§24. Radial Profiles of He/H Density Ratio and Bulk Temperature/rotation from Active Charge-exchange Spectroscopy

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Transport studies and high performance discharges are of increasing interest at LHD. Therefore, accurate density, temperature and velocity profile measurements of the impurity ions as well as the bulk ions (Hydrogen) are highly demanded. Especially the density ratio between Hydrogen and Helium is important, because the heating efficiency is dependent on it (1). Up to now, temperature and velocity measurements are done by measuring charge-exchange emission of Carbon impurities. Also He/H density-ratio measurements are available, derived from the recombination phase of the plasma using passive emission from the edge. But radial profiles of the main ions are missing, as well as radially resolved density-ratio profiles. These topics are addressed by the two-wavelength spectrometer, which was installed at LHD at the end of the 15^{th} cycle and was fully operational in the 16^{th} cycle.

Active charge-exchange emission of the bulk ions and also of the Helium impurity ions are measured simultaneously using one spectrometer with two grids. Doppler shift, Doppler broadening and the intensity are used to derive radially resolved temperature and velocity profiles of Helium and Hydrogen (see figure 1), which are in good agreement with the Carbon measurements. Also the time-trace of the He/H density ratio (figure 2) of the edge channel shows good agreement with the passive measurements from Goto et al. (2). The core channel has a significantly different shape in temporal evolution, which can be measured for the first time due to the radial resolved measurements. Figure 3 shows the radial profiles of two selected time points: one at the start of the gas-puff with a clear difference from edge to core channel and one later during the gas-puff where edge and core are nearly balanced.

The results from the 16^{th} cycle show, that He-ion velocity is measured with high accuracy while the bulk ion velocity measurement suffers from the large passive edge H_{α}-emission, especially for high temperature discharges. The temperature profile as well as the He/H density ratio is of good quality in both cases: high and low temperature discharges. The reason for this is, that these quantities mainly depend on the width of the measured spectrum, which is more stable against the interference of the edge H_{α}-emission.

In the upcoming 17^{th} cycle, measurements with optimized spectrometer settings and a larger set of plasma parameters will be carried out in order to improve the accuracy, especially for high performance discharges.

(1) Saito et al., NF 41, p 1021, 2007
(2) Goto et al., PoP 10, p 1402, 2003

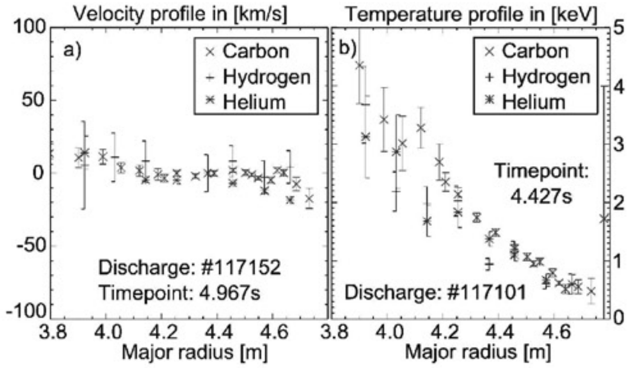

Figure 1: Comparison of measured radial profiles for H and He with the Carbon measurements: a) radial velocity- and b) temperature-profile

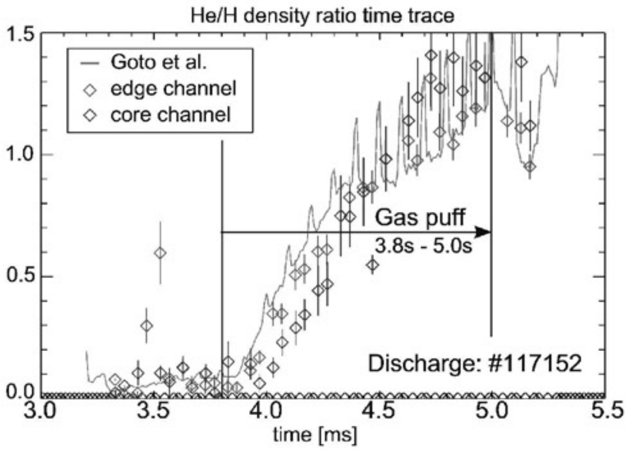

Figure 2: Temporal evolution of the He/H density ratio in comparison with the passive measurements from Goto et al.

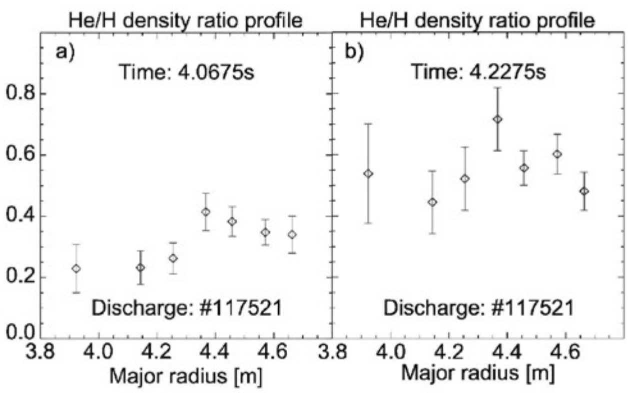

Figure 3: Radial He/H density ratio profiles for two different time points