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Plasma Effects in Full-Field MHD-Equilibrium Calculations for W7-X

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Wendelstein 7-X aims at quasi-steady-state operation to demonstrate the reactor-viability of stellarators optimized with respect to MHD-equilibrium and -stability, low neoclassical transport, small bootstrap current and good fast-particle confinement. To reach this goal an island divertor is foreseen for particle and energy exhaust, which utilizes the naturally occurring boundary islands connected with the appearance of low-order rational values of the rotational transform at the plasma boundary. The island separatrix thus bounds the plasma, and the strike lines of the island fans determine the heat load distribution on the divertor structures. Although the configuration of W7-X has been optimized to display a small impact of plasma currents on the configuration, these effects still persist and change the plasma shape and the boundary islands'width and location. From previous studies it is known, for example, that with growing plasma-beta the island width increases, and the X- and O-point locations move poloidally, consistent with the effect of the Shafranov-shift. A net toroidal current is known to shift the island-generating resonance radially which, depending on the amount of plasma current, can lead to undesired deviations from proper island divertor operation, e.g. the shifting of the island structures away from the divertor plates resulting in a limiter magnetic configuration or in heat loads misdirected to critical components.
The contribution presents and discusses an approach for full-field calculations based on the VMEC-EXTENDER code combination. The effect of plasma-beta and of net-toroidal currents on the width and location of the islands is investigated in configurations in which the bootstrap current is expected to be small enough (according to transport simulations) to allow high-performance, quasi-steady-state operation compatible with the island divertor. The calculated fields will be compared to calculations using the 3D MHD-equilibrium code HINT, whose numerical scheme does not rely on the existence of flux surfaces and allows the self-consistent treatment of islands and stochastic regions. The differences resulting from the two approaches will be discussed.

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