Evaluation of axial decay length of plasma pressure in detached plasma

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Detached divertor plasma, which is one of the most effective methods to reduce heat load on plasma-facing components, has been strongly investigated through complementary studies with magnetically confined fusion devices, linear diverter plasma simulators \cite{1}, and numerical simulations. The decay length of the plasma pressure along magnetic field is one of the most important parameters to characterize the detached plasma. In the linear divertor plasma simulator, NAGDIS-II, we have measured the detailed structure of the detached plasmas around the recombination front region by using a Langmuir probe system movable both along and perpendicular to the magnetic field to obtain the decay length of the plasma pressure \cite{2}. In this presentation, the decay length of the plasma pressure has been evaluated by a fixed-point laser Thomson scattering (LTS) measurement \cite{3-4} accompanied with spectroscopic measurement of light emission from a highly excited state at several points along the magnetic field near the view port of the LTS measurement.

The e-folding decay length $L$ of the plasma pressure was evaluated by the following equation;

\[
L^{-1} = \frac{1}{P_s} \frac{dP_s}{dz} = \frac{1}{P_s} \frac{dp}{dz} = \frac{1}{n_e T_e} \frac{d(n_e T_e)}{dp} \frac{dp}{dz}
\]

where $P_s$ is the plasma (static) pressure, $p$ is neutral gas pressure, $n_e$ is electron density, $T_e$ is electron temperature, and $z$ is axial position. By varying $p$, $d(n_e T_e)/dp$ can be obtained with the LTS measurement. Further, the position where the visible light emission at 370.5 nm is the maximum is defined as the position of the recombination front. From the axial profile of the emission at 370.5 nm near the LTS measurement, $dz/dp$ of the recombination front can be estimated.

The electron temperature at the axial position around the LTS measurement was controlled to be $T_e < 1$eV, and $L$ was quantitatively estimated to be 0.47 m by using the above equation.

\cite{1} N. Ohno, Plasma Physics and Controlled Fusion \textbf{59} (2017) 034007.