Status of the Design Work of Resonant Magnetic Perturbation (RMP) Coils for ITER.

M. Bécoulet[1], E. Nardon[1],G. Huysmans[1], Y. Gribov[2] , A. Polevoi[2], G. Saibene[3], G. Vayakis[3], A. Portone[3], A. Loarte[3].

[1]Association Euratom-CEA, CEA Cadarache, F-13108, St. Paul-lez-Durance, France
[2]ITER Naka JWS, 801-1 Mukouyama, Naka-shi, Ibaraki-ken, 311-0193 Japan
[3] EFDA close Support Unit,2 Boltzmannstrasse,D-85748 Garching, Germany
e-mail of the main author: marina.becoulet@cea.fr

Possible designs of external or in-vessel coils to generate Resonant Magnetic Perturbations (RMPs) for Type I ELMs control in ITER are presented for the reference scenarios (H-mode, Hybrid and ITB) taking into account physical, technical and spatial constraints. N=3 toroidal symmetry was considered to avoid triggering the most unstable MHD modes N=1,2 in the plasma core. The effect of screening of RMPs by plasma rotation is estimated analytically from the linear visco-resistive layer theory [1]. The optimum from the spectrum point of view and a minimisation of central perturbations is the design with the DC RMP coils situated close to plasma ,e.g. wined around blanket modules. For this design 25kA/11turns were found to be sufficient to produce marginal ergodisation of the plasma edge up to the top of the pedestal, where Chirikov parameter is ~1. Central islands on the q=4/3 surface that can be a potential trigger of (4/3) NTM is estimated to be about ~6cm without rotation and about ~2cm taking into account a toroidal plasma rotation in ITER. However, the technical difficulties of cooling and insulation of in-vessel coils in ITER remain an open question. As far as external coils are concerned, for example, the design with 18 coils around upper and lower ports combined with 18 upper and 18 lower coils in between upper/lower-ports and mid-port correspondingly with 2m toroidal length can be adapted for the H-mode scenario with much lager current~ 750kA and ~900kA for ITB and Hybrid. However the technical feasibility of such a system should be also estimated. The central perturbations are also larger compared to in-vessel coils (4/3 island is estimated to be ~8cm without rotation and ~2.6cm with rotation)

Coils wound around the 18 mid-ports plugs at 8.7m (with 0.5m width towards the wall and toroidal length 1.45m) could be fed with 150kA/11turns in n=3 configuration to produce similar edge ergodisation. However, the central (4/3) island is large as it is usual for mono-pole designs: ~10 cm w/o rotation (3.3 cm with rotation). Also if 6 ports are not available because of the heating systems the estimated current for 12 remaining RMP coils in ports is larger: ~250 kA/11turns (n=3). Compatibility mid-port RMP coils with other objects and, in particular, with mid-port diagnostics should be estimated.

The possible effect of plasma braking by a factor of 2 in plasma rotation frequency (f_{plas}=>$0.5f_{plas}$) gives a factor of ~2 more central perturbations on q=4/3 surface and $2^{½}$ in the island size.

β_p-scan demonstrated a negligible effect of β_p on the RMP spectrum in the relevant rage for ITER scenarios (β_p = 0.65 -1.2).

Heat transport modelling at constant density done with code TELM with ELMs and RMPs from blanket coils (25kA/11turns) showed ELM suppression in ITER H-mode scenario.

*[1] R. Fitzpatrick Nucl Fusion **33** (1993)1049*