Studies of the beta dependence of transport in ASDEX Upgrade

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Dedicated β scan experiments have been recently performed in ASDEX Upgrade in H-mode plasmas with type-I ELMs. Two sets of discharges, in different density ranges, provided β variations between $\beta_N = [1.4-2.2]$ and $\beta_N = [1.4-2]$. Global analysis of these β scan exhibits an unfavourable β scaling as $B\tau_{th} \propto \beta^{-0.9}$. This result is confirmed by the local transport analysis which shows an increase of the thermal heat diffusivity with increasing β as $\chi_{eff}/B \propto \beta^{0.65}$.

These results are in agreement with the β exponents derived from the multi-machine scaling law ($B\tau_E \propto \beta^{-0.9}$ [1]) and with experiments performed in JT-60U, which yield a β dependence as $B\tau_{th} \propto \beta^{-0.6}$ [2]. However, these results disagree with experiments carried out in DIII-D [3] and JET [4] where no β dependence was found for both energy confinement time and local diffusivity.

In this paper we investigate and characterize the micro-instabilities present in the core of ASDEX Upgrade β scaling discharges by means of the gyrokinetic code GS2.

In β scan simulations, using experimental values for temperature and density gradient lengths, micro-tearing modes appear to be the most unstable modes in the β range of ASDEX Upgrade experiments. However such modes are not expected to lead to a strong energy transport.

On the contrary, Kinetic Ballooning Modes (KBM) should dramatically degrade the confinement. Such modes are supposed to be unstable [5] for values of β comparable with the high β discharges of the experimental β scan of ASDEX Upgrade.

For this reason, we focused on KBM and we analyzed their stability taking into account all equilibrium and shape parameters such as the Shafranov shift, the triangularity, the elongation.

References

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