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Comparative modeling of plasma boundary corrugation due to the application of 3-D fields with ELM control coils in various ITER scenarios

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The plasma response to the 3-D external resonant magnetic perturbation (RMP) fields, applied for controlling type-I edge localized modes (ELMs) in ITER, is systematically computed in terms of the normal displacement of the plasma surface, in other words the 3-D corrugation of the plasma boundary. Five representative ITER H-mode plasma scenarios, ranging from an initial hydrogen plasma discharge in pre-nuclear phase to the Q = 10 nuclear phase DT operation. The plasma surface corrugation, computed using the MARS-F code, is used as a basis to understand the capability and robustness of the type-I ELM control in these ITER scenarios. A key aspect of this study is to assess effects of variation/uncertainty of pedestal plasma rotation on the plasma response. For each plasma scenario, a set of the toroidal rotation - both amplitude and radial profile - is generated by the transport code ASTRA, assuming different Prandtl numbers as well as different ratios of the toroidal momentum to thermal confinement times. Toroidal modeling results show that, (i) the plasma response is similar for the two DT scenarios with 15 MA/5.3T plasmas but with different fusion gain factors (Q=5 versus Q=10); (ii) the other plasma scenarios, with similar rotation profiles, have different plasma boundary corrugation; (iii) the effect on ELM control performance by utilizing 2 or 3 rows of coils, with the coil phasing optimization, varies depending on the availability of the ELM control coil power supplies. The plasma response database, generated in this study, can also be used for further studies such as the divertor footprint and heat load, or energetic particle losses due to RMP.

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