Observations of waves in plasmoids in the magnetosheath

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Abstract

Plasmoids, defined here as plasma entities with a higher anti-sunward velocity component than the surrounding plasma, have been observed in the magnetosheath in recent years. During the month of March 2007 the Cluster spacecraft crossed the magnetopause near the subsolar point thirteen times. Plasmoids with larger velocities than the surrounding magnetosheath were found on seven of these thirteen occasions. The plasmoids approach the magnetopause and interact with it. Both whistler mode waves and waves in the lower hybrid frequency range appear in these plasmoids, and the energy density of the waves inside the plasmoids is higher than the average wave energy density in the magnetosheath. When the spacecraft are in the magnetosphere, Alfvénic waves are observed. Cold ions of ionospheric origin are seen in connection with these waves, when the wave electric and magnetic fields combine with the earth's dc magnetic field to yield an $\vec{E} \times \vec{B}/B^2$ drift speed that is large enough to give the ions energies above the detection threshold [Gunell et al., 2014].

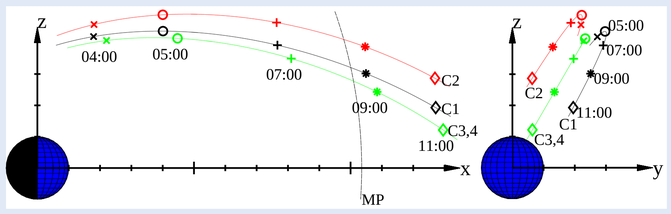

Figure 1: Cluster orbit on 15 March 2007.

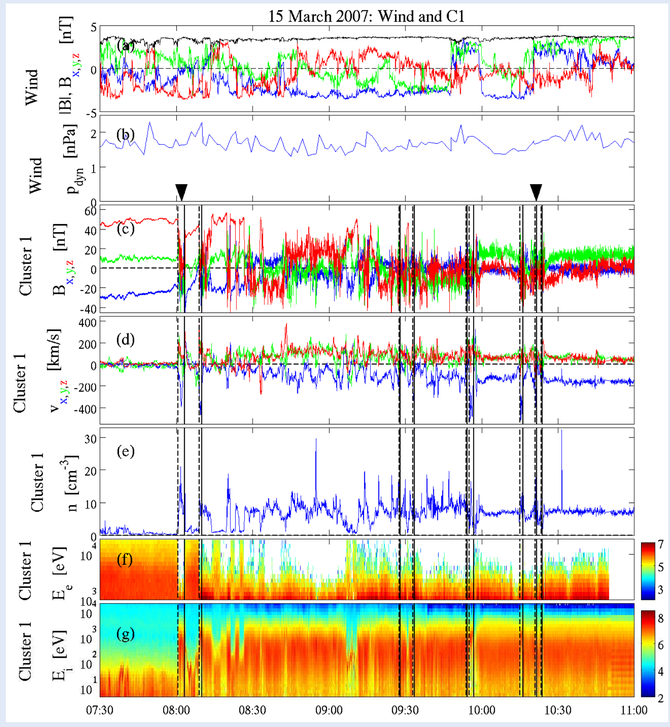

Figure 2: Cluster 1 and Wind data on 15 March 2007.

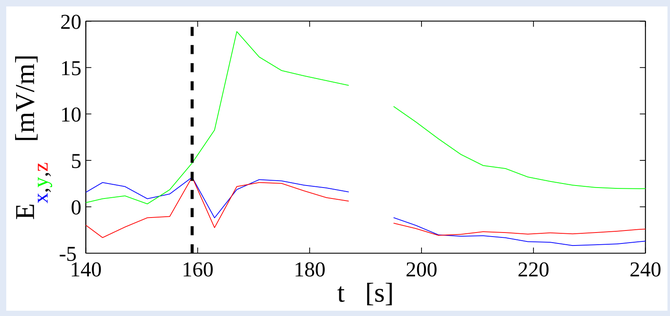

Figure 3: Electric field measured by Cluster 1 at the time of the magnetopause crossing after the plasmoid encounter shown in Fig. 5.

