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First divertor physics studies in Wendelstein 7-X

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Wendelstein 7-X (W7-X) went successfully into operation in 2015 [1-4]. With a 30 cubic meter volume, a superconducting coil system operating at 2.5 T, and steady-state heating capability of up to 10 MW, it was built to demonstrate the benefits of optimized stellarators at parameters approaching those of a fusion power plant. Operation phase 1.2a (OP1.2a), which was performed in the second half of 2017, was the first operation phase with a full complement of plasma-facing components, including 10 passively cooled fine-grain graphite divertor units. These have the same geometry as the water-cooled steady-state carbon-fiber-composite divertor units that will be in operation in the early 2020's (Operation Phase 2, OP2). They allowed the start of a divertor research program, but at pulse lengths limited to about 80 MJ of pulse energy, eg. 20 seconds at 4 MW.

The first divertor results in W7-X are very encouraging. For the foreseen magnetic configurations, the convective heat loads were deposited in the divertor, with strike line patterns closely resembling those predicted from edge modeling. Using trim and sweep coils, it was possible to eliminate the lowest order resonant field errors (n/m=1/1), and thereby symmetrize the heat loads onto the divertor units.

High densities were achieved first in helium and then, using the pellet system, in hydrogen (n_e0 up to 0.9x10^20 m^-3). With the higher hydrogen densities came the most remarkable divertor result of the OP1.2a campaign: Stable and reproducible heat flux detachment. The infrared cameras show a divertor heat flux reduction of an order of magnitude in all 10 divertor modules. During detachment, no degradation of core confinement was seen.

In addition to these results, several other results related to edge- and divertor physics in W7-X will be presented, including enhanced edge radiation by injection of medium-Z impurities, and operation in magnetic configurations mimicking those of long-lived high-performance discharges foreseen for OP2.

References
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