Comparing the scaling of the bulk radiated power between Carbon and ITER-Like-Wall environments in JET.

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With the recent use of tungsten (W) for the divertor in tokamaks, it is important to get information about the pollution of the bulk by this impurity. With this in mind, we define a global parameter that can be used to detect the pollution of the plasma bulk by highly radiative impurities. This parameter is defined as

$$\beta_r(t) = \frac{P_{\text{radbulk}}(t)}{(Z_{\text{eff}}(t) - 1) n_z^2(t)}.$$ 

It is the radiative loss parameter [1] of the mixture of impurities in the bulk of the plasma relative to their mean $z^2$. This time dependent parameter can be used to monitor a plasma shot and allows quantitative comparisons from shot to shot. We show that $\beta_r$ though being global is very sensitive to the presence of highly radiative impurities in the bulk of the discharge but much less to their spatial distribution. It is highly correlated to the level of a bundle of spectroscopic lines of tungsten with a line of sight passing through the center of the discharge. We use it to compare plasmas in JET equipped with carbon plasma facing components (JET-C) with plasmas in the ITER-Like Wall (ILW) environment. In JET-C the value of $\beta_r$ is around 1, indicating the absence of highly radiative impurities in the plasma. No change or even a small decrease is observed when going from L mode to H mode, the overall robustness of the parameter being in agreement with the result of the multi-machine scaling [2]. In the ILW environment, we observe that $\beta_r$ increases above 1, this increase being clearly dependent on the plasma scenario: the confinement mode, the fuelling of the plasma, the type of additional heating used. We observe that Neutral Beam Injection (NBI) does not dramatically increase the W content of the plasma with a $\beta_r$ between 2 and 3. Ion Cyclotron Radio Frequency (ICRF) heated plasmas reveal a $\beta_r$ of the order of 5 in L mode and 10 in H mode when no Edge Localized Modes (ELMs) are present. When ICRF and NBI are used together, $\beta_r$ is reduced to 5 illustrating the positive effect of the ELMs on the bulk pollution by tungsten. Finally, the change of $\beta_r$ after a transient impurity provides an indication of whether a low or high Z particle is responsible.


*See the Appendix of F. Romanelli et al., Proceedings of the 24th IAEA Fusion Energy Conference 2012, San Diego, US