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Error field measurement, correction and heat flux balancing on Wendelstein 7-X

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The measurement and correction of error fields in Wendelstein 7-X (W7-X) is critical to long pulse high beta operation, as small error fields may cause overloading of divertor plates. Accordingly, as part of a broad collaborative effort, the detection and correction of error fields on the W7-X experiment has been performed using the U.S. supplied trim coil system [1] in conjunction with the flux surface mapping diagnostic [2] and the U.S. supplied high resolution infrared camera [3]. In the early commissioning phase of the experiment, the trim coils were used to open an $n/m=1/2$ island chain in a specially designed magnetic configuration [3]. The flux surfacing mapping diagnostic was then able to directly image the magnetic topology of the experiment, allowing the inference of a small ~ 4 cm intrinsic island chain [4]. Scaled to the planned operating field (2.5 T), such error fields would be correctable using less than 10% the rated trim coil capacity. The suspected main source of the error field, slight misalignment of the superconducting coils, is then confirmed through a synthetic flux surface mapping diagnostic and detailed measurements of the coil positions. Confirmation of the error fields allows the assessment of magnetic fields which resonate with the $n/m=5/5$ island chain. Predictions of the extent to which these error fields, if left uncorrected, could limit plasma performance are presented. Plasma experiments without applied correcting fields show a significant asymmetry in neutral pressure (centered in module 4) and light emission (visible, H-alpha, and carbon). Such pressure asymmetry is associated with divertor heat load asymmetries between the modules. Application of trim coil fields with $n=1$ waveform correct the imbalance. Observations of the limiters temperatures in module 5 shows a clear dependence of the limiter heat flux pattern as the perturbing fields are rotated.

[1] Rummel T et al. "The Wendelstein 7-X Trim Coil System" IEEE Trans. Appl. Super. 24(3), 2014

[2] Otte M et al. "Setup and initial results from the magnetic flux surface diagnostics at Wendelstein 7-X", submitted to Plasma Physics and Controlled Fusion

[3] Wurden et al., this conference

[4] Lazerson S et al. "First measurements of error fields on W7-X using flux surface mapping." submitted to NF

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Primary author: Dr LAZERSON, Samuel (Princeton Plasma Physics Laboratory)

Co-authors: Dr BIEDERMANN, Christoph (Max-Planck-Institut für Plasmaphysik); Dr GATES, David (PPPL); Dr KOCSIS, Gabor (Wigner Research Center for Physics); Dr WURDEN, Glen (Los Alamos National Laboratory); Dr GEIGER, Joachim (Max-Planck-Institut für Plasmaphysik); Dr JAKUBOWSKI, Marcin (Max-Planck-Institut für

Plasmaphysik); Dr OTTE, Matthias (Max-Planck-Institut für Plasmaphysik); Dr BOZHENKOV, Sergey (Max-Planck-Institut für Plasmaphysik); Dr ANDREEVA, Tamara (Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, Germany); Dr SZEPESI, Tamas (Wigner Research Center for Physics); Prof. SUNN PEDERSEN, Thomas (Max-Planck-Institut für Plasmaphysik); Dr WENZEL, Uwe (Max-Planck-Institut für Plasmaphysik)

Presenter: Dr LAZERSON, Samuel (Princeton Plasma Physics Laboratory)

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