§ 33. Role of Recycling Flux on Gas Fueling in LHD

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For reliable and precise density control by gas puffing, it is important to understand the response of dN_e/dt to Φ_{puff}, where N_e is the total number of electrons confined in the plasma and Φ_{puff} is the electron flux supplied by gas puffing. The relation between these two is depicted in Fig. 1. Here, we define the effective fueling efficiency, α_{eff}, as;

$$\alpha_{eff} \equiv \frac{dN_e/dt}{\Phi_{puff}}. \quad (1)$$

In the hydrogen gas puff discharges, α_{eff} is distributed from 10 – 20 % for the most part, and the maximum of α_{eff} reaches 50 %. In the helium gas puff discharges, larger α_{eff} of 20 – 100 % are obtained. The data denoted as 'ref. 1' in Fig. 1 are obtained at the phase where particle fluxes other than dN_e/dt are not depending on Φ_{puff}. These can be fitted by an offset linear function;

$$\frac{dN_e}{dt} = 0.12\Phi_{puff} - 0.12. \quad (2)$$

In this case, the coefficient of 0.12 can be treated as the 'real' fueling efficiency of gas puffing, α_{puff}.

To investigate the cause of large dispersion of α_{eff}, we have analyzed the particle balance [2]. As is shown in Fig. 2 (a), α_{eff} seems to have $\bar{n}_e$ dependence. However, the linear correlation coefficient between them is small (0.65), due to the large scatter. In Fig. 2 (b), shown is the relation between the divertor recycling flux, (R_{div} Γ_{div}), normalized by N_e, where Γ_{div} is the total electron flux on the divertor plate and R_{div} is the divertor recycling coefficient. Large linear correlation coefficient of 0.92 is obtained in this case. From this, it can be asserted that the high α_{eff} is resulted from the large normalized recycling flux. Therefore, it is expected that α_{eff} saturates to α_{puff} = 12 %, as in Eq. (2), at the limit of small normalized recycling flux. This can be recognized in Fig. 2 (b), where α_{puff} ranges from 9 – 14 % in the regime of $(R_{div}\ \Gamma_{div}) / N_e < 120\ s^{-1}$.

In the helium gas puff discharges, both of the recycling flux and the recycling coefficient are large. If the recycling coefficient is 1, i.e. there is no particle sink, then dN_e/dt should be exactly equal to Φ_{puff} (and therefore α_{eff} = 1). Large α_{eff} of the helium gas puff discharges as shown in Fig. 1 can be explained by these reasons.

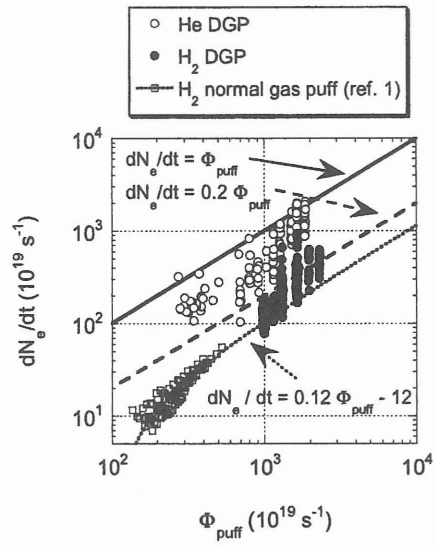

Fig. 1. Comparison between Φ_{puff} and dN_e/dt. Open circles and closed circles denote helium and hydrogen gas puff discharges, respectively. Open squares are the data from ref. 1.

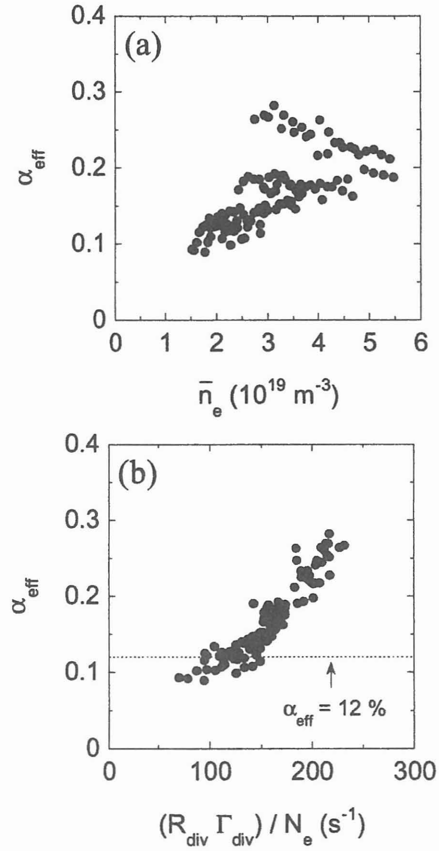

Fig. 2. The effective fueling efficiency, α_{eff}, as a function of (a) the line-averaged electron density, $\bar{n}_e$, or (b) the normalized recycling flux, $(R_{div}\ \Gamma_{div}) / N_e$.

Reference

1) Miyazawa, J. *et al.*, J. Nucl. Mater. **313-316**, 534 (2003)

2) Miyazawa, J. *et al.*, submitted to Nucl. Fusion.