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Optimization of Resonant and Non-resonant Magnetic Perturbations in KSTAR

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A non-axisymmetric (3D) magnetic perturbation can greatly improve tokamak performance if it is judiciously used. A well-known application is the control of edge-localized-mode (ELM)-crash using resonant magnetic perturbation (RMP). The non-resonant part of magnetic perturbation (NRMP) can be also beneficial against various instabilities, by changing local profiles of toroidal rotation. In any 3D field applications, the spatial distribution of magnetic perturbation should be optimized, in order to maximize each of expected utility while minimizing other degradations in confinement. Recently Korean Superconducting Tokamak Advanced Research (KSTAR) has been highly successful in the systematic optimization of 3D field, using presently unique 3 rows of internal coils. It has been shown that a key RMP metric for successful ELM-crash suppression is the decoupling of edge resonance from core resonance, and the use of a valid plasma response model to assess the resonance driving magnetic islands. This metric evaluated by the ideal perturbed equilibrium code (IPEC) [1] predicted the existence of ELM-crash suppression windows in unusual coil configurations, such as +75, +60, +45, -45 differential phasing as well as unevenly distributed currents in each row, in addition to the standard +90 phasing [2]. Remarkably, a set of experiment designed to test the prediction demonstrated every windows at the expected thresholds of RMP currents. In NRMP applications, on the other hand, it is important to minimize both edge and core coupling RMP, while leaving sizable non-resonant components. NRMP can then induce neoclassical toroidal viscosity (NTV) [3-4] and change toroidal rotation but without disturbing other channels of transport. Indeed, the metric defined by NTV vs. RMP, and the simulation using IPEC and also the general perturbed equilibrium code (GPEC) [5], provided the good explanation for quiescent magnetic braking [6] observed in the range of -90 to 0 differential phasing configuration of the internal coils. This successful validation on the predictive capability of the key RMP and NRMP metrics implies the possibility of advanced and systematic optimization of coils and configurations in tokamaks, without demanding expansive search of 3D field spectrum in experiments.

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