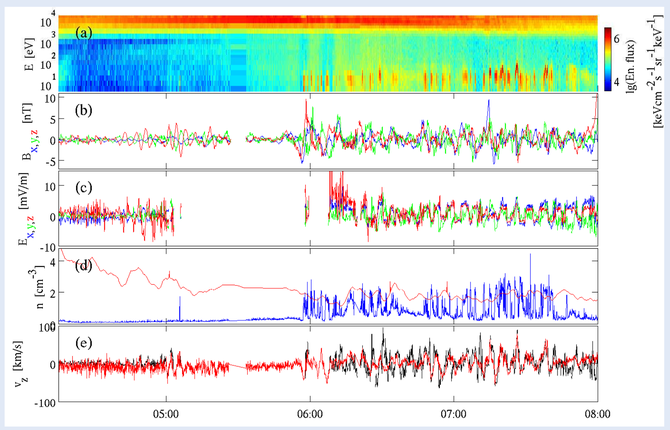

Figure 4: Data from Cluster 1 between 04:15 and 08:00 on 15 March 2007.

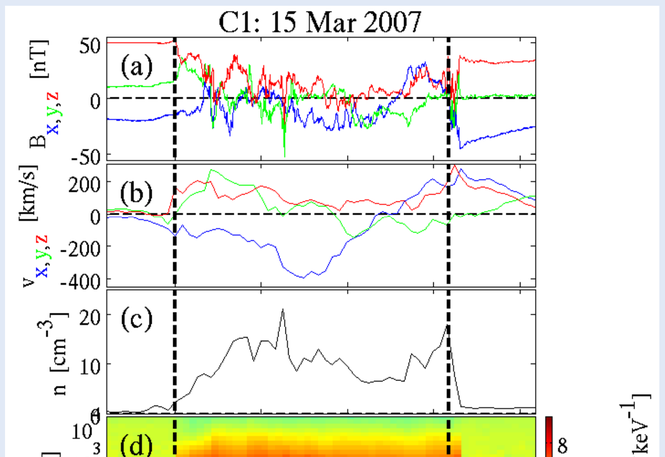

Figure 5: Data obtained by Cluster 1 on 15 March 2007. On the horizontal axis, time $t = 0$ corresponds to 08:00:39 UT. **(a)** Magnetic flux density in GSE coordinates; **(b)** ion bulk velocity in GSE coordinates; **(c)** ion density; **(d)** omnidirectional ion energy spectrum; **(e)** the x component of $\vec{B}$ measured by STAFF in the $0.6 \text{ Hz} \leq f \leq 180 \text{ Hz}$ frequency range; **(f)** power spectral density of $|\vec{B}|$; **(g)** power spectral density of $|\vec{E}|$; **(h)** propagation angle, i.e. the angle between $\vec{k}$ and $\vec{B}$; **(i)** ellipticity; **(j)** degree of polarisation. The vertical dashed lines mark the beginning and end of the plasmoid as it was identified [Gunell et al., 2014]. The blue curves on panels **(f-j)** show $0.1 f_{\text{ce}}$ (upper curve) and f_{lh} (lower curve).

