§31. Ray Tracing for Toroidal Correlation Reflectometry in CHS

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Using a toroidal correlation reflectometer, it is possible to obtain the information on the ι–profile [1]. The idea is to install two reflectometers with antennas at a given toroidal and poloidal distance. The geometrical configuration of the measurements defines a given ι value. Then we try to find the radial position of the field line corresponding to this ι value by scanning the radial position of the reflection layer. Fig.1 shows an example of a field line for $\iota/2\pi=0.5$. If we sweep simultaneously the frequency of both reflectometers the coherence should be maximum when the waves are reflected at the same field line (Point A and Point B in Fig.1). Due to the shear this will happen only for a given frequency which corresponds to the cutoff frequency of the field line, so that we determine the position of this ι surface.

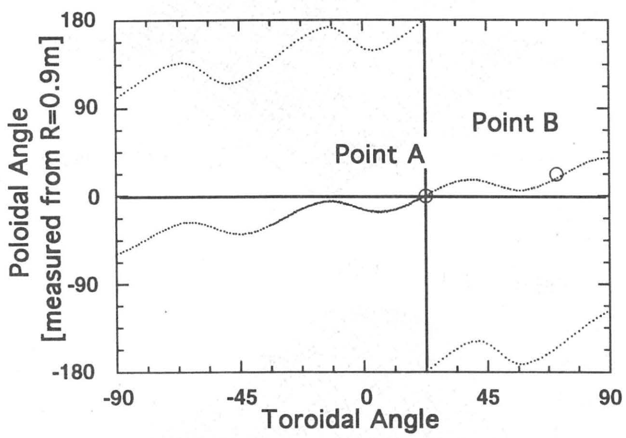

Fig. 1 A field line for $\iota/2\pi=0.5$. The present existing antenna measures Point A,and an antenna installed at one of the M-ports can measure Point B.

In order to measure the same field line, the position and angle of the launching (and receiving) antenna should be carefully chosen. Obviously, reflectometers require reflected wave to be received by the receiving antenna. Due to the complicated plasma shape, however, it is not obvious where and in which direction the antenna should be located. A ray tracing code has been developed for the design of millimeter wave diagnostics [2]. The code calculates rays for a given launching antenna position, for given plasma parameters. The direction of the launching microwave is iteratively calculated so that the reflected wave is received by the receiving antenna. In the present calculation, one antenna is used as the launching and receiving antenna. Figure 2 shows the obtained ray for the plasma with $n_e(0)=0.5\times 10^{20}\mathrm{m}^{-3}$, and for the launching microwave of 55 GHz and O-mode (Slow wave). The vacuum magnetic field and simplified plasma shape (twisted ellipse) are used. For a given cylindrical coordinates (R,ϕ,z), the normalized minor radius ρ is calculated from the equation

$$\rho^2=[\{R-R_{ax}+\Delta(1-\rho)\}\cos(m/l)\phi-z\sin(m/l)\phi]^2/a^2$$
$$+[\{R-R_{ax}+\Delta(1-\rho)\}\sin(m/l)\phi-z\cos(m/l)\phi]^2/b^2$$

where a,b are the shorter and longer axis of the ellipse, and Δ is the outward shift of the magnetic axis, R_{ax} is the major radius of the center of the outer-most ellipse. Figure 2 shows the trace to measure Point B in Fig. 1. With this pare of reflection points (A and B), the position of $\iota/2\pi=0.5$ can be determined.

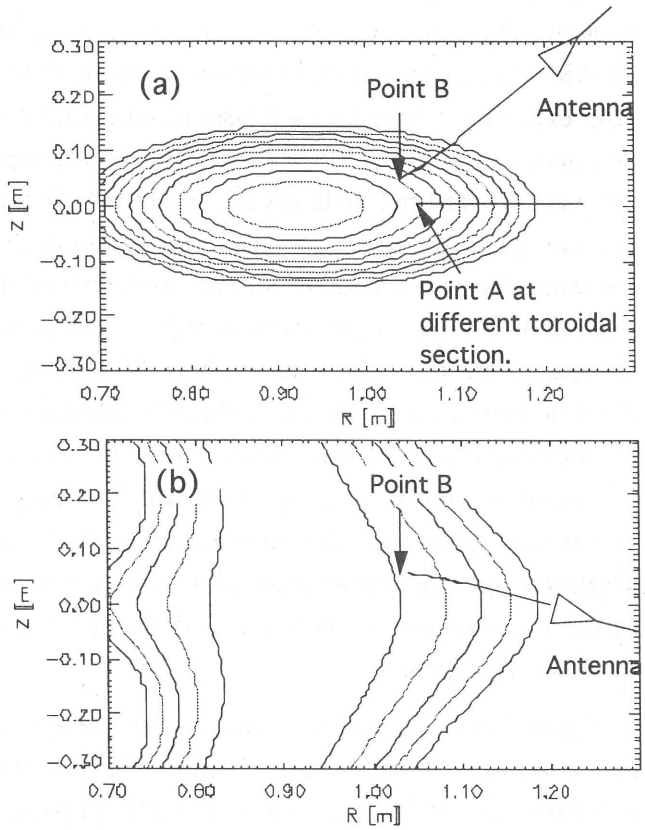

Fig. 2 Tangential view of the ray with the equi-density surfaces at a toroidal section (a), and top view with the equi-density surfaces at the midplane.

References
1) Sanchez,J., Private communication (1995).
2) Ejiri,A., et al., Ann. Rep. of NIFS (Apr.1994-Mar.1994).