O-X TRANSFORMATION IN TWO-DIMENSIONAL INHOMOGENEOUS MAGNETIZED PLASMA

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In ECR heating of toroidal plasma there is a well known problem of wave penetration into central parts of plasma column when the plasma density is above the critical one: $N_e > N_c = \omega^2 m / \left(4\pi e^2\right)$. One possible way of solving this problem is the so-called O-X-B coupling process [1]. The process is based on a number of mode transformation in an inhomogeneous plasma. A LFS launched ordinary wave (O-mode) is transformed into an extraordinary wave (X-mode) near critical surface ($N_e = N_c$). An electron Bernstein wave (EB wave) is generated from the slow X-wave originating at the upper hybrid resonance layer. Since for EB waves there is no density limit, they propagate towards central parts of plasma column with the dense plasma where they are absorbed in cyclotron resonance region.

We concentrate here on the problem of O-X transformation in the critical layer. In the one-dimensional approximation this problem is rather well investigated (see, e.g.[2]). In a toroidal magnetic trap, the surfaces of constant magnetic field strength and of constant plasma density are not coinciding in general. This means that even neglecting the curvature of these surfaces the transformation may be of two-dimensional nature, thus must be treated beyond the scope of one-dimensional approach.

In this presentation the theory of O-X transformation is developed with taking to account 2D inhomogeneity within the model in which both plasma density gradient and magnetic field gradient are perpendicular to the magnetic field and not parallel to each other. This models, for example, a situation with off-equatorial position of the injection point of quasi-optical heating beam into toroidal plasma. The set of approximate equations describing distribution of electromagnetic field in the vicinity of 2D inhomogeneous transformation region is obtained for the case of smooth inhomoneneity. The full analytical solution of this set has been found in the form of specific full orthogonal basis representing the transverse distribution of electric field in a wave beam. This allows calculation of O-X transformation efficiency for the arbitrary distribution of electric field complex amplitude over transverse aperture of the beam. Conditions for the necessity to take into account 2D nature of O-X transformation have been formulated.

The most pronounced features of 2D transformation are the following.

(1) Transformation efficiencies are different for cases of wave propagation in two opposite directions.

(2) For any transformation point at the critical surface space there is an optimal transverse structure of finite rf beam and optimal incidence angles which provide full transformation for the propagation in one of two opposite directions. This structure is evidently different from 1D case where the optimal structure is an infinite plane wave with quite definite incidence angles as well.

References

[1] Preinhalter J., Kopecky V., Plasma Phys., **10,** p.1 (1973).
[2] Tokman M.D., Plasma Phys., **10,** p.1205, (1985).