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

Yuki Kobayashi[1]; Shinobu Machida[2]; Naritoshi Kitamura[3]; Yoshifumi Saito[4]; Akimasa Ieda[5]; Shinsuke Imada[2]; Yoshizumi Miyoshi[1]
[1] ISEE, Nagoya Univ.; [2] ISEE, Nagoya Univ.; [3] ISAS/JAXA; [4] ISAS; [5] ISEE, Nagoya 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, MMS mission consisting of four spacecraft has been conducted aiming at elucidating the physical mechanism of merging the magnetic fields in the vicinity of the magnetic neutral line that exists in the central part of the structure. In this paper, we examine the magnetic field frozen in relation near the magnetic neutral line as well as the causal relationship between electron and ion dynamics in the frame of two fluid equations. It is thought that the electron dissipation region with the thickness of about the electron inertial length surrounds the magnetic neutral line, and the ion dissipation region with the thickness of about the ion inertia length further surrounds them. Theoretically, it is shown that electrons are frozen-in to the magnetic fields while ion-frozen-in relation is broken in the ion dissipation region. However, when we examined the observational data around 1307 UT on October 16, 2015 when MMS spacecraft passed through the vicinity of the magnetic neutral line [Burch et al., Science 2016] , it was confirmed that the frozen-in relation was not established for electrons in the ion dissipation region. In addition, we found that intense wave electric field activities in this region. From the spectral analysis of the waves, it turned out that their characteristic frequencies are the lower-hybrid and electron cyclotron frequencies.In the framework of the two-fluid equation, we can evaluate the values of each term of the equations of motion for both ions and electrons except for the collision term from MMS spacecraft data. Therefore, it is possible to obtain collision terms for both species. Since magnetospheric plasma is basically collisionless, it is considered that the collision term is due to anomalous resistivity associated with the excited waves . On the other hand, in the usual two-fluid equation system, the two vectors corresponding to the collision terms of ions and electrons have the same absolute value. Because the force exerted between the two is the internal force, they should face exactly in the opposite direction. However, the vectors corresponding to the collision terms obtained by using the actual data did not satisfy such a condition. In the previous presentation (JpGU, 2017), we reported that the momentum carried by the waves cannot be neglected, and also some instrumental error for measuring physical parameters may cause such a discrepancy. Moreover, the frequency of the low-hybrid wave is about 10 Hz, so that its period is100 ms which is almost the same to the sampling time of 150 ms for the ion measurement. Therefore, the time average is not sufficient to evaluate the collision term correctly, and it is natural that term does not cancel out with the electron collision term.After careful examination, we conclude that the effect of the anomalous resistivity in the ion dissipation region acts to some degree that cannot be ignored in the equation of motion of the two-fluid system.