XA9950858

EXP4/08

Characteristics of Hot Ions with a Strong RF Heating in the GAMMA 10 Tandem Mirror

M.Ichimura, H.Hojo, K.Ishii, A.Mase, Y.Nakashima, T.Saito, T.Tamano, K.Yatsu
Plasma Research Center, University of Tsukuba, Tsukuba, Ibaraki 305-8577, Japan

The RF heating system has been improved to create a more axisymmetric plasma in the GAMMA 10 tandem mirror. A high ion temperature is attained with the system and strong Alfvén ion cyclotron (AIC) modes are excited. With the AIC modes, high energy ions detected at the end increase and central ions with nearly 90 degree pitch angle decrease.

For initial plasma production and sustaining MHD stability, a fast Alfvén wave (RF1) is excited in the central cell. The wave is converted into a slow Alfvén wave which propagates towards the minimum-B anchor cell and heats ions on the cyclotron resonance layer. Another ion cyclotron range of frequency (ICRF) source is also applied in the central cell for main plasma heating with conventional double half-turn antennas. An ion temperature of 10 keV is attained with the high power ICRF heating[1]. The GAMMA 10 is designed to be an effectively axisymmetrized tandem mirror. The central cell has an axisymmetric mirror configuration and the anchor cells have a non-axisymmetric magnetic field configuration with an elliptic cross section. The four plate elements of the RF1 antennas consist of two pairs, one with vertical plates and the other with horizontal plates, in order to generate a rotating electromagnetic field. They are located near both ends of the central cell. A degree of plasma axisymmetry in the central cell is evaluated from the azimuthal distribution of the floating potential of eight-segmented limiter at the midplane and is controlled by changing a balance of the RF power applied to each pair of antenna elements. In a non-axisymmetric case, a significant reduction of the ion temperature is observed when the RF1 power is increased. When the portion of the power applied to the vertical antenna pair increases while the total RF1 power is fixed, the axisymmetry of the plasma is improved and the diamagnetizm increases as shown in Fig.1. The inlet of Fig.1 shows the azimuthal distribution of the floating potential and the degree of the non-axisymmetry. Under the improved axisymmetric condition, no reduction of the ion temperature are observed even with the increased RF1 power.

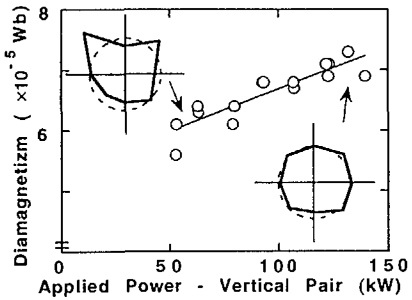

Fig. 1

With a strong ICRF heating, a temperature anisotropy defined as a ratio between perpendicular and parallel ion temperatures becomes greater than ten since the cyclotron resonance layer is located near the central cell midplane. Unstable AIC modes are driven because of the strong anisotropy. The AIC modes have a frequency range just below a local ion cyclotron frequency. The modes are excited as an eigenmode in the axial direction and has a standing wave region near the midplane of the central cell[2]. A clear correlation between the AIC modes and behaviors of the high energy ions has been observed. Semiconductor detectors are used for the measurement of high energy protons with energies above 5keV in both parallel and perpendicular directions to the magnetic field line. The detector installed in the central cell measure a pitch angle distribution of high energy ions. Figure 2 shows behaviors of the high energy ions and the amplitude of the AIC modes. When the diamagnetizm increases with time, the anisotropy becomes strong and the AIC modes increase. Endloss high energy ions show almost the same characteristics as that of the AIC signal and increase as the AIC modes are excited. High energy ions with a pitch angle near 90 degrees in the central cell midplane also appear initially as indicated by the dotted line, but decrease when the amplitude of the AIC mode becomes strong.

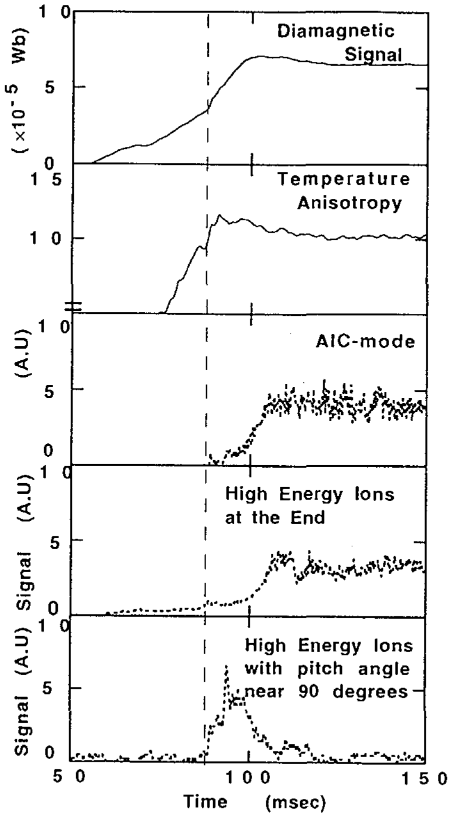

Fig.2

In summary, the plasma axisymmetry is improved and a high ion temperature is effectively created. Strong AIC modes are excited and the enhancement of pitch angle scattering of hot ions are observed.

REFERENCES
[1]TAMANO,T., et al., in Plasma Physics and Controlled Nuclear Fusion Research 1994(Proc. 15th Int. Conf. Seville,1994), Vol.2, IAEA, Vienna(1995)399.
[2]KATSUMATA,R., et al, Phys. Plasmas 3 (1996) 4489.