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Effects of Plasma Sources on Pressure Profile during ELMs Based on Three-field Bifurcation Model

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Edge Localized Mode (ELM) is a repetitive magnetohydrodynamic (MHD) instability that occurs in the pedestal region of tokamak plasmas whenever the pressure gradient or total plasma current exceeds a critical threshold. This results in a burst of energy and particles during the quasi-periodic relaxation of an edge transport barrier (ETB) that was previously formed during an L-H transition [1].

In this research, ELM instabilities in H-mode fusion plasmas are studied using the peeling-ballooning model, with the three field transport equations for thermal energy, particle density, and toroidal momentum solved numerically and simultaneously [2,3]. In addition, neoclassical and anomalous transports are included. The velocity shear mechanism that suppresses anomalous transport is calculated via the force balance between gradient pressure and Lorentz's forces. The total plasma current is contributed by the modified driven plasma current in quadratic form, and the intrinsic bootstrap current is driven by the pressure gradient. The toroidal and poloidal magnetic fields are calculated using Ampère's law. The constant sources of thermal, particle, and toroidal momentum are provided.

The results show that high confinement mode (H-mode) can be achieved once the plasma sources exceed their thresholds, resulting in the formation of an ETB. The numerical results are shown as 1-dimensional qualitative values, while the system is assumed to be symmetric in 3-dimension. It appears that ELM instabilities arise once the pressure gradient or total plasma current contributed by the bootstrap current at the ETB region exceeds its critical threshold. The time evolution of ELM events can also be traced through a repetitive sequence of phases involving the pressure gradient and total plasma current, known as the ELM cycle. This results in thermal and particle losses and causes fluctuations in the plasma profiles, which can indicate energy loss and ELM repetition frequency. Additionally, the impacts on pressure profile during ELM events are examined by varying thermal, particle, and toroidal momentum source coefficients, as illustrated in Figure 1. The three dashed lines illustrated in Figure 1 divide the contour field into four regimes: L-mode, ELM-free H-mode, ELM in ballooning mode, and ELM in peeling mode. The pressure values vary depending on the plasma source coefficients, as well as the plasma regimes based on the peeling-ballooning boundaries.

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References

[1] H Zohm, Plasma Phys. Control. Fusion. 38, 105–128 (1996)

[2] Ö. D. Gürcan *et al*, Phys. Plasmas. 17, 032509 (2010)

[3] B. Chatthong *et al*, Nucl. Fusion. 56, 016010 (2016)

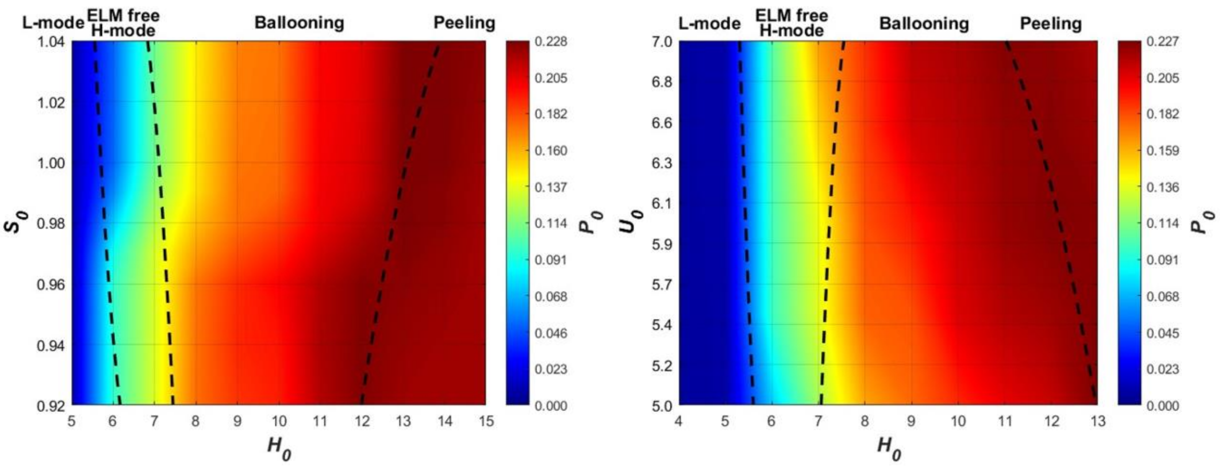

Figure 1. Pressure profile at plasma center during ELM events based on peeling-ballooning models, with the x-axis representing the thermal source coefficient (H_0), the y-axis representing the particle source coefficient (S_0), and the momentum source coefficient (U_0).