Center-solenoid free start-up of spherical tokamak plasma in UTST

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The merging technique is capable of providing center-solenoid free inductive start-up scheme of spherical tokamaks (STs) by using outer poloidal field (PF) coils. It involves efficient heating by magnetic reconnection that converts poloidal magnetic energy of the initial ST plasmas into kinetic/thermal energies. In the previous experiments, ion and electron heating during ST merging start-up has been demonstrated [1][2]. Since the merging process includes reduction of plasma volume, it also provides density increase via compression. These features of merging start-up are favorable to form a target ST for neutral beam injection heating, which requires high density and high plasma current for reducing the shine-through/orbit losses and high electron temperature for reducing the radiation loss.

Differently from the previous experiments, no in-vessel PF coils are equipped on the UTST device. Since the PF coils located outside the conducting vessel are utilized to form initial STs inductively, the field penetration is largely reduced by the eddy currents flowing on the vessel wall, limiting the plasma current smaller than that required for sufficient reconnection heating. However, the reconnection configuration during the ST merging has large toroidal magnetic field perpendicular to the reconnection magnetic field (poloidal field), providing effective electron acceleration in the reconnection region. Generation of energetic electrons have been observed as the ring-shaped emission of soft X-ray and line spectra from highly charged ions. The electron heating efficiency by reconnection will be evaluated including thermalization of these fast electrons.

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