet formation

Time evolution of the plasmoid-associated ion burst at Earth

Periodical nature of the reconfiguration process



Reconfiguration events at Jupiter tend to reoccur with an intrinsic time constant of 2 to 5 days. This is seen in the modulation of

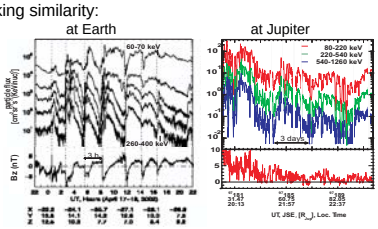
➢ the particle flow anisotropy (from corotational to radially outward or inward direction)

➢ the south-north magnetic field component

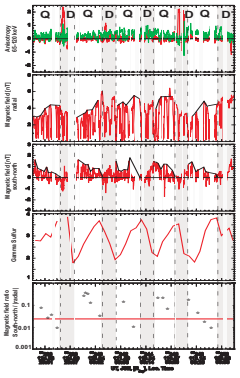
➢ the ion energy spectral index

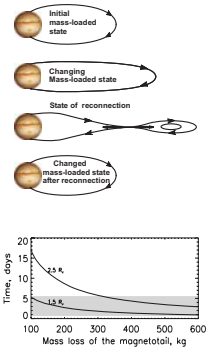
➢ the auroral radio emissions.

Periodical substorms at Earth and Jupiter shows a striking similarity:



Modeling of the periodic process





➢ Thinning of the plasma sheet leads to configuration favoring reconnection

➢ The tearing mode instability is a possible candidate in generation of reconnection

➢ From the local stress balance in the co-rotating system the typical time constant of the reconfiguration process can be estimated:

$$\tau \approx \frac{\frac{B_r^{rec}}{d}\frac{B_\theta^{rec}}{d} - \frac{B_r^0}{d}\frac{B_\theta^0}{d}}{\rho \mu_0 \Omega^2 r}$$

Conclusions

➢ Particle flow bursts are an outstanding signature of a large-scale process leading to a substantial reconfiguration of the jovian magnetotail. Tailward- and inward-streaming particle beams give evidence for reconnection.

➢ The analysis of the reconfiguration events at Jupiter shows similarities to the Earth's substorms, especially tight to the periodical substorms at Earth and Jupiter.

➢ Terrestrial substorms are driven by the interaction of the solar wind with the magnetosphere leading to storage of magnetic energy. For the jovian magnetotail we see no evidence for significant storage of magnetic energy.

➢ The presence of the inherent quasi-periodicity of the reconfiguration events suggests that solar wind – magnetosphere interactions are not the prime driving mechanism.

➢ The reconfiguration is an integral part of a cyclic mass release process which allows the jovian magnetosphere to eject mass and return magnetic flux to the inner magnetosphere. The typical time constant of the reconfiguration process can be explaind by a simple theoretical model.

Publications:

Kronberg E.A., Woch, J., Krupp, N., Lagg, A., Khurana, K.K. and Glassmeier, K.-H., Mass release at Jupiter: Substorm-like processes in the Jovian magnetotail, JGR, 110, A03211, doi:10.1029/2004JA010777, 2005

Kronberg E.A, Glassmeier, K.-H., Woch, J., Krupp, N., Lagg, A., Concerning a possible intrinsic mechanism of Jovian magnetospheric quasi-periodic dynamics, in preparation for GRL.

[a] Contact address : Elena Kronberg E-mail: kronberg@mps.mpg.de

Max-Planck Institut für Sonnensystemforschung, D-37191 Katlenburg-Lindau, Germany