THE MULTI-SPACECRAFT K-FILTERING TECHNIQUE:

APPLICATION TO THE CLUSTER DATA

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ABSTRACT

The four spacecraft Cluster mission open fundamental new possibilities concerning the analysis of complex electromagnetic wave-fields in the key regions of the magnetosphere-solar wind system. Based on the Cluster wave-field measurement a multi-spacecraft data analysis technique called "K-filtering" has been developed. It allows three dimensional electromagnetic structure identification in the wave-field. It is applied to the low frequency magnetic field fluctuations recorded onboard Cluster to estimate the field energy distribution as a function of the angular frequency and the three components of the wave vector. Results are presented and limitations related to the field and the experimental constraints are discussed

INTRODUCTION

Electric and magnetic fields measured in space plasmas commonly show fluctuations in time and space on all observed scales. The determination of the shape and dynamics of three-dimensional structures requires a minimum of four spacecraft arranged in a tetrahedral configuration and equipped with instruments measuring fields and flows in three dimensions. Based on the Cluster wave-field measurement a multi-spacecraft data analysis technique called "K-filtering" [1] has been developed. It allows to obtain an estimate of the frequency wave-vector power spectrum of the wave-field.

The existence of the spectral energy density estimator is based on the hypotheses of time stationarity and space homogeneity of the measured field. The validity of this estimator is also limited by an additional hypothesis requiring that the measured field be free of characteristic wavelengths smaller than the minimum inter-spacecraft distance. Otherwise an aliasing effect develops, which is similar to the one observed in the case of under-sampling of time series.

We selected a Cluster data set coming from the STAFF experiment [2] which is composed of magnetic field fluctuations measured in the solar wind. The selected event is observed simultaneously onboard the four Cluster spacecraft. It appears as a burst of VLF magnetic turbulence that lasted a few minutes with the same frequency characteristics. Applying the K-filtering data analysis technique to this data set we identified the wave vectors associated with the event. Using this information we were able to remove the frequency Doppler shift observed in the Cluster reference frame and to show that the selected event is mainly a planar spatial structure convected by the solar wind.

The presented application is a clear illustration of the interest of multipoint measurements and multipoint K filtering data analysis technique for data interpretation.

REFERENCES

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