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Optimization of RMP fields for ELM control and error fields correction in ITER

X. Bai[1], A. Loarte[1], Y. Q. Liu[2], J.-K. Park[3], Y. Gribov[1], S. Mcintosh[1], F. Koechl[1],
M. Dubrov[1], S. D. Pinches[1]
[1] ITER Organization, France [2] General Atomics, USA
[3] Department of Nuclear Engineering, Seoul National University
e-mail (speaker): Xue.Bai@iter.org

In recent decades, non-axisymmetric three-dimensional (3D) fields applied by external coils have been extensively utilized in tokamak devices. Despite their small amplitude, these externally applied 3D fields are able to have significant impact on plasma performance in both edge and core. In the edge region, externally 3D fields are often utilized to control Edge Localized Modes (ELMs) which can cause severe damage to plasma facing components [1]. Mitigation and even suppression of ELMs have been achieved in many tokamak devices by applying external resonant magnetic perturbation (RMP) fields [2]. On the other hand, in the core region, the impact of external 3D fields are utilized for the purpose of error fields correction [3]. Error fields are intrinsic small 3D fields that inevitably arise in the manufacturing of components and misalignment in the assembly process. In tokamak experiments, low-*n* error fields, in particular *n*=1 error fields, are very likely to drive large magnetic islands at rational surfaces in the core and induce mode-locking, which will brake the plasma flow and eventually lead to major disruptions. Therefore, it is critical to correct these error fields to avoid mode-locking induced disruption.

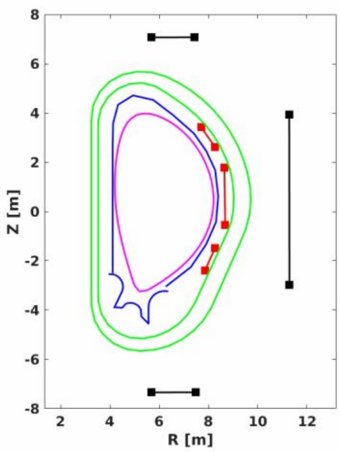

Fig. **1**. Poloidal location of the ELM control coils (red), EFC coils (black), vacuum vessel (green), the first wall and divertor (blue), and plasma boundary shape (magenta) in ITER.

Regarding to the two important purposes mentioned above, ITER also plans to implement external coils to achieve ELM control [4] and error fields correction [5], which are both essential for its future long-pulse operation. Two set of external coils will be installed in ITER, as illustrated in Fig. 1. The in-vessel coils, which have 3 rows and 9 coils in each row, are responsible for the ELM control and often referred to as RMP coils or ELM control coils. All 27 ELM control coils are equipped with independent power supply, which enables various choices of coil configuration. The ex-vessel coils, which consist of 3×6 coils, will be dedicated to error fields correction. Since low-n error fields are more dangerous, error fields correction (EFC) coils in ITER will be used for *n*=1 correction.

The performance of RMP coils and EFC coils to control ELM and correct EFs respectively depends sensitively on the spectrum of the applied 3D fields. Therefore, optimization of 3D fields is critical to maximize the control performance of external coils. Such optimization should also take into account of the plasma response [6], which can significantly modify the spectrum of the vacuum RMP field, by screening the resonant components of the applied radial field at corresponding rational surfaces and sometimes amplifying the non-resonant components via the so-called resonant field amplification (RFA) effect.

In this presentation, optimization of external 3D fields in ITER, from RMP coils and EFC coils, will be carried out utilizing the linear plasma response model MARS-F and GPEC. Different criteria associated with resonant component at rational surfaces and neoclassical toroidal viscosity (NTV) torque will be considered.

References

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