

# Magnetic coupling of the toroidal plasma with external asymmetries

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In the problem of the plasma stability active control in tokamaks, the plasma reaction to the externally applied magnetic perturbations must be found with account of the induced currents in the resistive wall, which leads to the non-self-adjoint formulation. The problem became an important issue because of the Resistive Wall Mode (RWM) studies for ITER [1].

The plasma dynamics and the damping effect of the wall are described by essentially different equations. There are also geometrical differences: the tokamak plasma can be described by 2D codes, while the wall is typically asymmetric because of the cuts and ports, and the discrete active coils bring additional asymmetry. This makes difficult a combination of the codes treating separately the plasma and the external structures. For example, in the VALEN code with realistic 3D description of the wall this was accomplished only assuming the tokamak plasma to be a single-mode object [2]. Much larger progress was achieved recently with the CarMa code [3], though with rather sophisticated numerical procedure.

Here we propose a general analytical solution of the coupling problem which is based on the first-principle equations and standard operations of the electromagnetic theory. The result allows a direct calculation of the plasma-produced field after calculating the perturbed plasma equilibrium. The method proposed here leads to the desired result in a more simple and direct way than the described in [3]. This also gives a convenient general formula for calculating the equivalent external currents in the problem of the perturbed equilibrium [4].

The discussed equations can be used with the plasma models incorporating the nonlinear effects and the plasma rotation. Several applications will be discussed including the RWM stability control, helical equilibria in tokamaks, error field amplification and the active diagnostics if the plasma with the use of the applied resonant magnetic perturbations.

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[4] Park Jong-kyu, Boozer A. H., Glasser A. H., Phys. Plasmas **14**, 052110 (2007).