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ITERにおける損失アルファ粒子計測の課題
Issues for lost alpha measurements on ITER

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Introduction

Alpha-particles produced by D-T reaction in a fusion reactor transfer their energy to plasma (self-heating). However, some losses, not only steady orbit losses, but also those coupled with various instabilities are anticipated. The loss of alpha particles means deterioration of the heating input power. Moreover, the loss localization may cause serious damage of the first wall of reactor. Deterioration of plasma performance due to the influx of impurities sputtered by these high-energy alpha particles striking the first wall would be also serious problem. Upon these reasons, measurement of alpha-particle loss and study of loss mechanism are required for machine protection and for optimization of discharge scenarios on ITER.

Measurement Requirement

An “ideal” lost alpha diagnostic should provide information on (1) loss distribution on the first wall, (2) Absolute values of lost alphas flux, or heat load caused by alpha-particle loss, (3) Time evolution of alpha-particle loss (4) Energy and impinging angles of lost alphas to identify the loss orbit. They should be reliable and withstand severe conditions of ITER environment (high neutron/gamma flux, high temperature, strong magnetic field, etc.), and the discrimination of alpha-particle loss from other ion or electron load should be made.

Diagnostic Methodology

A number of measurement techniques have been proposed for ITER[1]. As for the loss distribution on the first wall, an infrared camera viewing is suggested, but it cannot discriminate alpha-particle loss from other ion or electron load. Scintillator probes [2,3], which have been applied on many tokamaks and helical devices, faraday cups and bolometric detection using imaging foils [4] might have a problem with signal to noise ratio, and the fragility under the circumstance of high neutron flux and high temperature. The biggest problem of these probes is that they cannot be inserted close to the detectable region that is closer to the plasma boundary than the first wall (see Fig.1).

Possible Measurement Location

In ITER, alpha particles escaping drift downward, and only small fraction may arrive onto the equatorial surface region. Possible measurement locations are poison A and B in Fig. 1 but not near equatorial but on the lower blanket module surface. For those locations, only the infrared viewing, γ-ray detection, and activation [5] are applicable. In the recent equatorial port design of ITER, the front surface of a port plug is retracted by about 100 mm, as shown in Fig. 1. The orbit calculation shows the possibility of time-resolved measurement in case of 100 mm retraction [6]. The further work starting from the location C, which is allocated in EPP 8 of ITER is needed.

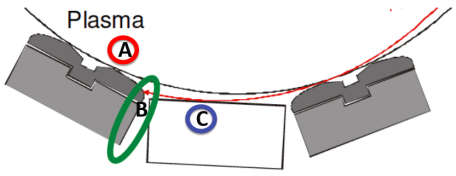

Fig. 1. Possible measurement locations in ITER for lost alpha diagnostic. Position A, and B should be on the lower blanket module surface.

References

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