Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PEM26-P05 Room:Convention Hall Time:May 24 18:15-19:30

Electron temperature anisotropy during compression of current sheets thicker than the ion skin depth

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Collisionless magnetic reconnection drives explosive release of magnetic energy to kinetic and thermal energy of plasmas in space plasma phenomena, such as solar flares and convection of plasmas and magnetic fields in the Earth's magnetosphere. Satellite observations in the Earth's magnetotail have shown that an initial current sheet ten times thicker than the local ion skin depth gets as thin as the ion skin depth, when magnetic reconnection is triggered in the sheet. According to the linear analysis of the tearing instability, the thicker the thickness of current sheets is, the exponentially lower the growth rate is, while the stronger the anisotropy of plasmas is, the higher the growth rate is. Current sheets can be thin due to the Dawn-Dusk electric field associated with the convection of magnetic fields in the Earth's magnetosphere and effects of the lower-hybrid drift instability. However, it is not fully understood how magnetic reconnection is triggered in a current sheet much thicker than the ion skin depth.

In this study, we perform the current sheet thinning by using the one-dimensional PIC simulation imposed the Dawn-Dusk electric field at boundaries with various initial parameters. We investigate the dependence on the initial parameters of the strength and the distribution of the anisotropy and of the compression level of current sheets. The results show that (1) the distribution of the anisotropy changes with the initial thickness of current sheets, (2) the strength of the anisotropy at the center of current sheets is explained by the adiabatic heating perpendicular to magnetic fields regardless of the initial parameters, (3) the compression level of current sheets normalized by the local ion skin depth is much lower than the ratio of the terminal strength of the lobe magnetic field to the initial strength of that. These results can be useful to understand processes of the current sheet thinning and the trigger of magnetic reconnection in multidimensional simulations including the tearing instability and/or the lower-hybrid drift instability.

Keywords: magnetic reconnection