§30. Study of Interaction between Energetic Ion and Energetic-ion-driven MHD Instabilities in a Helical Plasma Characterized by Low Magnetic Shear

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Good confinement of energetic particles (EPs) in magnetically confined fusion plasmas is essential in realizing a fusion reactor since fusion-born energetic α particles play an important role as a primary heating source in future burning plasmas. With a burning plasma stage imminent, the physics of the interplay between EPs and EP-driven magnetohydrodynamic (MHD) instabilities such as Alfvén eigenmodes and energetic-particle continuum modes (EPMs) have become more important in recent years. For this reason, physics experiments concerned have been conducted in Heliotron J [1,2]. To study transport and/or loss of energetic ions caused by EP-driven MHD instabilities, magnetic spectrometer-type lost fast-ion probes, e.g. a scintillator-based or Faraday cup-type probe have been often employed in tokamaks and helical devices, providing energy and pitch angle of lost fast ion simultaneously as a function of time [3-6]. Because Heliotron J has not been equipped with the lost fast ion probe based on a magnetic spectrometer concept, we are going to install a Faraday cup-type lost fast-ion probe (FLIP) as a first step. In FY2011, we have set up a Lorentz orbit code to find a position suitable for lost beam ions in Heliotron J. Subsequently, design and construction of the FLIP for Heliotron J were performed.

Figure 1 shows typical collisionless Lorentz orbits of co- and counter-going beam ions (H^+) reaching a candidate position of FLIP. The FLIP is inserted into a vacuum vessel from 6.5U port. The energy of beam ion (H^+) was set to be 28 keV. Pitch angles of co- and counter-going beam ions are 137 deg. and 30 deg., respectively. It is seen that both co- and counter-going beam ions of which orbits are substantially deviated from flux surfaces can reach the FLIP position. It looks that flux of co-going beam ion is expected to be higher than that of counter-going beam ions. Because co-going beam ions have been responsible for destabilization of global Alfvén eigenmodes (GAE) in Heliotron J, the FLIP is designed so as to detect co-going beam ions in Heliotron J.

Schematic drawing of detection section of FLIP is shown in Figure 2. The essential part of the FLIP is a molybdenum steel box with thin films of aluminum (Al) vapor deposited onto one face of the quartz substrate (34 x 34 mm^2, 1 mm thick) on the bottom of the box. The thickness of thin Al films is about 0.2 μm. The Al film (10 x 15.5 mm^2 for each) is divided into six zones to provide gyroradius centroid and pitch angle of lost fast ions simultaneously. Fast ions with larger gyroradii strike the Al films farther from the apertures than those with smaller gyroradii and their strike points are dispersed along a line passing through the center of the two apertures according to their pitch angles. The current from each Al film flows through a multipin vacuum feedthrough connector on a Conflat flange to current-input preamplifiers. The construction of FLIP was completed until the end of FY2011. Measurements of anomalous loss of beam ions while GAE activities occur will be carried out in FY2012 experiment campaign.

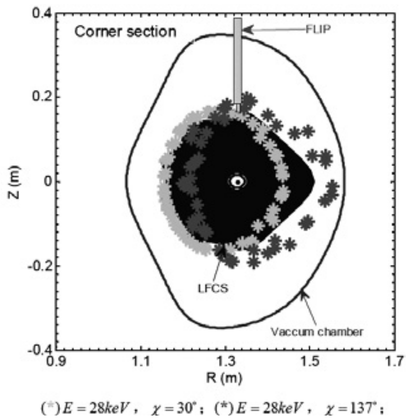

Fig. 1. Typical co- and counter-going beam ion orbits reaching the FLIP in Heliotron J.

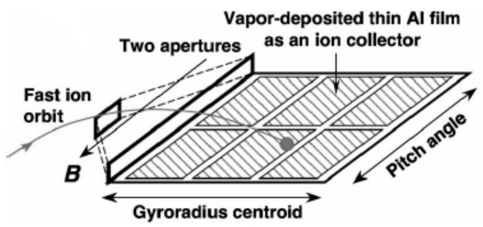

Fig. 2. Schematic drawing of detection section of lost fast-ion probe based on thin Faraday film FLIP.

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