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# Whistler and Alfven-Whistler Mode 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's magnetosphere (Cluster and Themis satellites; Wei et al., 2007, Eastwood et al., 2009, Le Contel, et al., 2009) 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. 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 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 encounter. Particle simulations are used to assess the momentum transport contribution from the lower frequency Alfven-whistler modes. Implications of these results to future missions, such as MMS, will also be presented.