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Effects of Reconnection Downstream Conditions on Electron Parallel Acceleration during Merging Start-up of Spherical Tokamak

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Axial merging method is one of the candidates to provide center-solenoid-free start-up of high beta spherical tokamak (ST) plasma, in which two initially formed STs merge through magnetic reconnection in the presence of the guide (toroidal) magnetic field, which is perpendicular to the reconnection (poloidal) magnetic field. Magnetic reconnection between two STs is capable of heating the electrons in the vicinity of the reconnection point, however, its mechanism has not been identified in laboratory experiments yet. During ST merging start-up, electrons are effectively accelerated near the reconnection point where the reconnection electric field is approximately parallel to the magnetic field and will provide the local electron heating. In order to observe the spatial distribution of generated energetic electrons, the SXR (> 100 eV) emission profile was observed by a fast imaging system equipped on the UTST device.

High-intensity SXR emission was observed particularly in the early reconnection phase when the SXR emission profile spread widely in the inboard-side downstream region. S Since the reconnection electric field had only toroidal component in the ST merging case, and large parallel component of the electric field in the inboard-side downstream region served to accelerate electrons along the field lines. In the middle merging phase, the SXR emission was clearly localized on two separatrix arms, which correspond to the magnetic field lines on which the electrons toroidally accelerated at the reconnection point will move. Though high toroidal reconnection electric field was still induced in the downstream region, its parallel component was cancelled by the charge separation mostly due to the electrons'motion.

A test particle calculation was carried out based on the experimentally measured magnetic and electric fields. Here, we assume that the parallel electric field in the downstream region is cancelled in the middle merging phase. The energetic electrons are generated in wide area of the downstream region in the early merging phase, possibly accounting for the broad electron heating. Then, the acceleration occurs only on the reconnection separatrix in the middle merging phase, indicating the localized electron heating near the reconnection point.

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