Confinement dependence on beta/power in the JET ILW hybrid scenario

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The hybrid scenario on JET has often an improved confinement compared to the H98y2 scaling prediction. This has been observed before on many other experiments, e.g. DIII-D and AUG. From a scaling point of view it is a very interesting question whether this confinement improvement is a consequence of the higher beta operation in the hybrid scenario compared to the traditional H-mode [1] or if the higher normalised confinement is e.g. due to a weaker power degradation as reported in [2]. The H-factor and the plasma β_N are derived both from the stored energy and hence tend to be strongly correlated.

In this paper, results from a database (DB) analysis of about 4500 points from the entire JET ITER- like wall period are shown. Here deuterium, hybrid pulses in a low triangularity lower single null shape are presented. The database is large and diverse enough to allow a derivation of the different scaling dependencies at different β ranges ($0.5<\beta_N<2.7$) under the assumption that all other scaling dependencies are as prescribed in a scaling law ($0.8\text{MA}<I_p<3\text{MA}$, $1\text{T}<B_t<4\text{T}$, $2\text{MW}<P_{in}<38\text{MW}$ dominantly NBI, $2\cdot10^{19}\text{m}^{-3}<n_e<7\cdot10^{19}\text{m}^{-3}$, geometry factors are constant in DB). This analysis has been done either assuming IPB98(y,2) or ITPA 20 – ITER like (IL20 from now on) [3] scaling properties. It is shown that the IPB98(y,2) exponents fit well to the experimental data as a whole. If only a subset of the data in a reduced beta range for medium beta is considered, the same agreement is found but the multiplication factor needed increases with beta (β_N as well as β_p). Deviations in the exponents are found at low and at high β.

As a further test, the scaling law has been changed to the IL20 properties which results in a better global agreement. The exponents of this scaling fit very well to the low beta part of the DB but not equally well to the medium beta part of the database. This might indicate that the low beta and confinement part of the DB, which is closer to the traditional H-mode operating space, indeed scales more like IL20, whereas the more hybrid like operation space (lower gas fluxes and higher input power) scales more like IPB98(y,2).

The observed deviations compared to the IL20 scaling assumption re-enforces the finding of the good agreement especially with the P_{abs} (but also n_e) dependence of the IPB98(y,2) scaling law despite the better general agreement with the IL20 like scaling. The driving factor of the confinement dependence seems not to be a weaker power degradation but an increase of confinement with beta which is not captured by the other engineering regression variables and would likely require additional variables. This findings might be explained by the observed better pedestal stability and lower turbulence growth rates at higher beta as also been indicated in [2].

References: [1] M. Beurskens *et al*, PPCF **55** 124043, [2] C.D. Challis *et al*, Nucl. Fusion **55** 053031, [3] G. Verdoolaege *et al* , Nucl. Fusion **61** (7) 076007

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