# §24. Estimation of the Particle Confinement Time of the Helium Ash in LHD

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The ratio of the helium ash confinement time to the energy confinement time ($\tau_\alpha$*/$\tau_E$) should be lower than 7 in the FFHR helical reactor to maintain ignition. However, as such data are not yet available in any helical device, there is the physics uncertainty in a helical reactor design. Although high energy He-beam should be finally injected into the plasma core to simulate the burning plasma, He gas was initially injected to measure such exhaust characteristics as a first step of this type of experiment.

Helium gas was injected by gas puffing at 1.2 sec in the outwardly shifted plasma with $B_o$=2.64T and $R_o$=3.75m. After the plasma density is adjusted to be flat, helium or hydrogen gas were injected. In an actual experiment, it is confirmed that helium gas puff was injected by monitoring the electron density. For comparison, experiment was also conducted without gas puffing.

As shown in Fig. 1, He-II line (4684Å) has a finite signal before helium gas was puffed. This means that residual helium gas may exists which was absorbed in the first wall. Therefore, it is necessary to check the other discharge with the respect to the wall recycling. Although this small signal starts from the zero at the beginning of discharge, it should be checked without plasmas.

As shown in Fig.1, it is confirmed that He-II line emission is increased by helium gas puffing in the shot of #49346. We have checked experimentally that H-I line is increased by hydrogen gas puffing in the shot of #49351, and that He-II line is not affected by hydrogen gas puffing.

As the waveform of the incremental value of the density Δn and He-II line are both similar, it is found that helium gas is the source of the electron density. However, the density signal is the line average, it cannot be determined whether helium is injected into the core or not. However, as it is certain that at least the helium is injected to the plasma edge and scrape off layer, it may be possible to study the helium exhaust characteristics in the plasma edge.

We have conducted initial rough estimations of the helium particle confinement time using the averaged particle balance equation in the plasma edge.

$$\frac{dn_{HE4}}{dt} = S_{HE4} - \frac{dn_{HE4}}{\tau_\alpha^*} \qquad (1)$$

Where $\tau_\alpha$* is the effective helium particle confinement time. The helium source term $S_{HE4}$ is determined by the waveform before and during gas puffing pulse. The temporal change in $\tau_\alpha$ provides the helium density $n_{HE4}$, which was fitted to the observed He-II line emission waveform. The resultant effective helium particle confinement time $\tau_\alpha$* may be roughly 0.25 ~1.5 sec as plotted in Fig. 1, which provides $\tau_\alpha$*/$\tau_E$=7~42 for the energy confinement time of 36 ms (#49346). More accurate determination of the confinement time and analysis on profiles, experiments for various operational conditions and with He-line profile diagnostics are required.

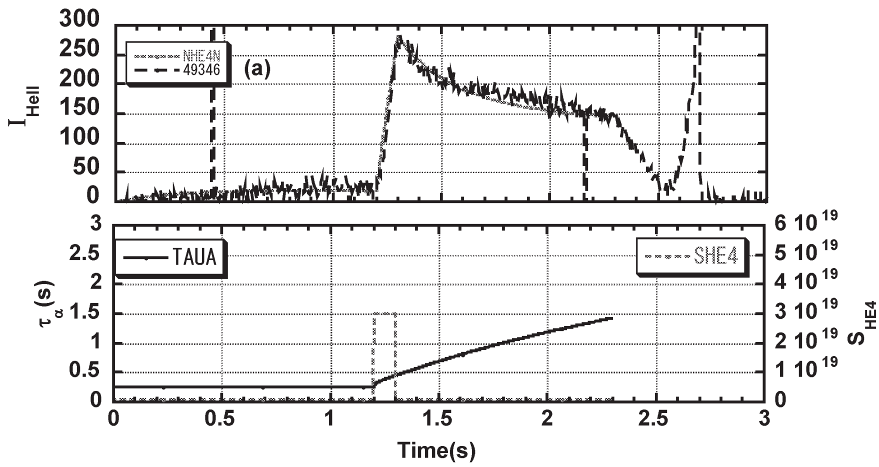


Fig. 1. (a) Observed He-II line (dashed line) in the outwardly shifted LHD plasma (#49346). Dotted curve is the calculated helium density normalized to the He-II line. (b) $\tau_\alpha$* is the effective helium particle confinement time. (solid line) to fit to He-II line. He gas fueling rate ($S_{HE4}$) is described by dotted line.