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EX/8-2: High Power Heating of Magnetic Reconnection for High-Beta ST Formation in TS-3 and UTST ST Merging Experiments

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The high-power reconnection heating of spherical tokamak (ST) has been studied in TS-3 merging experiment as a promising solenoid (CS)-less startup and also as a new type of efficient heating method. Our 2-D measurements of plasma flow, magnetic field, ion temperature T_i and electron density has first verified the mechanism of merging formation of the high-beta ST with significant ion heating of magnetic reconnection. When two ST plasmas merge axially together, the produced reconnection (X) point transforms inflows of their private magnetic fluxes into outflows of common flux of the produced new ST. The reconnection outflow accelerates plasma ions quickly up to the order of Alfven speed. Our 2-D Mach probe measurement clearly shows that the bi-directional inflow is transformed into the fast bi-directional outflow and also that the outflow velocity abruptly decreases to 1/3 at the down-stream where the ion temperature peaks. Our 1-D Doppler probe, electrostatic probe and magnetic probe measurements indicate that both of electron density and magnetic field strength change abruptly at two downstream positions where the outflow velocity damps. Their damping ratios ~2-3 almost satisfy the Rankine-Hugoniot relation. Those facts indicate that the accelerated ions are thermalized at the two downstream areas with the fast shock. The fast shock and/or viscosity damping of those ions probably forms two hot spots in the downstream. Unlike the reconnection heating caused by current-driven instabilities, the thermalized ions are confined by a thick layer of reconnected magnetic flux surrounding the X-point, forming a high-beta ST often with absolute minimum-B profile. After the fast shock forms the hollow magnetic field profile during the reconnection, this absolute min-B profile is often maintained after the merging/ reconnection. The series of our experiments indicate that ion temperature (thermal energy) increment is proportional to the square of the reconnecting poloidal magnetic field B_p. Since the ion outflow velocity close to Alfven speed scales with B_p, the T_i (and ion thermal energy) increment scales with its square. The reconnection outflow and fast shock damping quickly produce MW-class ion heating power (<30MW in TS-3) based on the square scaling of B_p, forming the absolute min-B profile quickly.

Country or International Organization of Primary Author

Japan

Primary author: Mr ONO, Yasushi (Japan)

Co-authors: Mr TANABE, Hiroshi (University of Tokyo); Mr KADOWAKI, Kazutake (University of Tokyo); Mr YAMASAKI, Kotaro (University of Tokyo); Dr YAMADA, Takuma (University of Tokyo); Mr KAMINO, Yasuhiro (University of Tokyo); Dr HAYASHI, Yoshinori (University of Tokyo)

Presenter: Mr ONO, Yasushi (Japan)

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