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Experimental study of energy conversion in the magnetic reconnection layer[1]

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Magnetic reconnection, in which magnetic field lines break and reconnect to change their topology, occurs throughout the universe: in solar flares, the earth's magnetosphere, star forming galaxies, and laboratory fusion plasmas [1]. The essential feature of reconnection is that it energizes plasma particles by converting magnetic energy to particle energy; this process both accelerates and heats the plasma particles. Despite the recent advances of reconnection research, the exact mechanisms for bulk plasma heating, particle acceleration, and energy flow channels remain unresolved. In this work, the mechanisms responsible for the energization of plasma particles in the magnetic reconnection layer are investigated in the MRX device together with a quantitative evaluation of the conversion of magnetic energy to ions and electrons. A comprehensive analysis of the reconnection layer is made in terms of two-fluid physics based on the measurements of two-dimensional profiles of 1) electric potential, 2) flow vectors of electrons and ions, and 3) the electron temperature, T_e and the ion temperature, T_i in the layer. It is experimentally verified that a saddle shaped electrostatic electric potential profile is formed in the reconnection plane. Ions are accelerated across the separatrices by the strong electrostatic field and enter the exhaust region where they become thermalized [2,3]. Electron heating is observed to extend beyond the electron diffusion region, and non-classical heating mechanisms associated with high frequency fluctuations is found to play a role. Our quantitative analysis of the energy transport processes and energy inventory concludes that more than 50 % of magnetic energy is converted to plasma particles, of which 2/3 transferred to ions and 1/3 to electrons. The results which demonstrate that conversion of magnetic energy occurs in a significantly larger region than theoretically considered before, are compared with the two-fluid simulations and the recent space measurements [4]. Broader implication of the present results will be discussed.

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[3] M. Yamada et al, Submitted *to Nature Communications* (2014).
[4] J. P. Eastwood *et al.*, *Phys. Rev. Lett.* **110**, 225001 (2013).

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