§39. Research on the Physics Mechanism of Anomalous Transport of Fast Ions and the Possibility of their Control

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Nonlinear behaviors of Alfven-eigen (AE) modes and related anomalous transport of fast ions are important subjects to be understood from view point of their control to prevent degradation of fusion energy gain in magnetically confined fusion burining plasmas. The suppression of fast ion driven AE modes by the application of electron cyclotron heating (ECH) are observed in DIII-D, TJ-II and LHD. The suppression by electron cyclotron current drive (ECCD) was also identified in Heliotron J. In order to understand the AE stability mechanism, the wave-particle interaction analyzer (WPIA) was temporary installed in Heliotron J experiment in fiscal year of 2015.

The WPIA was proposed for the measurement of space plasma in the Van Allen belt of magnetosphere and the origin of energetic electrons in the Van Allen belt will be clarified by the ERG project. The concept of WPIA is experimental evaluation of energy transfer rate between fast ions and the wave, which is summarized in Fig. 1. The sequence of the WPIA in laboratory plasma experiment is follows. The particle detection time is recorded for all particles detected by a detector. Then the phase of the wave interacting with the particles is evaluated by the timing information. Then the histogram of the particles is produced as a function of phase of the wave. If the particles interact with the wave and energy transfer rate is finite, a structure should be visible in the histogram. When the particles do not interact with the wave, the particle flux have no correlation with the wave, so a flat profile should be appear in the histogram. The system of WPIA for laboratory plasmas were developed and installed in LHD and also tested in TJ-II so far. The demonstration to confirm the concept was succeeded. In Heliotron J experiment, the WPIA system developed in the LHD experiment was temporary installed for the signal of CX-NPA in Heliotron J (see Fig.2). Figure 3 shows the component of pulse analyzer using a FPGA module. For the adjustment of circuit impedance, the isolation amplifier was utilized for this test operation, and the time resolution degrade to 1MHz (50MHz for FPGA module).

In the first trial of WPIA in Heliotorn J, the pulse analysis was successfully performed, however, some problems to be solved appeared.

1) Line of sight should be changed. The target should be passing particles, which is observable by Si-FNA detector.
2) The time resolution should be improved. So the electro circuit have to be upgraded to adjust the impedance.
3) The user interface should be built for Heliotron J experiment. The new system of pulse analyzer is under construction at this moment.

In the next campaign, the upgraded system for WPIA in Heliotorn J experiment will be installed and become operational for fast ion physics experiment in Heliotron J.

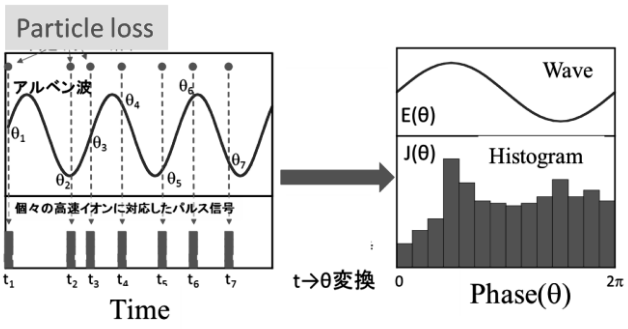

Fig. 1. Conceptual schematic of wave-particle interaction analyzer (PWIA).

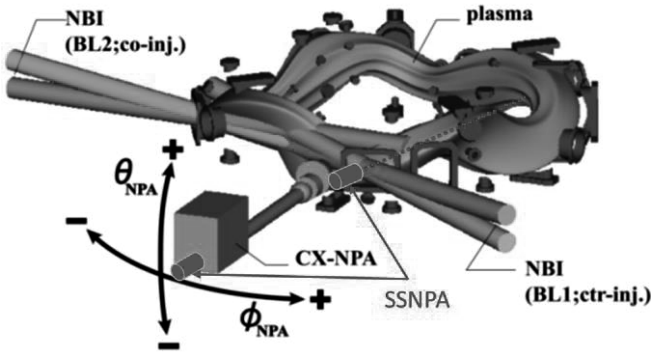

Fig. 2. Schematic of CX-NPA and Si-FNA (SSNPA) diagnostics in Heliotron J device.

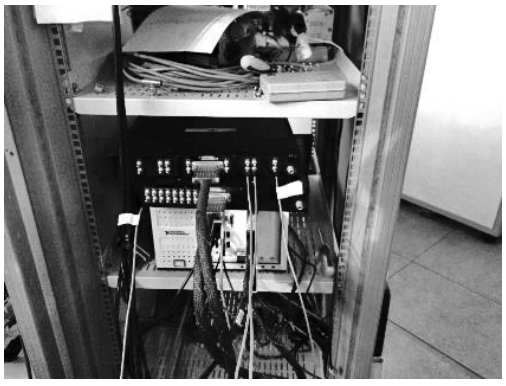

Fig. 3. Pulse analyzer system using NI-PXIe series was temporary installed in Heliotron J experiment.