CLUSTER MULTI-SPACECRAFT ANALYSIS OF SPATIAL SCALES OF LANGMUIR WAVEPACKETS IN THE FORESHOCK

J. Soucek[1], O. Santolik[1], V. Krasnoselskikh[2], T. Dudok de Wit[2], J. Pickett[3]

(1) Institute of Atmospheric Physics, Prague, Czech Republic (soucek@ufa.cas.cz)
(2) LPCE / CNRS, Orléans, France
(3) Department of Physics and Astronomy, University of Iowa, Iowa, USA

In this study we present the first multi-spacecraft analysis of spatial scales of Langmuir wavepackets in the terrestrial foreshock. The electron foreshock is a region of the solar wind magnetically connected to the bow shock, where beams of energetic electrons reflected by the shock generate electrostatic waves close to the electron plasma frequency [3]. Previous spacecraft observations of these waves reveal that the waves are very narrow-band, strongly modulated and appear in the form of short wavepackets. The observation patterns were previously interpreted in terms of stochastic growth [2], nonlinear processes, wave reflection [5] and other effects.

The four-spacecraft Cluster mission allows for the first time to investigate the spatio-temporal properties of this modulation and to estimate the spatial scales of the wavepackets. As standard amplitude based correlations proved to be ineffective due to instrumental constraints, we developed a spectral matching technique and applied it to high frequency waveform electric field data from the WBD instrument of Cluster [4] to identify simultaneous observations of the same wavepacket on multiple spacecraft. As the wavepackets are very localized, we had to restrict our analysis to multi-spacecraft WBD events observed at the smallest satellite separations of about 100 km. We present results of a detailed analysis of one four-spacecraft foreshock event and a statistics of the results based on data from four different days.

As the waves propagate close to parallel to the ambient magnetic field [1], it is natural to investigate the transverse and parallel scales separately. Our results clearly show, that the level of similarity of the observed spectra seen on a given spacecraft pair is ordered by the separation of the spacecraft in the B-perpendicular direction after a correction for the convection of the wavepacket by the solar wind flow. From the data we can conclude, that typical scales of Langmuir wavepackets in the direction transverse to the magnetic field fall between 40 and 100 km and their size in the parallel direction exceeds 150 km. Translating these spatial scales into the temporal domain by the solar wind flow, we show that the convection of the transverse wavepacket structure may be responsible for the large scale temporal modulation of the wavepacket, but other effects probably contribute to the fine structure of the waves.

References

[1] S. D. Bale, D. E. Larson, R. P. Lin, P. J. Kellogg, K. Goetz, and S. J. Monson. On the beam speed and wavenumber of intense electron plasma waves near the foreshock edge. *J. Geophys. Res.*, 105:27353–27367, 2000.

[2] I. H. Cairns and P. A. Robinson. First test of stochastic growth theory for langmuir waves in earth's foreshock. *Geophys. Res. Lett.*, 24:369–372, 1997.

[3] R. J. Fitzenreiter, J. D. Scudder, and A. J. Klimas. Three-dimensional analytical model for the spatial variation of the foreshock electron distribution function: systematics and comparisons with ISEE observations. *J. Geophys. Res.*, 95:4155–1173, 1990.

[4] D. A. Gurnett, R. L. Huff, and D. L. Kirchner. The wide-band plasma wave investigation. *Space Sci. Rev.*, 79:195–208, 1997.

[5] P. J. Kellogg, K. Goetz, S. J. Monson, and S. D. Bale. Langmuir waves in a fluctuating solar wind. *J. Geophys. Res.*, 104(13):17069–17078, 1999.