## §8. Examination O-X-B Mode Conversion Window in a FFHR-type Plasma

Igami, H., Kubo, S., Mutoh, T., Sagara, A.

A high-density operation scenario for ignition has been proposed for the Forth Free Helical reactor (FFHR) [1]. The highest central density in the operation scenario is several times as high as the cutoff density of the fundamental electron cyclotron (EC) wave therefore the fundamental electron cyclotron heating (ECH) by the electron Bernstein wave (EBW) which has no density limit in propagation and is cyclotron damped at the electron cyclotron resonance (ECR) layer is a promising way for the long pulse heating in such over-dense plasmas. For the plasma condition of FFHR, it is required to inject electromagnetic waves as the ordinary (O) mode with an appropriate angle so that it connect with the extraordinary (X) mode at the plasma cutoff and excite the electrostatic EBW at the upper hybrid resonance (UHR) layer (O-X-B method).

We estimate the O-X-B mode conversion rate in a plasma of FFHR size with use of the analytical equation [2]. Since the equation is obtained for the slab plasma, we adopt very roughly estimations to use the equation. They are, (1) the beam trajectory is straight. (2) From the plasma boundary to the area where the mode conversion takes place, the direction of the density gradient remains the same.

One of the field configurations of LHD ($R_{ax}$ , $B_{ax}$ $\gamma$, Bq)= (3.6m, 2.75T, 1.254, 100%) is extended to FFHR size where $R_{ax}$=14m and $B_{ax}$=6T. The electron density profile $n_e(\rho)$ is given as, $n_e$=4.0 x 0.5x[1.0-tanh{20.0($\rho^2$-0.2)}](x$10^{20}m^{-3}$). Fig.1 shows the locations of injection antennas of electromagnetic wave beam. The injection angle is defined by the coordinate point on the virtual target plane of the electromagnetic wave beam, tangential vertical plane for A and B, horizontal plane on the mid-plane for C and D. Fig.2 (1)-(4) shows contour maps of O-X-B mode conversion rate with use of antenna A-D. The mode conversion window appears if the target position can be set appropriately. It is not difficult to inject electromagnetic beam toward the region inside the mode conversion window with sufficient accuracy. However, whether the mode converted EBW is absorbed in the desirable region or not is another problem. Moreover, it has been indicated that if the power density of the wave exceeds a certain level in the UHR layer, there is a possibility that most part of the wave power is lost as parametric decay waves. Further experimental and theoretical studies are required for the application of EBW.

[1] O. Mitarai, A. Sagara et al., Plasma and Fusion Research **2** 021 (2007)
[2] E. Mjølhus, J. Plasma Phys. **31** pp.7 (1984)

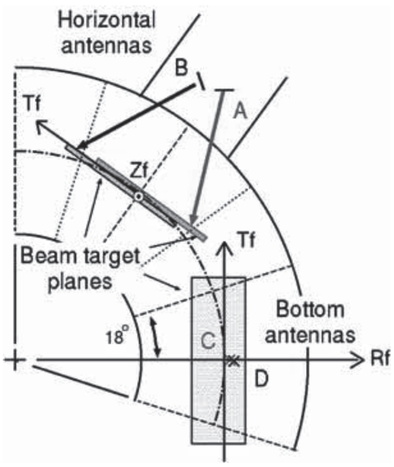


Fig.1 : Schematic top view of the torus and the antenna positions. The virtual target planes of the incident beams and the definitions of the sets of the coordinate axes on those planes, (Tf, Zf) and (Rf, Tf) are shown.

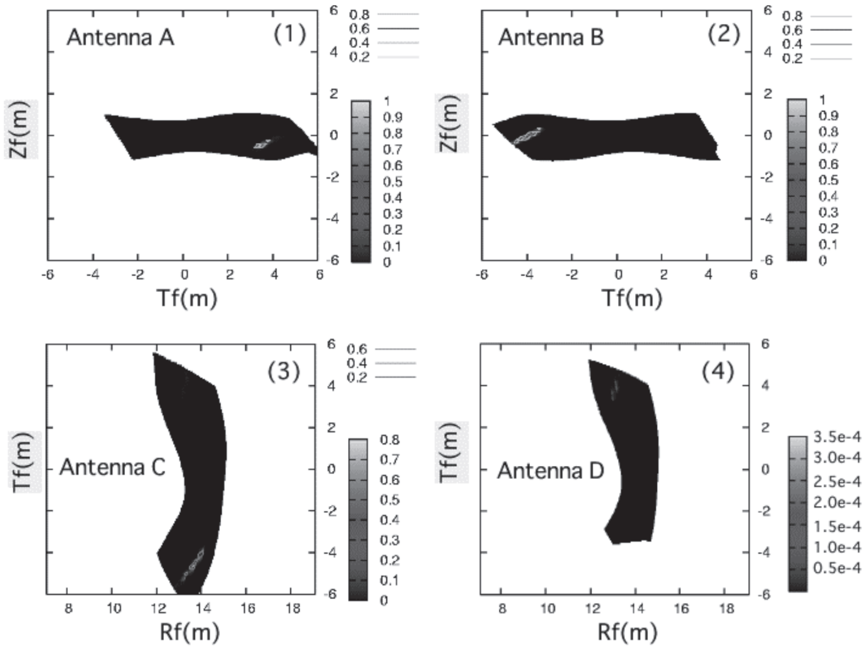


Fig.2: Contour maps of the O-X-B mode conversion rate plotted as functions of the coordinate point on the virtual target plane.