§16. Optimization of Helical System Concept

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The collaboration research between the Helitoron J group and other experimental groups such as the CHS group has been continued to understand machine-independent torus plasma confinement physics through the systematic study using the data obtained in this collaboration. The main purpose of this research is to promote experimental and theoretical studies based on the data of the improved confinement in Heliotron J and CHS for the optimization of helical confinement field aiming the control of the transport in the helical plasmas.

The five schemes for the collaboration research has been selected; (1) the database construction for plasma confinement, (2) the structure formation accompanying with the confinement transition, (3) ECCD, EBW heating, (4) the production and confinement of high energy particles and (5) the theoretical analysis of helical configuration optimization. Each group joined the plasma experiment and joined data analysis including the usage of fast internet for data exchange and analysis. For the collaboration of this year, we have put emphasis on the themes of the production and confinement of high energy particles, EBW heating and toroidal current drive.

Formation and confinement of high energy particles

High energy ion tail has been studied in ECH/ECCD plasmas in CHS. The relation of fast electrons to high frequency fluctuations in the presence of ion tail is studies in this year. This is aimed to inspect of the models of ion acceleration according to (1) LH wave excitation via mode conversion of the injected microwave and (2) the wave excited by the fast electrons. The tail temperature is the highest in the case that the toroidal current driven by EC wave flows reversely (reducing rotational transform) in the toroidal scan experiment of the injection angle of ECH at R_{ax} = 94.9 cm. The ion tail is observed at the density below 0.25 x 10^{19} m^{-3}. However, high energy electron cannot be observed. For the next step, the relation of ion tail to high frequency fluctuation will be analyzed using high frequency probe data, which contains up to 1 GHz component.

EBW heating

ECH is used for generation of currentless plasmas, electron temperature profile control, MHD instability suppression and so on. To apply ECH to the high density plasmas, mode conversion from an electromagnetic wave to an electrostatic wave can be utilized. The electron Bernstein wave (EBW) does not have the density limit for its propagation, and have an advantage that the one-pass absorption rate is nearly unity even in law temperature of about 10 eV.

Last, year, 54.5 GHz ECH beam was injected into NBI plasma to study mode conversion heating of OXB mode in CHS. However, stored energy did not increase clearly. Using X-B mode conversion of slow wave, EBW heating is performed with the injection power of 275 kW, this year. In the cross section where the plasma is vertically elongated, the ECH beam is injected from the top port, then, reflected by the mirror installed near the helical coil positioned at the outermost of the torus. Reflected wave from the high field side is converted at the HHR layer and introduces in to the central region of NBI target plasmas. The increase of the stored energy and the central electron temperature during ECH pulse is observed. This increase is considered to be due to EBW heating since the cross point of injected beam and cyclotron layer is positioned only at the edge of the plasma.

Toroidal current drive

It is considered that the drive mechanisms of the toroidal current are bootstrap (BS) current and ECCD in ECH plasmas. By reversing confinement field, the separation of these currents is performed. BS current and EC current are evaluated separately for various heating position and field configuration (bumpiness). It is found that the raio of Fisch-Boozer effect and Ohkawa effect in ECCD is changed by the bumpiness or heating position. The change of the confinement of fast electrons may cause the Ohkawa effect change, then, such result is observed.

References

[1] F. Sano et al., Proc. 21st IAEA Fusion Energy Conference, Chengdu, China, Oct. 16-21, 2006, EX/5-5Ra.
[2] K. Nagasaki et al., Proc. 21st IAEA Fusion Energy Conference, Chengdu, China, Oct. 16-21, 2006, EX/P6-14.