Investigation of the magnetic neutral line region with the frame of two-fluid equations

Yuki Kobayashi[1]; Yasunori Tsugawa[1]; Naritoshi Kitamura[2]; Akimasa Ieda[3]; Yoshizumi Miyoshi[1]; Shinsuke Imada[4]; Yoshifumi Saito[5]; Shoichiro Yokota[6]; Shinobu Machida[4]
[1] ISEE, Nagoya Univ.; [2] University of Tokyo; [3] ISEE, Nagoya Univ.; [4] ISEE, Nagoya Univ.; [5] ISAS; [6] Osaka Univ.

Magnetic reconnection is a basic physical process by which energy of magnetic field is converted into the kinetic energy of plasmas. In recent years, the MMS mission consisting of four spacecraft has been conducted to elucidate the physical mechanism of magnetic field merging in the vicinity of magnetic neutral lines that exist in the central part of structures. In this study, we examine the causal relationship between electron and ion dynamics in the frame of two fluid equations.

In the initial report using MMS data, Torbert et al. [2016] evaluated the anomalous resistivity based on generalized Ohm's law. However, the verification what kind of wave is responsible for the anomalous resistivity was left as an open question.

In this study, we try to clarify this issue, adopting two-fluid equations to the two events which occurred around 2015-10-16 / 13: 07 UT and 2016-11-23/07:49UT. In the two-fluid equations, all terms other that the collision term R can be directly evaluated from observational data, so that the value of R which can be regarded as anomalous resistivity in collisionless magnetic reconnection. By comparing absolute values of electron collision term with observed wave intensities, we investigated what kind of wave is responsible for the anomalous resistivity. As a result of the analysis, the absolute value of electron collision term and the intensity of the lower hybrid waves (LHWs) were found to be highly correlated, indicating that LHWs were responsible for anomalous resistivity. Theoretically, the collision terms represent internal forces exerted between electrons and ions, so that their collision terms should be anti-correlated. Such a tendency can be seen for the first event, but not seen for the second event, which may depend on the spacecraft separations. In fact, the separations were about 13 km and 7 km for the first and second events, respectively.