§10. Preliminary Results of Neutral Particle Measurements in LHD

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The time-of-flight type neutral particle analyzer (TOF-NPA) is installed at the central stage near the 10-0 port of LHD. During the second cycle, it has been set at 17 degree against the perpendicular line of the 10-0 port on the midplane although the TOF-NPA system can be scanned both horizontally and vertically. At this position it is very suitable for measurement because much charge exchange neutrals can be expected on the cross point of the two NBIs. The neutral particles are ionized in the stripping cell, separated to 16 energy channels at the cylindrical plate. The mass of ion is distinguished by the flight time in the TOF tube. The measurement of the start, stop signals has been performed every 5 ms using TOF modules (CAEN Co.) and Scaler/Memory (Technoland Co.).

The time resolved signals can be obtained from coincidences signals between the start and stop signals. The time-resolved energy spectra can be obtained by using the calibration data which was performed in Frascati. The vacuum system is controlled by VME in situ. The pressure in the gas cell, the detector bias and the voltage of the cylindrical plate are controlled through the CAENET from C117B CAMAC module.

The ion temperature can be mainly obtained in the NBI plasma. There is a limitation for the measurement, which is the line density of 6x10^{-19} (m^{-2}). Figure 1 is the typical energy spectrum and the ion temperature. It is important which energy region is used for the temperature, because the measurement is a line integral. From the calculation, the central temperature is obtained from the energy region over 4 keV. The maximum ion temperature can be obtained to be near 2 keV. Unfortunately we can not compare them with the ion temperature from the CXRS measurement because there are not measured at the same time. However both temperatures are similar in similar shots. As observed neutral particle amounts is too small in non-NBI plasma, the temperature can not be obtained in a single shot. In ECH plasma, the temperature can be obtained to be 0.3 keV by overlap of shot data. The value is equal to one from the spectroscopic measurement.

We compare the neutral flux in experiment with one in the calculation [1]. In calculation, the neutrals from NBI and the wall, and the atomic process in plasma are considered. The plasma condition and the geometric factor are also considered. Figure 2 shows the generation map of the neutral particles at the shot of Fig.1. The white line indicates the sight line. As there are many ambiguities in both experiment and calculation, the discrepancy is within twice. The fact is that the measurement is done correctly.

The high energy spectra can be also measured in NBI plasma. The observed maximum energy is near NBI energy. Much high energy particles are observed immediately after NBI. But as the density becomes high, they decrease. In ICRF heating experiment on ECH plasma, ion temperature and neutral flux slightly increase. The dependence of ion heating with hydrogen/helium ratio may be explained by the result. In ICRF heating experiment on NBI plasma, the particle acceleration may be slightly observed over 20 keV. But it is not clear because the power of ICRF is much smaller than the one of NBI. Helium flux in ICRF experiment is too small because the charge exchange cross section between He and H is not so large. And we use hydrogen gas in the stripping cell. The spectrum of helium can be obtained by the overlap of many shots.

References