Recent progress of magnetic reconnection research in the MAST spherical tokamak

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In the last three years, magnetic reconnection research in the MAST spherical tokamak achieved major progress by use of new 32 chord ion Doppler tomography, 130 channel YAG- and 300 channel Ruby-Thomson scattering diagnostics. In addition to the significant plasma heating up to \( \sim 1\text{keV} \) [1], detailed full temperature profile measurements including the diffusion region have been achieved for the first time. 2D imaging measurements of \( T_i \) and \( T_e \) profiles have revealed that magnetic reconnection mostly heats ions globally in the downstream region of outflow jet and electrons locally at the X-point [2]. The higher toroidal field in MAST (\( B_t > 0.3\text{T} \)) strongly inhibits cross-field thermal transport scaling as \( 1/B_t^2 \) and the characteristic peaked \( T_e \) profile at the X point is sustained on a millisecond time scale. In contrast, ions are mostly heated in the downstream region of outflow acceleration inside the current sheet width (\( c/\omega_{pi} \sim 0.1\text{m} \)) and around the stagnation point formed by reconnected flux mostly by viscosity dissipation and shock-like compressional damping of the outflow jet. Toroidal confinement also contributes to the characteristic \( T_i \) profile, forming a ring structure aligned with the closed flux surface. There is an effective confinement of the downstream thermal energy due to a thick layer of reconnected flux. The characteristic structure is sustained for longer than an ion-electron energy relaxation time (\( \tau_{ei} \sim 4 - 11\text{ms} \)) and the energy exchange between ions and electrons contributes to the bulk electron heating in the downstream region. The toroidal guide field mostly contributes to the formation of a localized electron heating structure at the X-point but not to bulk ion heating downstream. [1] Y. Ono et al., Phys. Plasmas 22, 055708 (2015). [2] H. Tanabe et al., Phys. Rev. Lett. 115, 215004 (2015).

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