Phase Differencing in 3D: Using Cluster Magnetic Field Data and Wavelet Analysis at a Range of Frequencies

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Obtaining the wave vector k is essential to determine the nature of plasma fluctuations. The application of the phase differencing technique to magnetic field measurements from all four Cluster satellites to calculate k has advantages over single or double satellite approach, where assumptions are often required and high error is expected. The aim of this work is to demonstrate that the phase differencing technique can produce sensible results when applied to a range of plasma frequencies. We use the Cluster Fluxgate Magnetometer (FGM) data and a Morlet wavelet to construct four scale-dependant time series. The central locations of wave packets from one satellite can be determined by locating peaks in the time series. These wave packets of one satellite were cross-correlated with corresponding wave packets from the other three satellites to obtain the time differences in the arrival of wave packets at different spacecraft. Phase differences are obtained using these time differences and k can be calculated for each wave packet. Taking Doppler shift into account, a dispersion plot in the solar wind frame can be found. The wave vector space anisotropy of the magnetic field fluctuations can also be explored. Dispersion plots show many wavepackets of low frequencies at low wavenumbers, with a larger spread of frequencies at higher wave numbers. The propagation angle with respect to the scale dependent mean field is more perpendicular than parallel. This work can lead to further insight into plasma fluctuations and turbulence.