Effect of aspect ratio on plasma response to resonant magnetic perturbations in tokamak devices

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The edge localized mode (ELM) is a common magnetohydrodynamic (MHD) instability in tokamaks operating in H-mode. The so-called type-I ELMs are potentially dangerous to the future fusion devices such as ITER, since a large amount of particles and energy can be relased from the plasma region onto the plasma facing components (PFCs) during each ELM burs [1]. The resonant magnetic perturations (RMP) is one of few techniques to control ELMs, which has been successfully utilized on most present major tokamak devices operating in H-mode.

Despite substantial experimenal and modeling efforts in many present-day tokamak devices [2-11], physics understanding of ELM control by RMP fields is still not complete. For instance, one limitation is that most modeling work forcuses on one or several given devices. On the other hand, the size of future diveces such as ITER will likely be larger than present tokamks. The objective of our work here is to investigate the machine size effect on the plamsa response, in particular the effect of the plasma aspect ratio R_0/a.

Starting from an experimental discharge (shot number 30835 at 3500 ms time) on ASDEX Upgrade, we generate a series of new plasma equilibria by gradually varying the major or minor radius independently in this work. In order to better isolate the device size effect from other effects such as the plasma parameters (in particular the edge safety factor q_a and plasma flow) and the geometrical distance between the plasma and the RMP coils, the latter are fixed as much as possible while we scan the plasma major or minor radius.

The present study utilizes the single-fluid, resistive MHD code MARS-F [12] to compute the plamsa response to the RMP fields. Two critiera are designed to quantify the plamsa response to the RMP filed. One is amplitude of the pitch-resonant radial magnetic field component near the plasma edge, for the total field perturbation including the RMP vacuum field and that due to the plamsa response. The other is amplitude of the normal displacement of the plasma boundary surface near the X-point. Both criteria have previously been demonstrated to correlate well with ELM control.

As the key result, the plamsa response to the RMP field is found to be non-monotonically dependent on both the major and minor radii of the device. Note that this is a machine size effect, by fixing the q_a-value, the equilibrium pressure and other plasma-coil parameters. Furthermore, the major/minor radius, that results in the strongest plamsa response, varies with the current phase difference between two rows of the RMP coils.

References

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