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モンテカルロコードを用いた再突入高速イオンの熱流束評価と高速イオン計測との比較

Comparison of Heat Flux Evaluation of Re-entering Fast Ion Using Monte-Carlo Method with Fast Ion measurement in LHD

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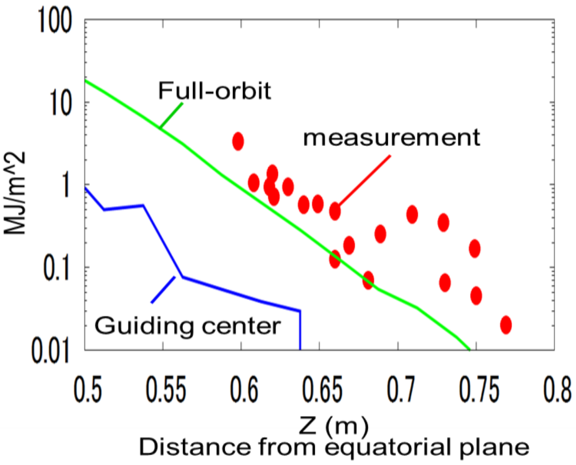
In a fusion reactor, it is an important issue to design the blanket. The design of the blanket requires that a heat flux due to alpha particles produced by the fusion is exceedingly-small. Especially, in the fusion reactor like the Large Helical Device (LHD), the space for installation of the blanket is not enough large because of a small distance between the plasma boundary and coil. Thus, the detailed analysis of the particle orbits is required. In such analyses, a full-orbit tracing of alpha particles using the Monte-Carlo method is usually used because a Larmor radius of the alpha particle is relatively large. However the Monte-Carlo code based on the full orbit tracing needs a long calculation time. In order to save the calculation time, a heat flux model of fast ions including the finite Larmor effect is required.

In the LHD, the reactor-relevant high-beta plasmas with the volume averaged beta value, $<\beta>\sim 5\%$, are achieved with about 0.5 T. In the LHD high beta discharge, the Larmor radius of a 180 keV fast ion produced by a NB is the almost same as that of alpha particle in a reactor. In addition, in the LHD high beta plasma, it is shown that most of fast ions produced by tangentially injected Neutral Beams are “re-entering fast ions”, which have closed orbit across the Last Closed Flux Surface[1]. In the LHD, the power density of their fast ions can be measured by a hybrid directional probe[2] and its power density can be compared with the power density evaluated by a calculation code.

We evaluated the power density of the re-entering fast ions by using a Monte-Carlo code, MORH[3], which can consider “re-entering fast ion”. Then the power density evaluated by the MORH was compared with the fast ion measurement of the probe. Figure 1 shows the power density of re-entering fast ions. In Fig. 1, a vertical axis is the power density of fast ions and horizontal axis denotes the measurement position of the probe. The power density (blue line) evaluated with guiding center orbits is less than one-tenth of the measurements (red points). On the other hand, the power density (green line) evaluated with full-orbits, in which the particle are traced with including the Larmor movements, is almost same value as the measurements. In the low field (~ 0.5 T), the Larmor radius of the fast ions produced by NBs is almost same as that of alpha particle produced by a fusion. The evaluation of the power density of fast ions needs to include the Larmor-movement in such plasma. In addition, we have developed a finite Larmor width model, and the developed model has been introduced to the MORH based on the guiding center orbits for saving the calculation time. The power density evaluated by using the guiding center orbit with the developed model is a little smaller than the measurements. A calculation time of the evaluation by the guiding center orbit with the developed model is less than one-tenth of the evaluation by the full-orbit. In this conference, the developed model and the MORH will be explained in detail. The power density of the re-entering fast ions will be discussed.



Comparison of fast ion measurements with that evaluated by MORH

Reference

[1] R. Seki, *et al.*, Plasma Fusion Res., 3, 016 (2008).

[2]K. Nagagoka *et al.*, Rev. Sci. Instrum. 79 10E523 (2008).

[3] R. Seki, *et al.*, Plasma Fusion Res., 5, 014 (2010).