Contribution ID: **76** Type: **Oral (Plenary Session)**

First-time analysis of detached divertor conditions in RMP ELM suppressed H-mode plasmas in ITER

Tuesday, November 5, 2019 9:50 AM (20 minutes)

The ITER divertor has been designed for axisymmetric configurations, yet symmetry breaking resonant magnetic perturbations (RMPs) will be applied for control of edge localized modes (ELMs). Recently,the numerical capability to investigate the predicted detached divertor scenario at ITER with such 3-D deformations has been made available after stabilization of the iterative framework [H. Frerichs et al., NME 18 (2019) 62] of the 3-D edge plasma and neutral gas code EMC3-EIRENE.

We have applied an n=3 RMP field to the baseline discharge for the pre-fusion power operation phase and included the plasma response from calculations with the single fluid resistive MHD code MARS-F. The divertor state is found to be sensitive to the toroidal flow impact on the plasma response. Even though screening of most of the resonances leads to a narrower region of broken flux surfaces, radial extension of the divertor footprint occurs due to field amplification near the separatrix. Detachment transition with RMP occurs at a lower gas puff rate and lower peak particle flux at the original strike zone, consistent with a lower upstream heat flux that it connects to along the 3-D scrape-off layer. However, a secondary non-axisymmetric strike location exists radially further outward, which remains attached because of a magnetic connection to higher upstream temperatures further inside the bulk plasma, carrying significant heat fluxes to this previously low flux domain in the divertor. This strongly reduces the potential for complete power dissipation, and it is a new feature in the ITER divertor revealing a challenge for the integration of RMP ELM control with a feasible divertor operation regime. The new results will be put into context with recent modeling efforts at other machines that include plasma response effects on the boundary plasma [J.D. Lore et al., Nucl. Fusion 57 (2017) 056025, M. Faitsch et al., 2019 PPCF 61 014008].

This work was supported by the US DOE under DE-SC0012315 and DE-SC0013911, by the CoE at the UW - Madison, and by the ITER Science Fellow Network.

Country or International Organization

United States of America

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Session Classification: Implications of Applied 3D Fields

Track Classification: Scrape-off Layer and Divertor Physics