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Whistler Waves Observed in Electron Diffusion Region of Collisionless Magnetic Reconnection

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Previous studies found that the whistlers in the separatrix region can propagate toward or away from the X-line during the magnetic reconnection process[1]. However, whether the whistlers can propagate into the electron diffusion region (EDR) and X-line along the separatrix is still unclear. There are few observations reported that the quasi-parallel whistlers are excited inside the EDR[2, 3]. These whistlers have small propagation angles with respect to the ambient magnetic field and are generated by the temperature anisotropy inside the EDR. The whistlers are suggested to contribute to reconnection triggering and anomalous resistivity[2]. However, so far, there is no direct evidence to confirm that. Burch et al. [4] reported the oscillatory reconnection electric fields within the EDR which characteristics are consistent with oblique quasi-electrostatic whistlers, but the generation mechanism has not been revealed. Thus, the sources and effects of whistlers inside EDR are necessary to further investigate.

We investigate the whistler-mode waves around the X-line of a magnetic reconnection observed by the Magnetospheric Multiscale mission on December 23, 2016. Such whistler-more waves propagate quasi-parallel to the ambient magnetic field. They come from the outside of the electron diffusion region (EDR), then propagate into the X-line, rather than locally excited within the EDR (Figure 1). The dispersion relation of the whistler-mode waves is measured for the first time within the EDR of magnetic reconnection, which shows that the cold plasma dispersion relation has remained for these waves (Figure 2). There is no evidence showing that these whistler-mode waves control the dissipation processes or efficiently scatter the electrons within the EDR. Our results reveal that the quasi-parallel whistler waves originated from the outside of the EDR may not be important for the kinetic process of reconnection at X-line.

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References

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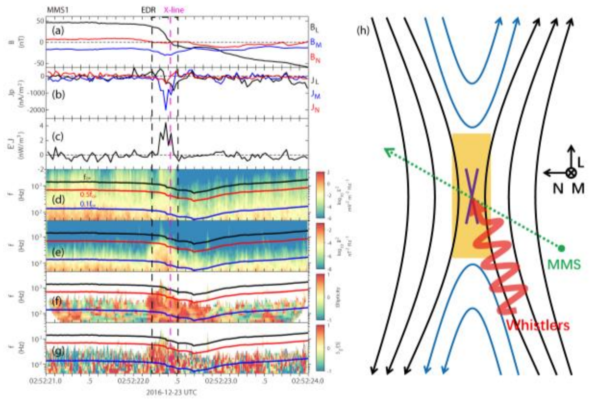

Figure 1. Whistler waves are observed in an electron diffusion region. Three components of magnetic field (a) and current density (b); (c) energy dissipation $J \cdot E' = J \cdot (E + Ve \times B)$; The electric field (d) and magnetic field (e) power spectral density; (f) ellipticity and (g) normalized parallel Poynting flux; (h) illustrated of spacecraft trajectory and propagating whistler-mode waves.

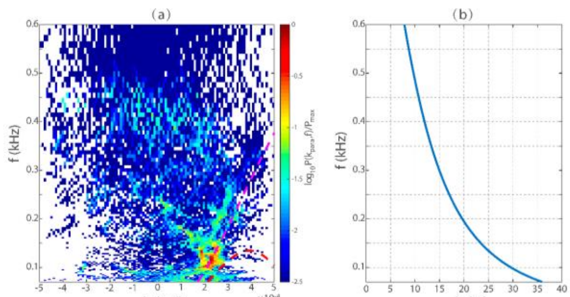

Figure 2. Features of the whistler-mode waves. (a) The dispersion relation of propagating whistler-mode waves observed by MMS. The Purple dashed curve presents the cold plasma dispersion relation. The red dashed curve presents the whistler dispersion relation (wave propagation angle is 0°) calculated by WHAMP based on local electron distribution. (b) The frequency-wavelength function is based on the cold plasma dispersion relation.