Subject: 7) Physics of stochastic edge plasmas with respect to error fields, locked modes and resistive wall modes.

Toroidal consideration of plasma response to penetration of an external low frequency helical magnetic perturbation into a tokamak edge plasma

I.M. Pankratov, A.Ya. Omelchenko, V.V. Olshansky

Institute of Plasma Physics,
National Science Center "Kharkov Institute of Physics and Technology"
Akademicheskaya str., 1, 61108 Kharkov, Ukraine

The control of plasma edge behaviour is the main purpose of the Dynamic Ergodic Divertor (DED) project of TEXTOR [1]. The DED helical coils create a specific topology of magnetic field at the plasma edge, where external rotating helical perturbations are resonant on the rational magnetic surfaces.

In the cylindrical model (two-fluid MHD) the penetration of external perturbations was investigated in [2]. General solution of MHD equations was found and investigated, which describes the structure (components of the penetrating field, the radial distribution of the perturbed current density and the radial profile of the poloidal driven force density) of the occurring resistive modes.

The toroidal modelling (without consideration of the plasma response) shows a more strong perturbation decrease with the distance from DED coils as compared with the cylindrical model (see, e.g., [1]). In the present paper for an adequate comparison with DED experiments the theoretical treatment of the DED operation is investigated in the toroidal geometry on the basis of two-fluid MHD equations with the plasma response being taken into account.

The covariant form of the equations that describe the penetration of external helical magnetic perturbations has been derived for the toroidal geometry in the first-order of a/R approximation. These equations take into account the toroidicity-caused couple of each poloidal harmonic m to its neighboring $m\pm1$ sidebands. Their preliminary analysis is carried out. The electron and ion pressures, ion gyroviscosity tensor and radial electric field are included. The incompressible plasma motion ($div\boldsymbol{V}=0$) is considered. This situation corresponds to operation of the Dynamic Ergodic Divertor (DED) in the TEXTOR-DED tokamak [1].

It is shown that as a first approximation it is possible to use the results of the cylindrical model [2] with the small factor $J_{m^*-m}(m\,|\,\lambda\,|)$ being taken into account, where $J_{m^*-m}(m\,|\,\lambda\,|)$ is the Bessel function. Recall that for TEXTOR-DED m/n=12/4 mode operation m^*=20. Here

$$\lambda(a)=-\xi'(a)-a/R\ ,\quad \xi'(a)=\frac{1}{aR}\left(\frac{\chi'(a)}{2\pi R}\right)^{-2}\int_0^a\left[4\mu_0 p_0(b)+\left(\frac{\chi'(b)}{2\pi R}\right)^2\right]b\,db$$

and $p_0(a)$ is the plasma pressure profile, χ' is the radial derivative of the poloidal flux.

This factor strongly reduces the effect of DED coil field. The radial components of the plasma velocity and magnetic field perturbations drop as $J_{m^*-m}(m\,|\,\lambda\,|)$. Hence the poloidal driven force drops as $J^2{}_{m^*-m}(m\,|\,\lambda\,|)$ in comparison with the cylindrical case [2].

[1] M.W. Jakubowski, S.S. Abdullaev, K.H. Finken. Nucl. Fusion **44** (2004) S1.
[2] I.M. Pankratov, A.Ya. Omelchenko, V.V. Olshansky, K.H. Finken. Nucl. Fusion **44** (2004) S37.