Investigation of transient transport dynamics induced by compact torus injection in the EAST tokamak

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Compact Torus (CT) characterized by high density, self-organization, and hyper-velocity (>100 km/s), serve as an efficient means for fueling and momentum injection in magnetic confinement devices. Capable of penetrating strong magnetic fields through magnetic reconnection, CT injection offers a high promising fueling solution for future fusion reactors such as ITER and CFEDR. The penetration depth is determined by the balance between CT kinetic energy density and tokamak magnetic energy density. The EAST-CTI system was recently successfully installed to EAST as shown in Figure 1 and physical experiments were carried out [1][2]. The EAST tokamak's CT injection system exhibits broad operational parameters (velocity: 100-300 km/s, average electron density: 1×10^{22} m^{-3}), enabling controlled deposition through kinetic energy modulation.

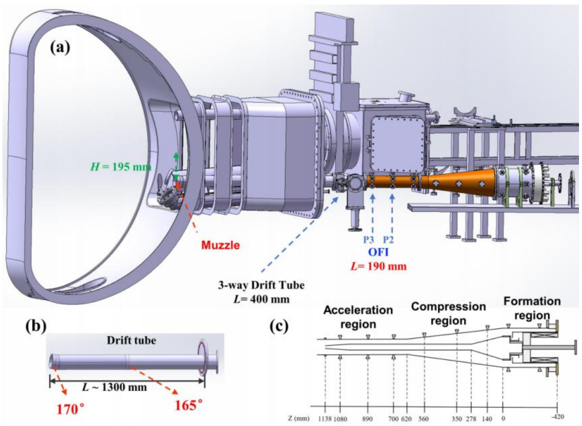

Figure 1. Schematic of the EAST-CT installation: (a) layout, (b) internal drift tube, (c) CT sketch.

As shown in Figure 2, cold pluses are introduced in Ohmic EAST tokamak plasmas via injection of CT with compact torus injection system, revealing for the quick increase in core electron temperature shortly after the cold-pulse injection at low collisionality. High-temporal-resolution diagnostics including electron cyclotron emission (electron temperature), density profile reflectometry (electron density), and Doppler backscattering reflectometers (turbulence) were employed to track plasma evolution [3]. The hyper-velocity CT propagation induces rapid edge-to-core density redistribution. As shown in Figure 3, the amplitude evolution of the scattered signal measured by the DBS system during the non-local period after CT injection. As the results show, an increase in the fluctuating signal across the full frequency range. This may be due to the fast response of density inhibiting TEM-dominated core turbulence and reducing electron heat transport, which explains the increase in transient core electron temperature [4][5]. Temperature inversion phenomena were observed to diminish with increasing plasma density. Spatiotemporal evolution of electron temperature, density, and turbulence fluctuations during CT injection has been systematically investigated.

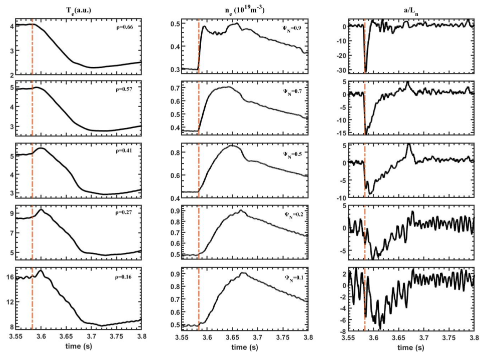

Figure 2. Evolution of electron temperature and electron density

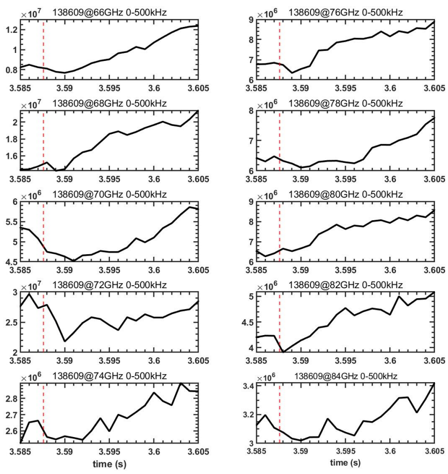

Figure 3. Evolution of the scattering signals measured by DBS system

This study provides new physical understanding of transient transport regulation in magnetically confined plasmas through CT injection. The identified correlation between CT injection parameters and turbulence suppression effects offers novel approaches for optimizing fueling strategies and developing active turbulence control techniques in fusion devices.

References:

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