地球磁気圏尾部リコネクション領域におけるイオン・電子温度のフロー速度依存性

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Dependence of ion and electron temperatures on bulk flow speed in the near-Earth reconnection regions

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It remains an unresolved problem what determines the energy partition between ions and electrons during magnetic reconnection. It is thus important to investigate ion electron temperature ratio around the reconnection regions. Plasma in the Earth's magnetosphere are heated up to 1-10 keV and stored in the plasma sheet in the magnetotail. Magnetic reconnection is a major process that heats/accelerates plasma up to this energy range by releasing the magnetic energy accumulated in the lobe. Heated/Accelerated plasma are transported both earthward and tailward as fast flows with a speed of several hundred kilometers per second or faster. Such fast plasma flows have been observed in the plasma sheet [e.g., Angelopoulos et al., 1994] and are termed as bursty bulk flows (BBFs). It has been reported that the properties of plasma sheet plasma such as ion temperature T_i, electron temperature T_e, and ion electron temperature ratio T_i/T_e depend on fast flow conditions and spatially vary [Kaufmann et al., 2005, Wang et al., 2012, Runov et al., 2018]. However, there have been few studies which focus on macroscopic profiles of ion and electron temperatures around reconnection regions in the magnetotail.

In this study, we examine the average profiles of the temperatures and their ratio in the plasma sheet in the range of -25 $R_E < X_{GSM} <$ -15 R_E and -10 $R_E < Y_{GSM} <$ 10 R_E by using data obtained from MMS for a period from May 1st to September 30th in 2017. We reconstruct both inflow and outflow regions of the reconnection using the X and Z components of the magnetic field. We then present spatial characteristics of ion and electron temperatures and their ratio. We also examine the flow speed dependence of the spatial characteristics.

Our analysis shows that T_i, T_e and entropy increase as they get farther from the neutral point in the outflow region. The entropy increase indicates nonadiabatic heating. T_i/T_e in the outflow region are smaller than in the inflow region. Both T_i and T_e decrease with increasing flow speed for earthward flow. T_i do not change when flow speed increases in the outflow regions while T_e decrease with increasing flow speed for tailward flow so that T_i/T_e in tailward flow are larger than in earthward flow.

The results suggest that electrons are heated more effectively than ions on the separatrix. In addition, the results indicate that less energy partitions into thermal energy when more energy partitions into kinetic energy if magnetic field in lobe regions are constant.