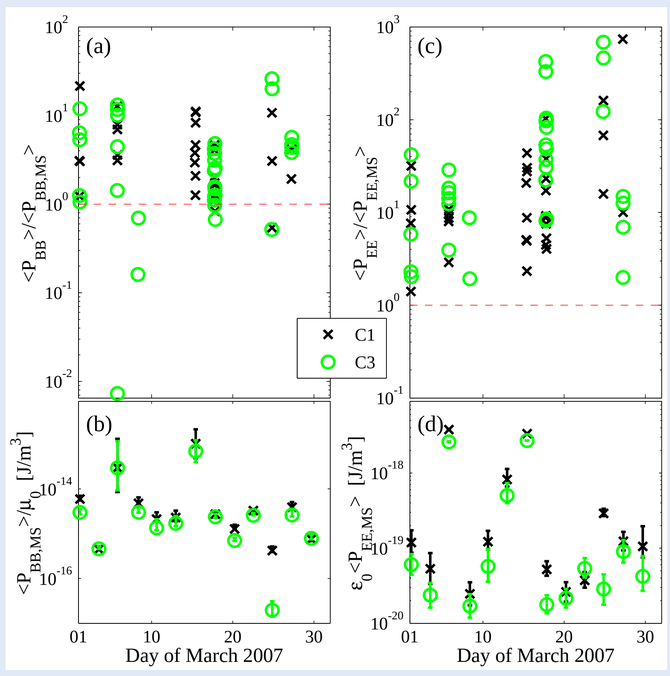

Figure 6: Magnetic and electric energy of waves measured by STAFF.

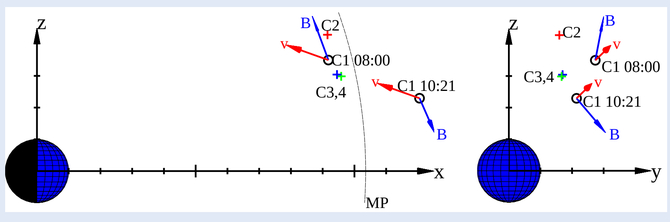

Figure 7: Plasmoid encounters on 15 March 2007. The line marked "MP" shows a Shue model magnetopause.

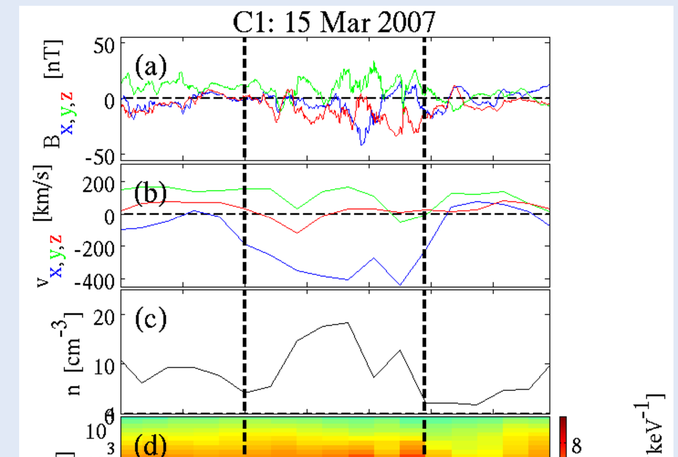

Figure 8: Data obtained by Cluster 1 on 15 March 2007. On the horizontal axis, time $t = 0$ corresponds to 10:21:05 UT. The panels show the same quantities as those in Fig. 5.

Conclusions

- Fast plasmoids were found in the magnetosheath on 7 of the 13 outbound orbits of Cluster 1 and 3 in March 2007.
- There are waves inside these plasmoids – both whistler mode waves and waves in the lower hybrid frequency range.
- The wave energy density is higher in the plasmoids than in the average magnetosheath.
- When the plasmoids hit the magnetopause a cold ion plasma in the magnetosphere is set in motion by means of an $\vec{E} \times \vec{B}$ drift.
- The plasmoid impacts generate Alfvénic waves that are seen deep in the magnetosphere.

Acknowledgement

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References

H. Gunell, G. Stenberg Wieser, M. Mella, R. Maggiolo, H. Nilsson, F. Darrouzet, M. Hamrin, T. Karlsson, N. Brenning, J. De Keyser, M. André, and I. Dandouras. Waves in high-speed plasmoids in the magnetosheath and at the magnetopause. *Annales Geophysicae*, 32(8):991–1009, 2014. doi: 10.5194/angeo-32-991-2014.