Probing the foreshock wave boundary

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Foreshock ultralow frequency (ULF) waves play an important role in the dynamics upstream of planetary bow shocks and can affect the downstream magnetosheath region. Due to limited available spacecraft measurements, the waves are often analyzed with incomplete information about their overall spatial structure. Common wave vector analysis techniques built around these limitations often invoke the divergence free condition of the magnetic field without considering the possibility that the wave amplitude profile could have a strong spatial dependence. We explore the consequences of this assumption in the Earth's ion foreshock using both ARTEMIS spacecraft data and a 2-D hybrid Vlasov simulation conducted using the Vlasiator code. The observed foreshock ULF waves have a finite extent in the direction perpendicular to the Interplanetary Magnetic Field, and incorrect application of standard techniques at the boundary yields a false wave vector orientation that may be used as a novel edge detection method. Our results stand as a cautionary tale for wave analysis in other space physics contexts where the wave geometry is less clear.

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