High-field side error field effects on H-mode plasma performance and their correction in ITER-like experiments on COMPASS

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Plasma performance in magnetic confinement fusion (MCF) devices is degraded by the presence of error fields (EF) e.g. due to misalignments of magnetic coils during assembly process. By utilizing error field correction (EFC) coils, detrimental effects of EF can be annulled or, alternatively, artificially induced. Typically, EFC coil-induced EF couples equally well to both the core and the edge plasma resonant surfaces due to their location on the low-field side (LFS) of the device. However, coupling of the intrinsic EF originating at the high-field side (HFS) of a tokamak (e.g. due to a tilt of the toroidal field coils (TF) or of the central solenoid (CS)) is different. The effects of such EF on the plasma or the need for their correction have not been sufficiently characterized yet (mainly due to lack of capabilities of the present MCF devices to generate controlled HFS EF). However, they are highly important for ITER since the magnitude and correction of such effects have direct implications on the accuracy of installation and alignment of the TF/CS coil sets.

In the COMPASS tokamak we have used EFC coils at the HFS to generate controlled EF in ITER-like (q95=3) plasmas, mimicking the effects of tilt and displacement of the CS on H-mode plasma confinement and on the L-H transition/H-mode access. We report that these effects prevent H-mode access (due to disruptions), and if EF are applied to a pre-existing H-mode, they lower the energy confinement by 20%. We show that while n=1 EFC by LFS coils can fully recover the H-mode energy confinement, H-mode accessibility is only partially restored – 50% of the discharges in which this EF correction scheme is applied disrupt. Initial experiments show that an addition of the top and bottom coils (as available in ITER) to the correction of the HFS EF decreases significantly this disruption rate. The experimental observations are interpreted using IPEC and MARS-F modelling and the implications for ITER are discussed.