Plasma current crashes and the associated dynamics of the 5/5-island chain in W7-X

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The stellarator W7-X is optimized with respect to reduce neoclassical transport. The magnetic configuration at W7-X can be varied over a wide range of iota values at the last closed flux surface (LCFS) ranging from 0.8 to 1.2. In the standard configuration where $\iota = 1$ is achieved at the LCFS, a 5/5 island chain generates an island divertor. Configurations in between these extreme cases can be achieved by changing the current in the planar coils. Starting from the high iota configuration ($\iota = 1.2$) by changing the current in the planar coils the 5/5 island moves slowly towards the LCFS [1]. At the so called FMM002 configuration an increase of the diamagnetic energy is observed. This improvement is interrupted by sudden crashes in the plasma current [2]. It is of interest to understand the dynamic of this process which seems to be related with the island chain close to the last closed flux surface and its dynamics.
With the help of a poloidal correlation reflectometer (PCR) the region of the plasma edge is monitored by changing the probing frequency and the related cut-off density in steps. In the cross section where the instrument is mounted the sight line intersects one of the 5/5 island. When the cut-off density is located at the island separatrix a mode of $f = 4.8\,\mathrm{kHz}$ is observed. This is observed in other diagnostics e.g. Mirnov coils, too. This low frequency mode is accompanied by high frequency modes of 700 kHz to 1000 kHz visible in the coherence spectra of the PCR. Together with the Poincaré plot and an averaged density profile the mode number in the island can be determined. In case of a sudden collapse of the plasma current the all modes disappears in both the PCR and Mirnov signals which is evidence for a abrupt change of the plasma properties in the vicinity of the island. At probing positions located outside the island a strong change in the poloidal rotation and radial electric field is observed. The change in the rotation suggests a movement from a region inside the LCFS into the scrape off layer due to a density profile relaxation. After the crash the island is again detectable.

[1] J. Geiger et al., submitted to 28th IAEA Fusion Energy Conference (FEC2020), Nice, France, 10th May 2021
[2] G. Wurden et al., 46th Conference on Plasma Physics (EPS), Milan, Italy, 8th July 2019

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