Plasmoid reconnection in transient coaxial helicity injection on HIST

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The Spherical Torus (ST) is a promising candidate for an advanced fusion reactor due to the compactness. Elimination of the central solenoid coil to allow an approach to lower aspect ratio configurations requires for the non-inductive plasma start-up and the transient coaxial helicity injection (T-CHI) is a leading candidate for its method. One of the most important issues in T-CHI is whether it can establish a current sufficient in closed flux surfaces for succeeding current drive and heating. Understanding the flux closure during the start-up process is the primary purpose of the T-CHI experiment on the Helicity Injected Spherical Torus (HIST: R=0.30 m, a=0.24 m, A=1.25) [1]. Also, the CHI provides a good platform for pursuing MHD relaxation and magnetic reconnection physics. Magnetic reconnection is an essential element in understanding of self-organization phenomena such as sawtooth oscillations and Taylor relaxation in fusion plasmas and also eruptive mass ejection of solar flares in astrophysical plasmas. To prove the flux closure issue in the CHI start-up, we have investigated the fast magnetic reconnection driven by multiple plasmoids [2].

Here, we report that in the formation process of T-CHI start-up plasma with the plasmoid reconnection, (i) two or three small-size plasmoids are generated in elongated toroidal current sheet with the full width δ~0.05 m, a long length L=0.6-1 m and a high density n_e= 0.3-2x10^{20} m^{-3}, (ii) one of plasmoids becomes a large-scale closed flux surface during the decay phase, and (iii) in the He discharge, the reconnection rate on the mid-plane is slower than that in the H_2 discharge and the self-generated toroidal magnetic energy (poloidal current) increases rapidly, leading to the formation of a doublet-type magnetic configuration. The observation of the regular oscillations of the reconnecting magnetic field B_z, n_e and the axial out flow V_z in the current sheet provides a strong evidence of the plasmoid reconnection. These findings could verify that the plasmoid reconnection in the elongated current layer in the presence of the strong toroidal field allows the fast flux closure in the T-CHI.

References

[1] M. Nagata, et al., Phys. Plasmas **10,** 2932 (2003).

[2] F. Ebrahimi and R. Raman, Phys. Rev. Lett. 114, 205003 (2015).