9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Experimental results of Tokamak-Stellarator hybrid configuration by external rotational transform on J-TEXT

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Major disruptions in tokamak plasmas pose serious risks to device integrity, making effective control and mitigation strategies essential for future reactors. Experiments on current-carrying stellarators have shown that applying an external rotational transform (ERT) can suppress MHD instabilities and prevent disruptions [1,2,3]. Hybrid configurations that combine tokamak and stellarator features offer a promising pathway to enhance plasma stability and confinement. However, most existing studies focus on stellarator-based hybrids, while experimental investigations originating from conventional tokamak configurations remain limited.

In this context, a set of 3D ERT coils has been designed and installed on J-TEXT to explore the hybrid configuration based on the conventional tokamak setup. The designed dominant mode of the ERT coil is m/n = -2/2, non-resonant mode is chosen to prevent disruption due to resonance penetration, as shown in figure 1(a). Simulation results indicate that applying the ERT coils leads to non-axisymmetric plasma shapes, modifies q profile and improves plasma stability. In standard J-TEXT discharge, the ERT coil can induce an external rotation transform is $\iota_{vac}/\iota_0 \sim 0.1$ at the plasma edge [4,5,6].

The ERT coil system has been successfully applied to the J-TEXT plasma, experimentally realizing a Tokamak-Stellarator hybrid configurations. Several promising experimental results have been observed:

1) Suppression of tearing modes. Experimental results demonstrate that the application of ERT can effectively suppress both classical and neoclassical tearing modes, as illustrated in figure (b) and (c). Furthermore, the threshold range required for complete suppression of the tearing modes has been identified.

2) Expansion of the operational range. Based on the suppression effect of ERT on MHD instability, the experiment successfully utilized ERT to expand the operation range. The maximum stable plasma current is enhanced by approximately 20%.

3) Runaway electron and disruption mitigation. ERT can actively suppress runaway electrons during disruptions [7]. Additionally, the ERT coils can function as passive coils for both disruption mitigation and runaway electron suppression.

4) Modification of plasma parameters. ERT influences key plasma properties, including electron temperature and density. Notably, in electron ITB plasmas, ERT increases core T_e, achieving an improvement of approximately 60%.

This work is supported by the National MCF Energy R&D Program of China (No. 2019YFE03010004), and the National Natural Science Foundation of China (No. 12475223).

References

[1] W VII-A Team 1980 *Nucl. Fusion* **20(9)** 1093
[2] Hirsch M. et al 2008 *Plasma Phys. Control. Fusion* **50** 053001
[3] Pandya M.D. et al 2015 *Phys. Plasmas* **22** 110702
[4] Huang J. et al 2021 *Plasma Fusion Res.* **16** 2403047
[5] Jiang Z.H. et al 2022 *Plasma Sci. Technol.* **24** 124014
[6] Li Y.B. et al 2024 *Fusion Eng. Des.* **206** 11459
[7] Yan W. et al 2025 *Plasma Sci. Technol.* **27** 035104

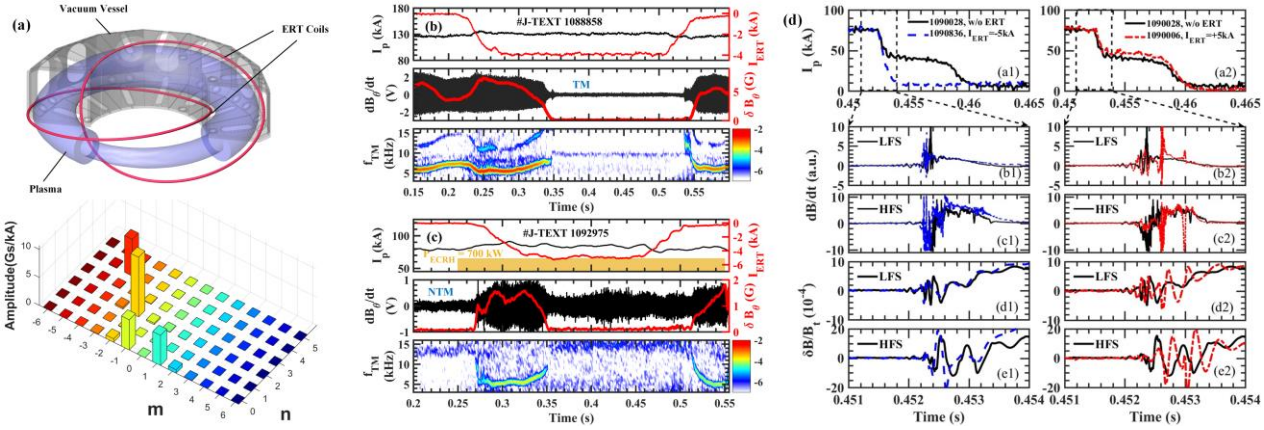

Figure 1 (a) Layout of the External Rotational Transform (ERT) coil system on J-TEXT and the spectrum of the poloidal magnetic field generated by ERT. (b) A typical discharge of ERT suppress classical TM. (c) A typical discharge of ERT suppress NTM. (d) Experimental results of ERT suppress runaway electrons.