磁気リコネクションにおける高エネルギー電子加速が起きやすい条件

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Favorable conditions for energetic electron acceleration during magnetic reconnection

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Magnetic reconnection has been discussed as one of the important mechanisms for plasma heating and particle acceleration in space. One of major aspects of magnetic reconnection is rapid energy conversion of stored free magnetic energy to kinetic, thermal, and nonthermal particle energy. These energy conversions are fundamental and essential to understand dynamical behavior of plasma in the Earth's magnetosphere. The fundamental and important question of magnetic reconnection is what determines the energy distribution rate from magnetic field energy to plasma particle energies. Especially, it is important to understand what conditions control particle acceleration efficiency during magnetic reconnection. To answer it, we have studied favorable conditions for energetic electron acceleration during magnetic reconnection in the Earth's magnetosphere using the Geotail data. We have found the strong energetic electron acceleration in some reconnection events. On the other hand, the other reconnection events show weak electron acceleration. We have studied the reconnection characteristics for 10 events in which the Geotail satellite observed the vicinity of the diffusion region to discuss what reconnection characteristics determine energetic electron acceleration efficiency. We have classified the relationship between the reconnection characteristics and the electron acceleration efficiency into three types: (1) good correlation (absolute value of correlation coefficient |r|> 0.6); (2) ambiguous correlation (0.6 >|r|> 0.3); and (3) no correlation (0.3 > |r|). We found that ion heating, electron heating, current sheet thickness, reconnection electric field, and converging normal electric field could be categorized into good correlation. Ion/electron temperature ratio, total amount of reconnected magnetic energy, and reconnection rate were classified in ambiguous correlation. We could not find any correlation between energetic electron acceleration efficiency and absolute value of outflow velocity, current density parallel to magnetic field (Hall current system), and satellite location in the Earths magnetosphere. From our analysis we claimed that the electrons are efficiently accelerated in a thin current sheet during fast reconnection events.

GEOTAIL 衛星を用いて、磁気圏尾部で起こる磁気リコネクションで、どのようなときに高エネルギーの電子が加速されやすいかを議論する。いくつかの磁気リコネクションイベントでは強い加速が観測された。また、いくつかのイベントでは加速がほとんど観測されなかった。磁気リコネクションの特徴と高エネルギーの電子が加速の関係について議論するため、１０例のイベントについて解析をおこなった。結果、イオン・電子加熱、電流層の厚み、リコネクション電場、分極電場は電子加速と非常に良い相関を示す事がわかった。また、電子・イオンの温度比や、解放された総磁気エネルギー、リコネクションレートは弱い相関を示した。一方、アウトフロー速度、沿磁力線電流、衛星の観測位置には電子加速との相関が認められなかった。これらの結果をこれまで提案されている理論モデルと比較し、結果として、薄い電流層で起こる磁気リコネクションは効率的に電子を加速するのではないかと考えている。