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合体球状トカマクの電子加熱
Electron Heating in Merging Spherical Tokamaks

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When two plasmas merge together to form a single plasma, magnetic field lines reconnect, and their energies are converted to the plasma kinetic or thermal energies during a very short period. It has been reported that electrons are heated inside the current sheet during magnetic reconnection, while ions are heated at around the two downstream areas [1]. However, compared to the ion heating, the electron heating has not been clarified in detail, e.g., when and where in the current sheet electrons are heated. This work determined that the electrons are locally heated at the merging X-point in the Mega Ampere Spherical Tokamak (MAST) device, which is the world's largest plasma merging device.

MAST has the highest magnetic field (~0.6 T) and Lundquist number (10^6–10^8) among the merging laboratory plasma devices. The plasma merging start-up method in MAST is called merging-compression, which creates two initial plasmas around a pair of in-vessel poloidal field coils by its current ramping down and merges them at the mid-plane. In MAST, initial currents up to 500 kA and initial electron heating up to 1.2 keV were measured during the merging-compression plasma formation. Figure 1 shows the two-dimensional electron temperature profile at 10 ms, which is about 5 ms after the merging. Several shots, which were vertically controlled by the in-vessel coils, were used to reconstruct the two-dimensional electron temperature profile. The narrow central electron temperature peak is approximately circular, having almost the same width in the radial and vertical directions. In addition, there is a structure surrounding the central peak like an outer rim. Data from a different series of shots with larger outer rim structure, in which the filling gas pressure was lower than those in the shots of Fig. 1, made it clear that the outer rim structure also had a circular shape. The origins of these structures are considered to be as follows. The electrons are heated inside the current sheet by the toroidal electric field produced by reconnection via Joule heating. This expectation is supported by the fact that the electron heating was observed both with the CS and without the CS. However, most of the heated electrons flow to the downstream and only a narrow peak at the X-point region remains. The relaxation from the hot ions, which were heated by reconnection in the downstream areas, makes another electron temperature peaks in the plasma edge. After the plasma merges and forms closed surfaces, the temperature peaks at the edge create an outer rim structure surrounding the central peak.

[1] Y. Ono *et al.*, Phys. Rev. Lett. **107**, 185001 (2011).

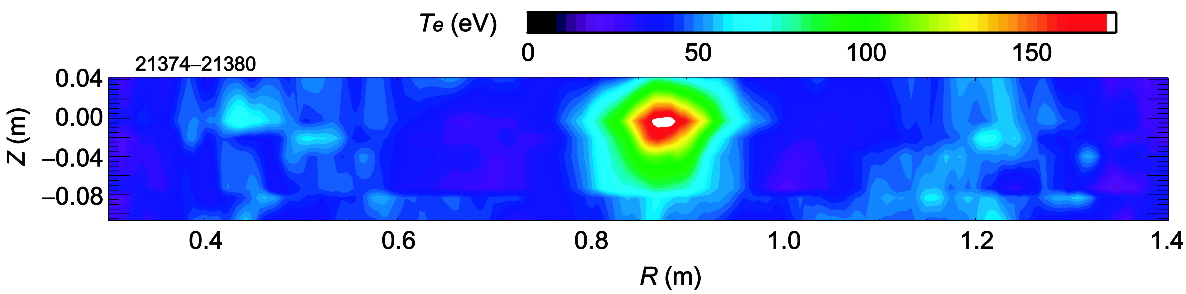

Fig. 1. Two-dimensional electron temperature profile at 10 ms measured with ruby Thomson scattering. Several vertically controlled shots were used. Almost circular narrow peak at the X-point and a structure like an outer rim surrounding the central peak were observed.