§14. Numerical Study of Wave Propagation near the OX Mode Conversion Region

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In the LHD, experiments of electron cyclotron resonance heating (ECRH) by the electron Bernstein wave (EBW) excited via the ordinary-extraordinary-EBW (O-X-B) mode conversion process are performed in high density plasmas. In this collaboration research program for the LHD experiments, we are developing numerical calculation code to analyze the ordinary (O) - extraordinary (X) mode conversion process that takes place near the plasma cutoff and to compare the result with experimental results.

To excite the EBW via the O-X mode conversion process, the ordinary (O-) mode should be injected from the low magnetic field side at an appropriate injection angle to reach the region where the plasma cutoff and the left hand cutoff are located close to each other. From now in the experiments, the injection angle has been set according to the theoretical prediction with use of the equation to give the O-X mode conversion ratio (T_{OX}) written below.

$$T_{OX} = exp\{-\pi (\omega/c) L_n(\beta /2)^{1/2}[2(1+ \beta)(N_{//} - N_{//opt})^2+N_v^2]\} \quad (1)$$

Here plasma parameters at the reference point where the component of the refractive index that is parallel to the density gradient becomes zero and reflected closed to the evanescent region between the plasma cutoff and the left hand cutoff in the ray-tracing are used. Since the ray-tracing cannot treat the wave propagation near and inside the evanescent region, we introduce an artificial method for ray-tracing after the transmission. There, the re-start point of the ray-tracing beyond the evanescent region is determined to be located in a direction along the density gradient at the reference point with conserving the wave vector. The effect of the finite beam width is investigated by multi ray-tracing. For each divided ray, the reference point and the restart point are determined. Note that a reduction of the T_{OX} caused by density fluctuation near the plasma cutoff.

Adding to the artificial method written above, we are developing a numerical code to analyze the O-X-B mode conversion process of the electron cyclotron wave that has a finite beam width including the effect of collision with use of TASK/WF2D that solves the Maxwell equations as a boundary problem. With use of multi ray tracing and some interpolating method, the spatial distribution of the wave vector components of the wave electric field that has a finite width is determined near the evanescent region. As a first step we have introduced a coordinate system for the calculation to proved the plasma parameters as two-dimensional meshed data. Fig. 1 shows the definitions of the directions in the coordinate system. A point near but not very close to the evanescent region, the *x* direction is defined along the perpendicular direction to the magnetic surface that corresponds to the direction along the density gradient. The *z* direction is determined with taking the cross product of the direction of the wave group velocity vector and the x direction. The y direction is determined with taking the cross product of the normal vectors in the *z* and the *x* directions. Any arbitral coordinate points in the *x-y* plane in Fig. 1 can be corresponded to original three-dimensional coordinate points used in the ray-tracing to refer the plasma parameters.

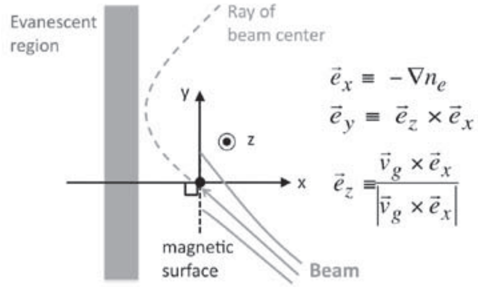

Fig.1: Definition of the *x, y, z* directions used in the two dimensional calculation.

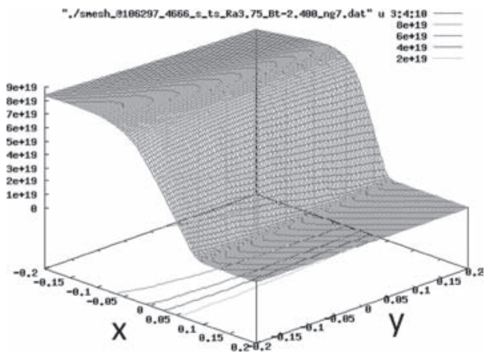

Fig. 2: Two dimensional density profile given as a meshed data in the coordinate system defined in Fig. 1.

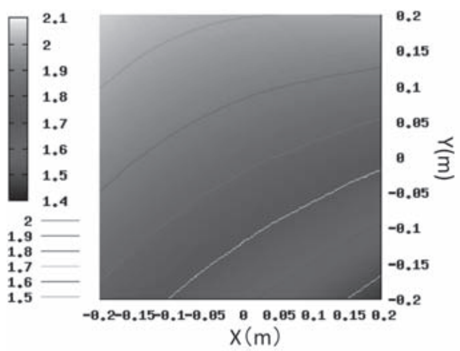

Fig. 3: Two dimensional profile of the *y* component of the external magnetic field vector given as a meshed data in the coordinate system defined in Fig. 1

Fig. 2 shows the density profile given as the meshed data and Fig. 3 shows the profile of the *y*-component of the external magnetic field. It is expected that characteristic of mode transmission and mode conversion process in such system that is not uniform in one direction can be obtained.