Merging start-up and sustainment experiments on the UTST spherical tokamak

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The plasma merging method is expected to provide a high power initial heating to produce a high-beta spherical tokamak (ST) plasma. When two plasmas merge together to form a single plasma, magnetic field lines reconnect, and the magnetic field energy is converted to the plasma kinetic or thermal energy, increasing the plasma beta up to 50% during a very short period [1,2]. The University of Tokyo Spherical Tokamak (UTST) device was constructed for the purpose of formation and sustainment of ultra-high beta ST plasma using double null plasma merging and radio-frequency (RF) / neutral beam injection (NBI) heatings. The main feature of UTST is that the poloidal field coils are located outside the vacuum vessel in order to demonstrate the start-up in a more reactor relevant situation. Pre-ionization for generating the seed plasma is performed by a washer gun located inside the vacuum vessel. Initial operations were carried out using partially completed power supplies to investigate the appropriate conditions for plasma merging. Plasma current of the merged ST was 50 kA, and reached 170 kA by using the central solenoid coil for assistance of plasma formation. Merging of two ST plasmas through magnetic reconnection was successfully observed by using two-dimensional pickup coil arrays (290 channels), which directly measure the toroidal and axial magnetic fields inside the UTST vacuum vessel. There are two methods, which are now in progress, to sustain the ultra-high beta ST created on UTST; RF heating (400 kW and 21 MHz) and NBI (500 kW and 15 ms).

[1] Y. Ono *et al.*, Nuclear Fusion **43** (2003) 789.
[2] A. Sykes *et al.*, Nuclear Fusion **41** (2001) 1423.