WEST CORE RADIATIVE COLLAPSE MODELLING WITH RAPTOR

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In the WEST database, constructing starting from the data collected during the C3 and C4 campaigns (2018-2019), has been observed that two different confinement states coexist, the cold and the hot branches at a given $P_{tot}/n_{e,vol}$. In the "hot branch" the $T_e(0)$ is higher than 2keV, the energy content and li are larger. While in the "cold branch" is the opposite.
Moreover, the 25% of the detected plateaus are effected by a rapid collapse of the central electron temperature. This causes the plasma to enter a central low-temperature degraded state where q profile reverses can trigger tearing mode. Since reaching plasmas with enhanced stability is fundamental to obtain high tokamak performances, radiative collapse must be studied, understood and avoided.
This phenomena is observed in JET during Ip ramp up [1] and FTU [2].

First of all, a simple model to detect the collapse in WEST database is developed. All the unstable plateaus are located in the region between 1.5 keV and 3 keV and it is consistent with the tungsten cooling factor unstable range taken from ADAS 50 database.
Then, a lot of parameters are analysed in order to understand the major players that lead to the collapsing pulses. During the unstable phase, a first low decrease of a central temperature is observed, then, a fast collapse occurs and, at the end, the plasma goes in a degraded confinement state with a temperature of about 1.5 keV. At the same time, the estimation of the tungsten central density is constant during the first part of the collapse and then starts to increase very quickly until it reaches a peak. While, the signal of the hard X-ray central channel (number 20) for the energy band 60-80 keV decreases and this confirms that the LHCD absorption shifts off-axis.

In order to understand which are the actuators that lead to a collapse, it is modelled using METIS (a fast integrated tokamak modelling tool [3]) to prepare the simulations and RAPTOR (a 1D transport physics code [4]) coupled with QuaLiKiz neural network (a quasilinear gyrokinetic code [5]) to model the collapse and to compute the transport coefficients.
LUKE code [6], used in sand alone, is needed to determine the LH power deposition profile during the non-inductive current drive experiments.

For the simulations done, $j(\rho, t)$, $T_e(\rho, t)$ and $T_i(\rho, t)$ are predicted from the core to $\rho = 1$, while n_e, n_i and Z_{eff} are fixed from METIS simulation. The tungsten density time evolution is set manually in the code. The radiated power is computed from ADAS50 for the tungsten concentration. LH profiles are taken from the LUKE code. The transport coefficients are computed using QuaLiKiz for which a 10D Neural Network version has been coupled dividing the collisionality by 4.
Taking into account both the increase of the tungsten density and the decrease of the LH power injected in the plasma center, the collapse of the central electron temperature can be reproduced.

References

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