MMS Analysis of EMIC waves in the magnetosheath

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Using MMS measurements of the electric field, magnetic field, ion density, and ion velocity perturbations, the phase and relative amplitudes of electromagnetic ion cyclotron waves in the magnetosheath are analyzed. We show that the relative phases and amplitudes are consistent with linear theory between all types of measurement combinations, despite $\delta b/B \sim 0.1$. The wave vector was derived using k-filtering, Bellan's method, and multi-component phase analysis, all where found to be consistent to within a 20° cone. To within a sign the k vector direction was also consistent with that from with minimum variance and polarization analysis of the magnetic field. We found a parallel δE component, which we don't understand, and will further investigate it in this paper. No burst data exists for these magnetosheath EMIC events, so high resolution trigger data is used to compute the ion density and velocity perturbations. We validate the trigger data by comparing trigger data with burst mode data during a period when kinetic Alfven waves where observed in the magnetopause boundary layer.

An event will be discussed in detail, for which GEOTAIL, which is 5 R_E upsteam of MMS in the magnetosheath, also detected these waves. Velocity shear in the magnetosheath tends to bend the waves in the anti-shear direction. The current warm plasma ray tracing codes can't handle velocity shear, which is needed to study the effects of shear on the wave propagation. We briefly will discuss the required modifications that must be made to these codes. In lieu of a proper tracing code, we use kludges for wave propagation in an attempt to handle the velocity shear. We will study the convective growth and interconnectivity of waves observed by spacecraft MMS-GEOTAIL separated by large distances (~50 wavelengths) in the magnetosheath. To study the wave propagation in the magnetosheath we will use a modified version of BATSRUS that includes temperature anisotropy and a plasma depletion layer for the magnetosheath ray tracing background.