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Multi-point measurements of Kinetic Alfven wave like fluctuations in the solar wind and the magnetosheath

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The multiple spacecraft of the Cluster and the Magnetospheric MultiScale Mission enables the wavevector of the turbulent fluctuations in the magnetic fields and other measurements to be determined [1,2]. The orientation of the wavevectors are found to be perpendicular to the mean magnetic field direction and make moderate angles with the bulk flow direction [1]. The fluctuations can then be Doppler shifted from the spacecraft frame into the plasma frame by using the obtained wavevector. The ω -k relation can then be obtained and compared with linear theory. The frequency predictions from linear theory for kinetic Alfven waves (KAW) and for ion Bernstein waves (IBW) are obtained from the New Hampshire Dispersion Solver [3] and are shown in Figures 1a,b. Using two different complementary methods; the Multi point signal resonator technique[4] and Bellan's method [5] we determined the wavevectors and the plasma frame frequencies from MMS in an interval of turbulent magnetosheath are shown in Figure 1c. The frequencies are generally low and consistent with KAW like fluctuations. Broadening around the in the frequency is interpreted as a broadening due to wave-wave interactions [6]. As an additional diagnostic of the fluctuations the ion [7] and electron Alfven ratios are calculated. This is only possible using the high time resolution of plasma data on MMS. The linear theory predictions show that the ion Alfven ratio for KAWs in Fig 1d decreases as the wavevector increases (black line) and increases for the electron Alfven ratio (Fig 1e). For IBWs both the electron and ion Alfven ratios increase. The measured data (Fig 1f) are more consistent with the KAW. The results show that plasma frame frequencies, Alfven ratios, cross correlations of density and magnetic field strength and compressibility supports that fluctuations in the Earth's magnetosheath are more characteristic of KAWs than other modes i.e. IBWs.

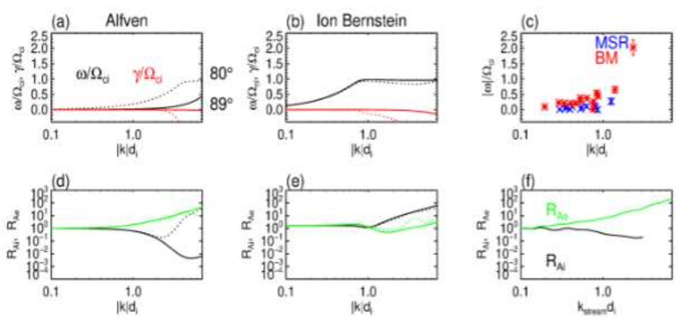

Figure 1. (a) Linear theory prediction for the KAW frequencies (black) and damping rate (red), (b) predicted frequencies for IBWs. (c) Measured plasma frame frequencies from the MSR method (blue) and Bellan's method (red). (d) Ion (black) and electron (green) Alfven ratios for KAWs, (e) Ion and electron Alfven ratios for IBWs (f) the measured data from the MMS spacecraft.

References

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