§15. Initial Analysis of Escaping Fast Ion Measurement on CHS

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Escaping fast ions have been measured with a scintillator-based probe which can provide both information of pitch angle and gyroradius of detected ions in Compact Helical System(CHS). The measurement was started in February 1997. It was confirmed that output signals are due to neutral beam(NB)-injected fast ions[1,2].

To understand the loss process of detected fast ions, a full gyro-orbit following calculation code was developed and fast ion orbits were calculated in the CHS magnetic field. The numerical model to follow ion motion is as follows,

$$m\frac{d\vec{v}}{dt}=q(\vec{v}\times\vec{B}+\vec{E})$$

m is ion mass, v is ion velocity, B is vacuum magnetic field of CHS. Here, "ion" actually means NB-injected fast ions. Electric field E is set to be 0 in this calculation. Fast ion orbits start from detector position and are computed backwards in time. A poloidal cross section of CHS vacuum vessel has elliptical shape and it rotates toroidally. It is not so easy to judge whether ion hits the wall or not by poloidal projection((R,Z) plane) of orbits. The position of limiter, i.e., first wall of CHS is therefore included in this code.

Fig. 1 shows the poloidal projection of computed fast orbit with the energy of 36 keV and the pitch angle of 48° at the probe position in a discharge of R_{ax}=97.4 cm and B_T=0.9 T. The computation shows a passing orbit which is largely deviated from the outer most magnetic surface. Fig. 2 indicates the pitch angle variation of fast ion orbit seen in Fig. 1. The pitch angle of core region(R<100 cm) is higher than that of peripheral region because of μ conservation. To check whether there exist ions which can reach the probe or not, the birthplace and its initial pitch angle of NB-injected fast ions were calculated with HFREYA code. Particles of 5,000 with the energy of 36 keV were launched. The profile shape of n_e and T_e are given by $p(r)=p(0)\{1-(r/a)^2\}^{\alpha}$. The parameter α determining the peakedness was set to be 0.5 for n_e and 1.0 for T_e. The calculation was done with $T_e(0)$ of 0.5 keV and $n_e(0)$ of 2.6×10^{19} m^{-3}. Dots seen in Fig. 3 show initial pitch angle distribution of deposited ions. From the comparison between pitch angle variation of computed fast ions(Fig. 2) and initial pitch angle distribution of birth fast ions, it turns out that fast ions whose birthplace is in the core region can not reach the detection point directly. If ions change their direction in velocity space due to pitch angle scattering, fast ions generated in central region may reach the probe. The analysis suggests that the lost ion flux is mainly from ions whose birthplace is in the peripheral region[1].

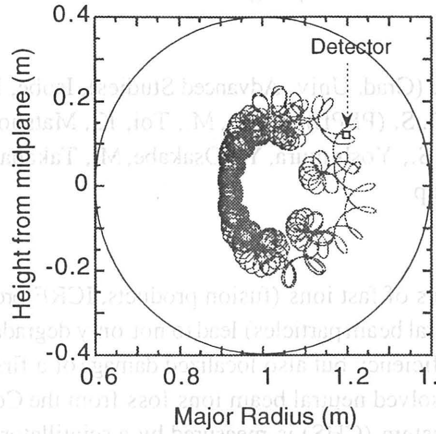

Figure 1. Computed fast ion orbits which can reach the probe position.

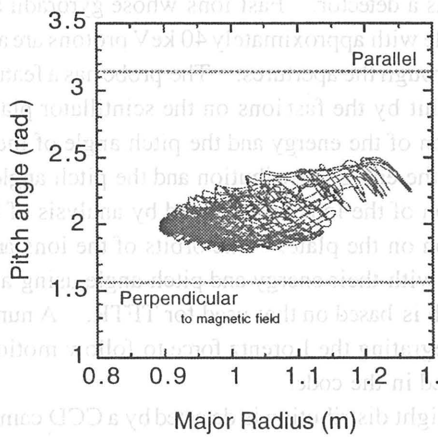

Figure 2. Pitch angle variation of fast ion orbit seen in Fig.1

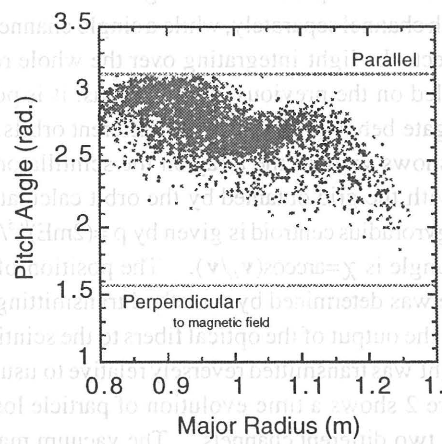

Figure 3. Initial pitch angle distribution on R-Z plane.

References
[1] D.S. Darrow *et al.*, J. Plasma Fusion Res. SERIES, Vol. 1(1998)362.
[2] M. Isobe *et al.*, proceedings of 12th High Temperature Plasma Diagnostics, Princeton, U.S.A.