The ion temperature is reevaluated in LHD

April, 2009

Department of Large Helical Device Project

The 12th cycle experimental campaign of the Large Helical Device (LHD) ended on December 25th last year. By introducing new experimental techniques such as swinging magnetic axis during the plasma discharge pulse for example, a plasma having better performance was obtained successfully. In the course of the experiment, it was found that it is necessary to retool the derivation method of the ion temperature, which is reported here.

The charge exchange spectroscopy system (CXS) using a high-power hydrogen neutral beam for plasma heating (NBI) has been developed intensively in LHD for the measurement of the spatial distribution of the ion temperature. In this method the ion temperature is evaluated from the Doppler broadening of the light emitted from carbon ions by the charge exchange recombination with the injected atomic hydrogen beam. This method is superior in obtaining the spatial distribution of the ion temperature as well as the rotational velocity and the electric field. The study of the ion energy transport has progressed in LHD by using the behavior of the temperature distribution measured by CXS.

In CXS, the background light from the surroundings of the plasma also enters the spectrometer. In order to know the background level, the NBI beam used for the measurement ceases for a short time periodically, which is called "beam modulation". The signal can be obtained by subtracting this background from the total emission. Until the 11th campaign, the temperature had been derived even when the signal was much smaller than the background level. In the 12th campaign, the amount of signal light was increased by using bundled the optical fibers. As a result, the time resolution of CXS was improved and the Off-time of beam modulation was able to be shortened. Then it was found that the evaluated ion temperature depends on the Off-time interval of the modulation, especially when the phenomenon "impurity hole" occurs, in which the spatial distribution of carbon ions becomes extremely hollow when the central ion temperature becomes high. It is concluded that the ambiguity of evaluated temperature becomes large when the signal becomes much smaller than the background level very quickly.

From these observations we thought it necessary to revaluate the data obtained before. Until then the technique had been used left a half of the amount of the beam in the beam modulation to avoid the fall of the ion temperature. Now all of the beam is stopped shortly in the beam modulation, and it is confirmed that the background is small enough to eliminate the large uncertainty in evaluating the temperature. Under these guidelines, the high ion temperature experiments have been conducted again. The reliable highest central ion temperature was obtained as 5.6keV (65 million degrees) The electron temperature is about 3.5keV in this case, and therefore the situation was also produced in which the temperature of the ions is higher than that of the electrons. The inflection point of the ion temperature gradient was also observed, and all the results obtained in the 10^{th} experimental campaign were reconfirmed except the absolute value of the maximum ion temperature.

We apologize that the highest ion temperature value of 6.8keV made public last year was incorrect.

For a more detailed explanation, please refer to "Reevaluation of Ti by CXS".