

## Intermittent Merging Operation of Spherical Tokamak Plasmas

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Extensive investigations have been conducted on the merging start-up of two spherical Tokamak (ST) rings formed inductively during the ramp-down phase of Poloidal Field (PF) coils current. This phenomenon has been studied in various ST devices, including START, TS3/4, MAST, TS-6, and ST-40. The merging start-up has been found to induce plasma current and elevate plasma temperature by converting magnetic energy into thermal and kinetic energies. Another important effect of Tokamak merging is magnetic helicity injection and current drive. The intermittent merging is proposed to realize a new current drive without density limitation like RF current drive [1]. In this approach, a pair of newly formed plasma rings is injected into the mid-plane of the plasma torus, resulting in sustained plasma current drive. It is essential to highlight that during the process of ST merging, the plasma maintains a stable Magneto hydrodynamic (MHD) configuration. However, the need for continuous plasma current drive encourages the implementation of intermittent merging.

To enhance plasma stability and improve current drive efficiency, the parameters of the "PF coils" responsible for creating the second pair of STs, such as their location, current waveform, and pinch-off time, necessitate

meticulous optimization.

As depicted in Figure 1(2D-MHD[2]), a duo of plasma toroids initially takes shape around the primary poloidal field (PF) coils and merges at the mid-plane (a), ultimately conjoining into a solitary, energized plasma toroid (b). Once the plasma achieves stability, a fresh pair of Spheromak Tori (STs) materializes encircling a secondary set of PF coils (c). This occurrence serves to propel the plasma current and elevate the maximum poloidal flux magnitude.

### References

- [1] Y.Ono et al, Plasma Phys. Contrl. Fusion 2 619-625, 1993
- [2] T.Ahmadi et al, Nuclear Fusion 61 066001, 2021
- [3] T.Ahmadi et al, *Fusion Energy*, IAC 1, 2023

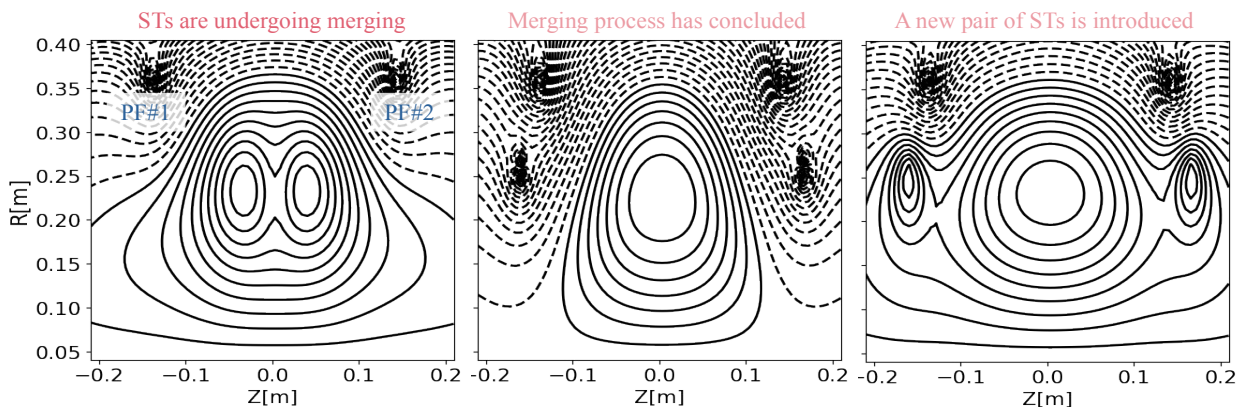


Figure 1: A pair of STs undergoing the merging process (a), a single stable ST is formed at the mid-plane(b), and a fresh pair of STs is introduced to the mid-plane ST to drive the plasma current(c).