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Enhancement of W7-X performance by symmetrization of limiter loads with error field correction coils

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In the first Wendelstein 7-X operational campaign a dedicated limiter configuration was used for both helium and hydrogen plasmas. The achievable discharge duration and the heating power depend on the symmetry of power distribution between five limiters. Toroidally asymmetric loads appear due to misalignments and intrinsic error fields. It is found numerically that for misalignments of a few millimeters, one module receives about 10% higher power fraction. Error fields introduce helical deformations of flux surfaces and affect the power deposition even in a non-resonant case.

An $1/1$ error field of about 10^{-4} results in about 30% increase in the heat flux to one module. These findings are confirmed experimentally. Plasma-limiter interaction was studied with different amplitudes and phases of $n=1$ perturbation produced by W7-X error field trim coils. A clear change in the heat and particle fluxes to the limiters is observed with the perturbation. The observed change is consistent with $n=1$ structure. Without perturbation, the neutral pressure typically has a clear maximum in module 4. With a suitable perturbation phase and amplitude a toroidally symmetric neutral pressure is observed. This decreases the impurity accumulation and therefore extends the pulse duration.

These results are of interest for the later steady state W7-X divertor operation, where a similar question will have to be addressed.

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Primary author: Dr BOZHENKOV, Sergey (Max-Planck Institute for Plasma Physics)

Co-authors: Dr BIEDERMANN, Cristoph (Max-Planck Institute for Plasma Physics); Dr KOCSIS, Gabor (Wigner Institute, Budapest, Hungary); Dr WURDEN, Glen (LANL); Mr NIEMANN, Holger (Max-Planck Institute for Plasma Physics); STEPHEY, Laurie (University of Wisconsin); Dr JAKUBOWSKI, Marcin (Max-Planck-Institut für Plasmaphysik); Dr KÖNIG, Ralf (Max-Planck Institute for Plasma Physics); Prof. WOLF, Robert (Max-Planck-Institute for Plasma Physics); Dr LAZERSON, Samuel (Princeton Plasma Physics Laboratory); Dr SZEPESI, Tamas (Wigner Institute, Budapest, Hungary); Prof. SUNN PEDERSEN, Thomas (Max-Planck-Institute for Plasma Physics); WENZEL, Uwe (Max-Planck Institute for Plasma Physics)

Presenter: Dr BOZHENKOV, Sergey (Max-Planck Institute for Plasma Physics)

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