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Whistler, Lower Hybrid and Alfvenic Wave Emission from Magnetically Reconnecting Current Layers
Whistler, Lower Hybrid and Alfvenic Wave Emission from Magnetically Reconnecting Current Layers

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Analysis of whistler mode and Alfven-whistler emissions from magnetically reconnecting current layers can serve as a useful remote-sensing probe of plasma conditions in the vicinity of the electron diffusion region. Whistler waves associated with magnetic reconnection are frequently observed in the Earth magnetosphere (recent examples: Geotail and Cluster satellites; Wei et al., 2007, Eastwood et al., 2009, Le Contel, et al., 2009, etc.) and in laboratory experiments. From the observations, electron beams and electron thermal anisotropy have been identified as possible free energy sources for the whistler/electron cyclotron emission. In addition, kinetic Alfven waves have also been observed to propagate outwards from the reconnection X-line and that these waves may drive significant transport through the diffusion region (Chaston et al., 2005, 2009). Further analysis by Huang et al., 2010 using the Cluster spacecraft indicates highly oblique propagating modes consistent with the Alfven-whistler branch which seem to interpret the measurements. More recently, Khotyaintsev et al, 2011 have analyzed wave-particle interactions in the flux pile-up region of reconnection jet outflows in the magnetotail using Cluster spacecraft. Their analysis shows whistler waves and lower hybrid fluctuations and suggest they play a role in energy conversion during plasma jet breaking. In light of these observations we make comparisons with kinetic simulations. In our previous work, using 2D electromagnetic particle-in-cell model with adaptive mesh refinement in a Harris-type current sheet (Fujimoto and Sydora, Geo. Res. Lett., vol. 35, L19112 (2008)), we found that whistler modes driven by electron temperature anisotropy transiently formed in the downstream region of the electron outflow where the magnetic field is intensified due to pileup of the field lines. The maximum wave power from the unstable electromagnetic fluctuations ranged from 0.1 to 0.6 of the local electron cyclotron frequency and the quasi-parallel propagating (right-hand polarized) whistler modes were found to contribute weakly to the electron momentum transport. In this presentation we extend our previous results and analyze electron and ion beam-generated whistler fluctuations and Alfven-whistler modes in the vicinity of the outflow regions. A theoretical analysis of the maximally unstable modes and wave polarization properties are presented based on parameters consistent with Cluster spacecraft X-line encounters. We find that whistler mode fluctuations are capable of increasing the phase space density up to 2keV and higher within a second time scale and play a role in beam generation. Implications of these results to future missions, such as MMS, will also be presented along with possible laboratory experiments.

キーワード: magnetic reconnection, plasma waves, kinetic simulation, particle acceleration, energy transport
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