ELECTRIC FIELD MEASUREMENTS OF LOW FREQUENCY WAVES ON CLUSTER

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ABSTRACT

The Electric Field and Wave (EFW) investigation on Cluster measures the potential difference between spherical probes in the spin plane of the spacecraft and computes two components of the electric field in that plane. The four-point measurements on Cluster are well adapted for studies of small-scale plasma structures in three dimension from the plasma sphere out to the solar wind for a range of scales. A selection of events from several near-Earth plasma regions is presented where the electric field plays an important role. In particular, data from the four spacecraft show that signatures in the electric field with high coherence are frequently observed for timescales of tens of seconds or longer in many regions along the orbit of Cluster. Attempts are made to determine the detailed characteristics of the waves that are observed and to relate them to physical processes in order to get new insight into small-scale plasma phenomena.

Investigation

A summary is given of observed wave phenomena with special emphasis on the three dimensional characteristics of the waves. The EFW instrument measures the potential difference between spherical probes in the spin plane of the spacecraft and computes the electric field. The potential difference between the probes and the spacecraft is used to obtain the plasma density with high time resolution [1]. The electron density and gradient of electron density are fundamental plasma parameters where EFW can routinely produce spacecraft potential data with a time resolution of 0.2 seconds. The four-point measurements on Cluster are well adapted for studies of small-scale plasma structures in three dimensions from the plasmasphere out to the solar wind for a range of scales. To fully utilize the 4-point possibilities with Cluster the EFW instrument has been designed for detailed study of phenomena on spatial scales corresponding to the separation distance of the four spacecraft and their interpretation of the role they play on a more global scale to shape the properties of different regions along the orbit. Together with rigorous pre-launch testing and calibration programme, a novel design of the probe environment enables EFW to measure electric fields with higher sensitivity than previously obtained in this region. The four-spacecraft Cluster mission provides the first opportunity to determine the three-dimensional time-dependent plasma characteristics. The inter-spacecraft tetrahedron separation determines the scales to be studied. A major consideration for wave observations in a fast-flowing medium is the Doppler effect. Waveform data from four spacecraft in a tetrahedron configuration allow correction for this effect when the wavelength is comparable with the inter-spacecraft separation. If the wavelength is small compared to this distance the determination of the wave normal directions on the four spacecraft yield information about the source location. A selection of events from several near-Earth plasma regions is studied where the electric field plays an important role. In particular, data from the four spacecraft show that signatures in the electric field with high coherence are frequently observed for timescales of tens of seconds or longer in many regions along the orbit of Cluster. Most of the events with wave structure in this frequency range show one or more dominant peaks above 1 mHz. An example with high coherence between all four spacecraft is shown in Fig.1. The internal burst capability of EFW which allows synchronized sampling of both spin-plane electric field components to 9 kHz, opens a window on physics in the VLF regime. The waveform data allows a high degree of flexibility during post-processing. Crossing of the magnetopause often shows many wave phenomena. One example is surface waves with apparent periods of several tens of seconds that are driven by the solar wind or generated through Kelvin-Helmholtz type instabilities. Bidirectional electric field structures are observed in most plasma regions along the Cluster orbit. In particular, very large electric field amplitude structures, 100 mV/m or more, are observed on field lines related to auroral acceleration regions. Studies are initiated to study the details of wave phenomena in the turbulent regions near the magnetopause and to relate them to physical processes.

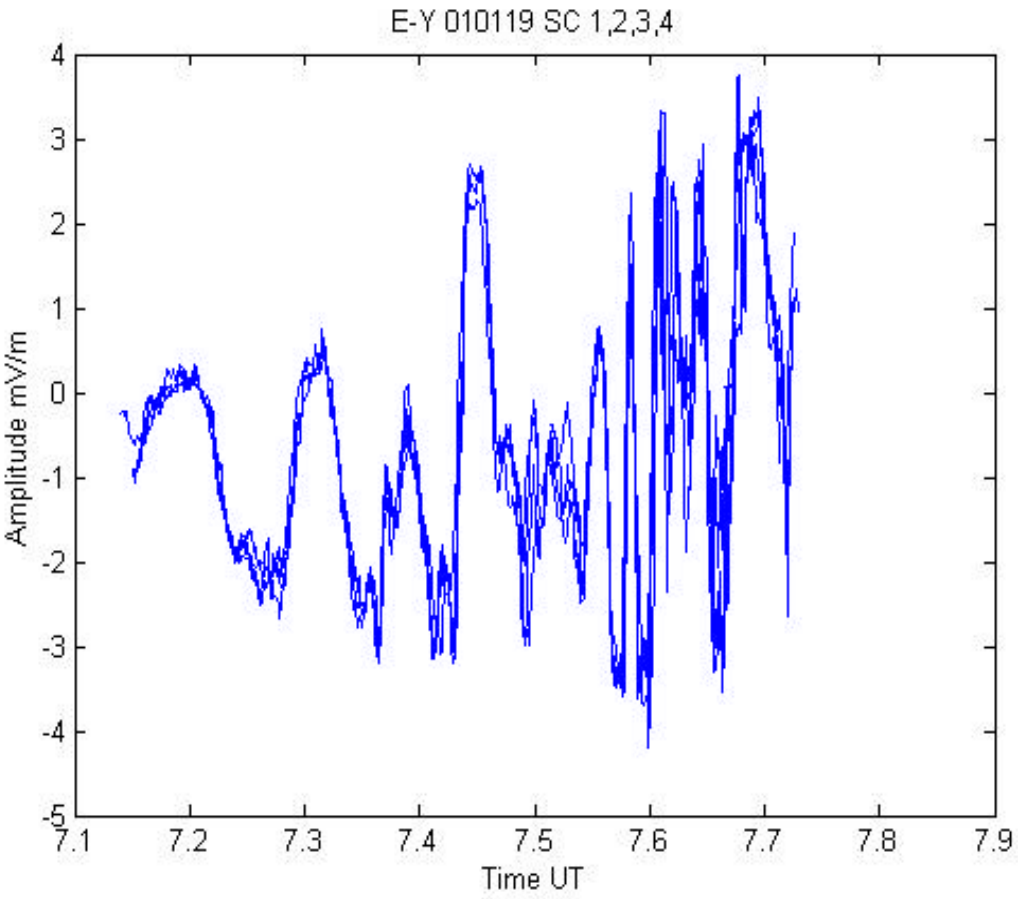

Fig. 1 The y-component of the electric field from all four Cluster spacecraft. Peaks in the spectrum of the data are observed at about 1.5 and 10 mHz.

Reference

[1] First results of electric field and density observations by Cluster EFW based on initial months of operation, *Annales Geophysicae* 19, 1241-1258, 2001