Recent Results from Helicity Injection Experiments on HIST

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Coaxial helicity injection (CHI) using a magnetized coaxial plasma gun (MCPG) is expected to be the attractive non-inductive current-drive method for a spheromak and a spherical tokamak (ST). The HIST machine (R = 0.30 m, a = 0.24 m, A = 1.25, $B_t < 0.2$ T) [1] is characterized by the device's ability to create the spherical torus (ST) configurations from spheromaks with a central conductor to spherical tokamaks by varying the external toroidal field (TF). At present, the key issue for CHI experiments in the spheromak/ST configurations is to reveal current drive mechanism related to plasmoid ejection and magnetic reconnection dynamics during helicity injection. It is crucial in not only nuclear fusion but also space plasmas to develop detailed understandings of how the dynamo works in various relaxed ST configurations.

So far, the rotating helical kink mode of n=1 of the central open flux tube was observed in several spheromak machines (CTX, SPHEX, FACT/HIST, SSPX, Caltech-Sph etc.) and has been thought that which plays important role in a poloidal flux amplification and sustainment. As for ST, we observed in the HIST that kinking of the central column is stabilized by the TF and so proposed that as a possible explanation for the intermittent current drive, the repetitive merging process of an axisymmetric plasmoid injected by the MCPG. In a recent HIST experiment [2], we have observed that ST plasmas tend to self-organize to the flipped states with conserving the sign of helicity while reversing rapidly the direction of TF. The reversal mechanism is closely associated with the kinking of the open field lines around the central conductor as well as during the sustainment of spheromak [3]. Furthermore, it is of interest to investigate whether the flipped ST (F-ST) plasma that consists of only closed flux can be sustained by CHI. We have demonstrated the sustainment of the F-ST and identified kinking dynamics of non-flipped magnetic flux tube as current drive mechanism; rotating dynamics of the kinked flux column causes fluctuations at the outer edge region of the flipped ST, resulting in current drive. In a future experiment, we will challenge to produce high-β configurations having characteristics of two-fluid plasmas by high voltage biasing or compact toroid (CT) injection.

References

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