Contribution ID: **536** Type: **Poster**

The Contribution of Perturbation Coil Geometry Induced Sidebands and MHD Response in KSTAR and DIII-D

Wednesday, 19 October 2016 08:30 (4 hours)

In this work we show that the application of a "square wave"n=1 toroidal perturbation on DIII-D and KSTAR leads to significant n=3 toroidal sidebands. In the vacuum model, these n=3 sidebands assist in creation of wide stochastic field in the edge of the plasma. In KSTAR, the n=3 sideband fields create vacuum islands in the right places to extend the vacuum island overlap width to more than 25%. We have also shown that these n=3 sidebands are screened less by the plasma response, and the "rational surface resonant"fields are of similar size with the main n=1 fields in KSTAR. The effect of these sidebands in the RMP ELM suppression should be studied more carefully both experimentally and numerically as these sidebands may play an important role. Recent studies on DIII-D [1] have shown that RMP ELM suppression may be achieved with a reduced number of RMP coils and less total injected magnetic flux due to the increasing role of toroidal sidebands. Application of "square wave"n=4 and "discretized cosine"n=3 waveforms in ITER RMP coils has also shown some advantages of "square wave"waveforms as they are naturally capable to generate multiple toroidal sidebands [2]. The modeling results suggest the importance of self-consistent, nonlinear modeling of the plasma response including the full toroidal mode spectrum that is applied, since interactions among the toroidal sidebands may be important. These results also provide a hypothesis for why RMP ELM suppression with an n = 1 spectrum has been more difficult to achieve in DIII-D than either n = 2 and n = 3, since the kink-driven screening of the applied RMP field is more complete at n = 1 than n = 2 or 3. Finally, the direct implication for ELM suppression in ITER is that the number of coils (and hence larger toroidal mode number) should be preserved to maintain the highest margin for success.

[1] D.M. Orlov, et al., "Suppression of Type-I ELMs with reduced RMP coil set on DIII-D", Nuclear Fusion, 56, 2016, 036020, doi:10.1088/0029-5515/56/3/036020

[2] T.E. Evans, et al., "3D Vacuum Magnetic Field Modeling of the ITER ELM Control Coil During Standard Operating Scenarios", Nuclear Fusion, 53, 2013, 093029, doi:10.1088/0029-5515/53/9/093029

Paper Number

EX/P3-19

Country or International Organization

United States of America

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Session Classification: Poster 3

Track Classification: EXS - Magnetic Confinement Experiments: Stability