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Plasma beta effects on the island divertor of Wendelstein 7-X

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The Wendelstein 7-X Stellarator relies on an island divertor to control its heat- and particle-exhaust. In this divertor concept, the scrape-off layer is formed by a magnetic island chain between the divertor plates and the main plasma. This arrangement results in high magnetic connection lengths above 100m and wetted areas above 1m^2 [1]. It is important to retain these favorable properties in the up-coming steady-state experimental campaign. However, as seen in figure 1, the magneto-hydrodynamic plasma response driven in finite-beta plasmas can substantially effect the magnetic topology in the plasma edge.

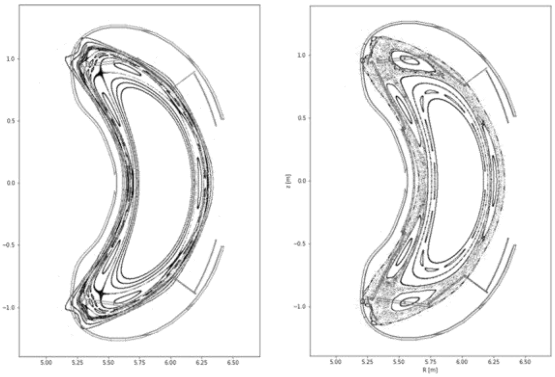

Figure 1: Magnetic topology in 5/5 (standard) configuration in vacuum (left) and at 5% central beta (right).

Depending on the configuration, the plasma response can lead to distinctly different effects, with the standard (5/5 edge island chain), high-iota (5/4 edge island chain) and low-iota (5/6 edge island chains) showcasing diferent responses to increasing plasma pressure.

This presentation will showcase finite-beta MHD equilibrium simulations for finite-beta plasmas in different magnetic configurations of W7-X, calculated with the 3D MHD equilibrium code HINT. Based on these simulations, we then extrapolate the heat-loads on plasma-facing components using an anisotropic diffusion model (exemplarily shown in figure 2).

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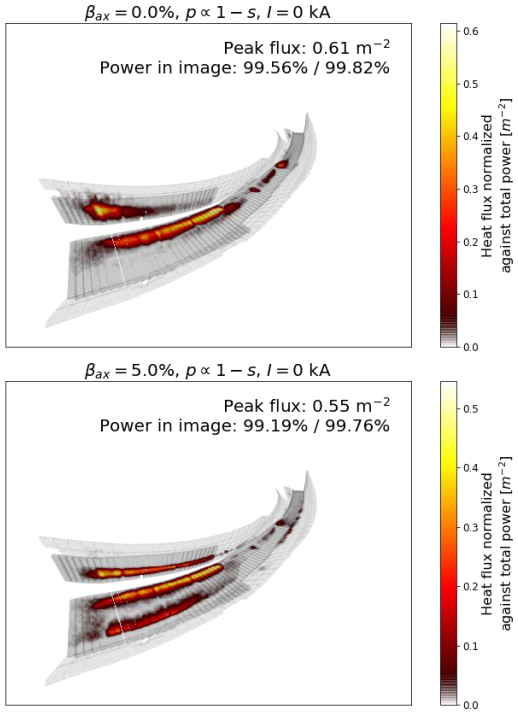

Figure 2: Simulated heat-loads onto the divertor in vacuum (top) and at 5% on-axis beta (bottom) in magnetic standard configuration.

References:

[1] Niemann, H. et al. (July 2020). Large wetted areas of divertor power loads at Wendelstein 7-X. In: Nuclear Fusion 60.8, p. 084003. doi: 10.1088/1741-4326/ab937a.