Overview of Magnetic Flux Surface Measurements at W7-X

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The existence of closed and nested magnetic flux surfaces is mandatory in magnetic confinement plasma machines and is one of the optimization criteria at the Wendelstein 7-X (W7-X) stellarator. The existence and quality of vacuum magnetic flux surfaces was already confirmed during the initial operation phase OP1.1, and the error field was found in the expected range as well [1, 2]. However, a comparison with field line tracing simulations taking into account the ideal but also the as-built geometry of the coils revealed small but measurable deviations in the radial profile of the rotational transform $\iota = \iota/2\pi$. A systematic decrease of iota of $\delta\iota/\iota \sim$ 1-2% with respect to the ideal coil geometry could be derived from the measurements. The effect, also observed at the predecessor experiment W7-AS [3], is related to the deformation of the non-planar coils of up to ~ 10-15 mm under electromagnetic loads, which are generating the rotational transform.

In the first divertor campaign OP1.2a, performed in the second half of 2017, the accessible magnetic configuration space was extended. Additional flux surface measurements were performed for new magnetic configurations. The experimental results are compared with different field coil models. Furthermore, measurements addressing the potential error field have been conducted again. The dominating n, $m = 1$ Fourier harmonic was characterised in amplitude and phase for different magnetic configurations. Utilizing the flux surface diagnostic, it could be shown that this error field component can be compensated with the trim coil set installed outside the plasma vessel, which results in a symmetrisation of the heat loads on the divertors during plasma operation [4].

References

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