地球磁気圏尾部で観測された磁気リコネクションによる非熱的プロトン加速の統計解析

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Statistical study on the suprathermal proton acceleration in magnetic reconnection observed in the Earth's magnetotail

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Magnetic reconnection is believed to be one of the most important agents for producing energetic particles in various environments in space, since it rapidly converts stored magnetic energy into particle energy. In the Earth's magnetotail, energetic electrons and ions accelerated up to several hundreds keV are observed accompanied by fast flows induced by reconnection [e.g., Mobius et al., 1983]. In solar flares, a significant fraction of the released magnetic energy is transferred to energetic electrons and ions, with ions reaching energies in the range of GeV [e.g., Lin et al., 2003]. In the solar wind, however, no significant energetic particles (> 50keV) are found associated with reconnection encounters [Gosling et al., 2005]. What determines the energetic particle acceleration in reconnection is an open question which need to be solved in order to get integrated understanding over high-energy phenomena in the solar-terrestrial environment.

In this paper, we report on the statistical study on the suprathermal proton acceleration in reconnection observed in the Earth's magnetotail by the Geotail spacecraft. Suprathermal protons accelerated up to several hundreds keV are observed in the reconnection outflow region characterized by fast bulk flows and heated electrons. Suprathermal protons exhibit a power-law spectrum with the typical power-law index 4-5. We statistically studied the relationship between the observed suprathermal protons and the estimated reconnection parameters such as the reconnection rate and the thickness of the current sheet. We found that the power-law index of suprathermal protons is harder when the reconnection rate is larger. We also found hard spectrum and large flux of suprathermal protons when the thin (comparable to the ion inertia length) current sheet is observed. The similarities/differences with energetic electrons will be discussed as well.