Confinement properties in the large aspect ratio, full Tungsten environment WEST tokamak

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WEST is the metallic machine operating since December 2016. Its original characteristics are an aspect ratio value of 5-6 and the inner wall covered with tungsten tiles. Its plasmas are dominantly electron heated (ICRH and LHCD) and torque free (no NBI) [1]. In this work, we analyze extensively the database of WEST plasma to characterize the operational domain. Then, we apply a turbulent transport model and explore its validity on WEST operational space.

The parametric dependence of the confinement time with respect to the aspect ratio (A) is obtained by adding WEST data to the existing ITER database with machines having A ranging from 2.41 to 7.78, but with few shots in the range 5-6 [2]. WEST database contains more than 1000 entries in L mode (P_{AUX}>0.5MW), deuterium only pulses, heated by lower hybrid and ion cyclotron resonance heating. The performed studies take into account statistics calculated on plateaus of total power intersecting plasma current plateaus (quasi-steady states). Different diagnostic measurements are averaged at each plateau and added to the database. When injecting 1000 WEST plateaus (automatically detected as the intersection of the total power and the plasma current plateaus) to the existing 1312 entries, the computed regression coefficient associated to aspect ratio is close to zero, as previously found for L96 in spite of the new aspect ratio range covered by WEST. The A scaling of H98 leads to τ_E predictions similar at large A for H and L mode. This property will be checked on WEST H mode data. The absence of impact of A on the L mode confinement is explored with gyrokinetic QuaLiKiz [3]/GKW analysis.

In WEST database 20% of the detected plateaus are affected by a rapid collapse of the central electron temperature or do not reach more than 1.5 keV at the core. The temperature collapse occurs when $T_e(0)$ enters an unstable region, a slight decrease of T_e leads to enhanced W cooling factor, hence enhanced radiation. This leads to a vicious circle where hollow T_e profiles lead to flat or hollow current profiles and the onset of 2/1 tearing modes as also reported in JET during I_p ramp up [4], WEST [P. Maget to be submitted] and FTU [5]. Since reaching plasmas with enhanced stability is fundamental to obtain high tokamak performances, the core radiative collapse is modelled using RAPTOR-QLKNN [6][7]. This allows understanding which are the actuators that lead to a collapse. A simulation that converges to a stable state matching the experimental data at the time in which the collapse starts is performed. After reaching the steady-state condition, parameters such as the electron and tungsten density evolutions, tungsten concentration and LH power injection position and width are changed. The various actuators affecting the collapse onset and dynamics are explored: density and temperature at the separatrix, the LHCD power deposition location and width, the role of Zeff, of Te/Ti, on the turbulent transport etc. A strategy for the next campaign to avoid such collapses is proposed.

Références

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