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Full-2D imaging measurement of ion heating/transport process during high field merging experiment in TS-6

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Ion heating/transport and its fine structure formation processes through magnetic reconnection have been investigated by high guide field tokamak merging experiments in TS-3 and TS-3U (TS-6). In addition to the previously reported demonstration of high temperature plasma startup without center solenoid, detailed fine structure formation process of reconnection heating has been revealed using a new 96CH/320CH ultra-high-resolution 2D ion Doppler tomography diagnostics which covers full-volume of two merging flux tubes and also satisfies a sufficient spatial resolution in the order of ion gyro radius: typically ρ_i < 20mm in high guide field reconnection. By identifying double-axis field configuration of merging tokamaks with X-point at the midplane using 150CH in-situ magnetic probe diagnostics, the high resolution imaging measurement successfully revealed that ion temperature profile forms two types of characteristic heating structure both around X-point and downstream. The former is affected by Hall effect to form tilted heating profile (fine structure inside the diffusion region tilts poloidally into $j_{Hall} \times B_t$ direction), while the latter is affected by transport process which forms poloidally double-ring-like structure by field-aligned parallel heat transport. Achieved ion heating mostly depends on reconnecting component of magnetic field ($\Delta T_i \propto B_{rec}^2$) and the contribution of guide field to decrease heating efficiency tends to be saturated in high guide field regime when guide field ratio is sufficiently high $B_t > 3B_{rec}$. Under the influence of better toroidal confinement with higher guide field, the downstream ion heating is transported vertically mostly by parallel heat conduction ($\chi^i_{//}/\chi^i_{\perp} \sim 2(\omega_{ci}\tau_{ii})^2 > 10$: perpendicular heat transport is strongly suppressed by high guide field which increases ion gyro frequency related to the transport coefficients) and finally forms poloidally ring-like hollow distribution aligned with closed flux surface at the end of merging.

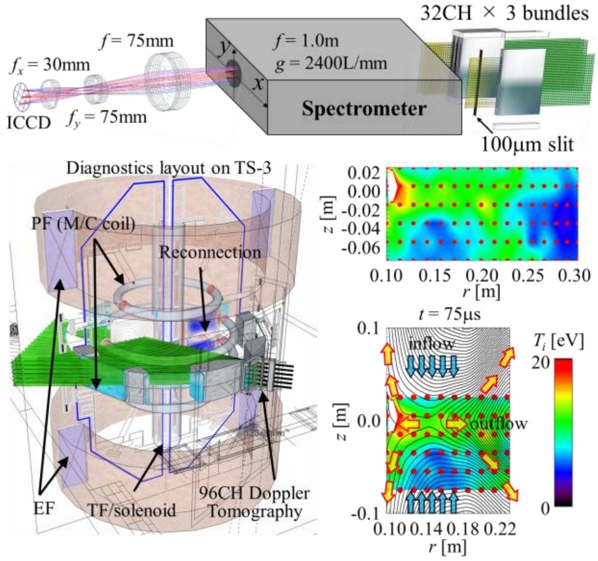

Figure 1 96CH 2D ion Doppler tomography diagnostic which enables clear visualization of fine structure formation process during merging/reconnection in TS-3. Ion temperature increases both inside current sheet and downstream region of reconnection outflow [8].

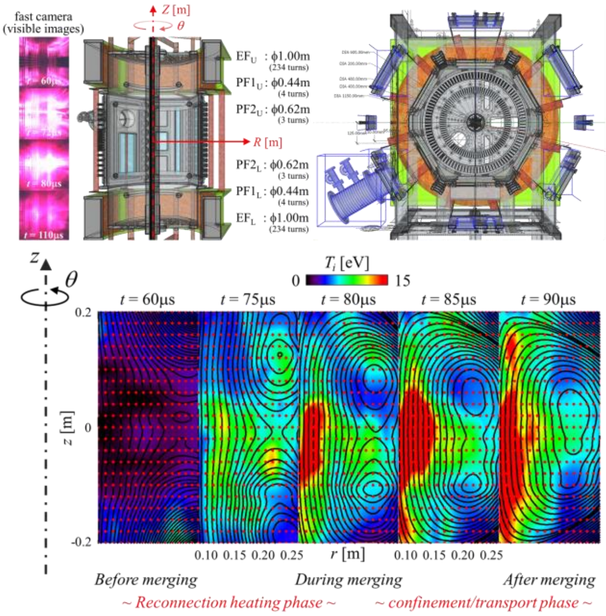

Figure 2 Full-2D/ultra-high-resolution measurement of ion temperature profile in TS-3U (TS-6) merging experiment which enables global diagnostics access. In addition to the microscopic feature of reconnection heating around X-point, global thermal transport process has clearly been visualized in the new experiment [8].

References

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