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ヘリオトロンJのネオンガス入射実験における真空紫外スペクトル空間分布の時間発展

Temporal Evolution of the Spatial profile of VUV spectra for Neon gas injecting experiment in Heliotron J

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VUV spectroscopy (EUV region, in particular) has been applied to study impurity behaviors in fusion relevant magnetic confinement plasmas [C. Dong, S. Morita et al., PFR, volume 6, 2402078 (2011)]. However, measurement of the spatial distribution is sometimes difficult due to the limited port access and sight lines.

In this paper, we attempt to reconstruct the local radiation intensity of neon ions in Heliotron J. So-called "standard" magnetic configuration charactered by the coil current setting of [HV, TA, TB, AV, IV] = [-89, -74, -81, -51, -71] percent, respectively, were chosen. Electron cyclotron hearting (ECH) was applied from 170 to 310 ms and neutral beam injection (NBI) were superposed from 200 to 270 ms. We used the shot-by-shot sight-line scanning system of EUV spectrometer that was designed to move vertically by every one degree, as shown in Fig 1. Reproducible five discharges from Shot #79850 to #79854 were measured with the time resolution of 5 ms. Spatial profile of line-integral intensity of neon lines for 240 to 260 ms are shown in Fig 3. Since the reconstruction demands smooth spatial distribution with small spatial separation, we interpolated original 12 sight lines (in red color) to totally 33 lines by considering the magnetic flux surface that correspond to the average minor radius as plotted in Fig 1 ($\Delta\rho = 0.03$). Here we needed to assume that the intensity near the wall is zero. Calculation of the sight line length $L_{l,\rho}$ between each magnetic flux surface was performed and utilized based on the following equation:

$$\begin{pmatrix} J_1 \\ J_2 \\ \vdots \\ J_{32} \end{pmatrix} = \begin{pmatrix} L_{1,1} & L_{1,2} & \cdots & L_{1,32} \\ 0 & L_{2,2} & \cdots & L_{2,32} \\ \vdots & \ddots & L_{31,31} & \vdots \\ 0 & \cdots & 0 & L_{32,32} \end{pmatrix}^{-1} \cdot \begin{pmatrix} I_1 \\ I_2 \\ \vdots \\ I_{32} \end{pmatrix}$$

I_l and J_ρ correspond to the line-integral and local intensity for lth sight line and ρth flux surface, respectively.

Interpolated line integrated intensity for Ne V (19.55 nm, Ei = 126.3 eV) was shown in Fig 2, where Ei is the ionization energy of Ne^{4+} ion. Fig 3 is the preliminary result of the reconstructed local emission intensity. The data of the normalized major radius between 0.0 and 0.6, hatched in Fig. 3, which includes negative values is not reliable. The line-integral intensity in the peripheral region has its peak around the sightline of -8 degree, which passes the flux surface $\rho = 0.78$ with the longest path length. This peak moved to around the sightline of -4 degree after turning off the NBI. This is the reason why the local intensity reached its maximum at $\rho = 0.75$ but reduced and flattened after NBI was turned off at 270 ms. This observation is qualitatively reasonable in that Ne^{4+} with low ionization energy distributes at the peripheral region.

In this work for standard configuration, the outermost observed sight line was at the normalized major radius $\rho = 0.82$, which degraded the reconstruction quality. Moreover, only five sight lines was used. We are planning to apply it to smaller plasma such that the sight line passes through the outside of the last closed flux surface.

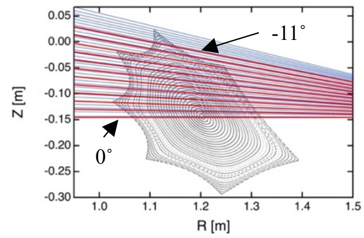

Fig 1. Sight lines and magnetic surface. Existing ones are indicated in red color

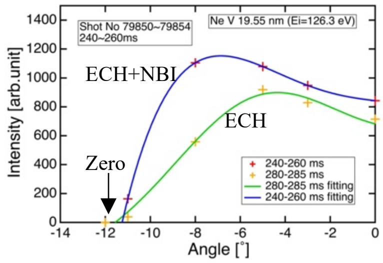

Fig 2. Observed line-integral emission intensity for 240-260 ms and 280-285 ms with their fitting lines for the interpolation

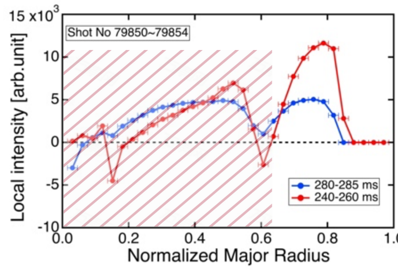

Fig 3. Reconstructed local intensity distribution for 240-260 ms (with NBI) and 280-285 ms (without NBI).