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Acceleration Dynamics of KTX-CTI Compact Torus Plasma

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Compact torus (CT) injection, a critical technology for core fueling in magnetic confinement fusion, requires precise optimization of its acceleration dynamics to achieve efficient plasma delivery. This study presents a comprehensive investigation of CT acceleration in the newly developed KTX-CTI injector integrated into the Keda Torus eXperiment (KTX) reversed field pinch device. By employing the instantaneous frequency analysis and circuit analysis, we reveal the dynamic interplay between electromagnetic drivers and plasma behavior during acceleration. A novel variable-mass acceleration model is introduced, challenging the conventional point-model assumption of CTs as dimensionless current sheets. Experimental results demonstrate that CTs undergo significant spatial expansion during acceleration, progressively accumulating mass from the surrounding environment. This mass-loading effect, driven by magnetic-plasma coupling and circuit-load interactions, fundamentally alters acceleration efficiency and trajectory. The findings underscore the necessity of accounting for time-dependent mass evolution in CT injector design, offering critical insights for optimizing fueling speed, mass control, and energy efficiency in fusion reactors. This work advances the predictive capability of CT dynamics and provides a framework for next-generation injector development, directly impacting the scalability of magnetic confinement fusion technologies.

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Keyword-2

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Keyword-3

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