Seminar

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Institute for Plasma Research

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Title: The role of edge neutrals in exciting tearing mode activity and achieving flat temperature profiles in LTX-β

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Date: 30th July 2024 (Tuesday)

Time: 11.00 AM

Venue: Seminar Hall, IPR

Abstract

We present observations, numerical simulations, and analysis from experiments in the Lithium Tokamak Experiment-Beta (LTX-β) in which the electron temperature profile ($T_e(r)$) shifts from flat to peaked and a tearing mode is also destabilized when the average density (n_e^{ave}) exceeds ~10^{19} m^{-3}. Flat $T_e(r)$ is obtained routinely in LTX-β, with a lithium coated, low-recycling first wall, once the external fueling is stopped and consequently the density decays [1]. In the present experiment, flat $T_e(r)$ can be sustained while maintaining constant n_e^{ave} below a line averaged density threshold ($n_e^{ave}{}_{th}$) of ~ 10^{19} m^{-3}. Above $n_e^{ave}{}_{th}$, $T_e(r)$ shifts from flat to peaked and a tearing mode is destabilized. Due to low recycling, the achieved n_e^{ave} can be controlled precisely by external fueling. Hence, a certain threshold of the edge neutral inventory from the external fueling, which is required to excite the tearing modes, is experimentally manifested through $n_e^{ave}{}_{th}$. The goal of the present work is to investigate the role of edge neutrals in determining $T_e(r)$ and MHD stability in the unique low-recycling regime of LTX-β. Our hypothesis is that the peaking of $T_e(r)$ beyond $n_e^{ave}{}_{th}$ is due ultimately to the edge cooling by the cold neutrals beyond a critical fueling flux. At lower fueling flux, flat $T_e(r)$ results in broader pressure profile and lower resistivity, which in turn stabilizes the tearing mode. This hypothesis is supported by edge neutral density estimation by DEGAS 2 code. Mode analysis by singular value decomposition confirms the tearing mode structure to be m/n = 2/1 (m and n being the poloidal and toroidal mode numbers). Linear tearing stability analysis with M3D-C1 predicts that plasmas with $n_e^{ave} > 10^{19}$ are highly susceptible to a n = 1 tearing mode. M3D-C1 scans for resistivity, q profile and pressure profile also confirm that a flatter $T_e(r)$ will provide a flatter pressure profile and/or a lower resistivity at the mode rational surface, thus stabilizing the tearing mode. ORBIT simulations, however, confirmed that the tearing modes do not contribute to the loss of fast ions from neutral beam injection. This study shows for the first time that the neutral inventory at the edge could be one of the deciding factors for the achievability of the unique operation regime of flat $T_e(r)$ and the excitation of tearing activity that could be disruptive for the plasmas.

[1] D Boyle et al., Nucl. Fusion 63 (2023) 056020