§7. Effect of Radiation Power Loss Due to Impurity Gas Puff to Divertor Plasma

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We need to prevent serious damage of divertor plates from high heat load in a fusion device such as the ITER, a DEMO and a helical reactor FFHR[1]. One of feasible ideas to reduce the heat load is impurity gas injection into a divertor plasma, since radiation power loss caused by impurity gas decreases electron temperature, which would result in plasma detachment. There are several transport calculations considering the effect of impurity gas puff for scrape-off layer and divertor region for ITER[2,3] and JT-60SA[4]. Nitrogen, neon, argon, and other noble gases are the candidates for impurity gas injection.

We carried out one-zone theoretical calculations to examine the effect of impurity gas puff for peripheral plasmas[5]. We found that Ne and N gas puff can reduce electron temperature down to a few eV if gas puff rate is high enough with 1% contamination rate. Dominant ionic states for radiation loss are different with different electron temperature.

In the 17th and 18th LHD experimental campaigns we injected impurity gas to the divertor region and measured extreme ultraviolet (EUV) spectra to examine how the impurity gas contributes to reduce electron temperature[6]. Fig. 1 shows EUV spectra when Ne gas was injected and Ne VIII and Ne VII lines were observed. Fig. 2 shows temporal distribution of various quantities for discharge #125895 in the 18th campaign. Gas puff port was moved far from the divertor region and Ne VIII line intensities increased, which is different from the similar discharges in the 17th campaign with nearly constant Ne VIII intensities[6]. However, those intensity ratios are almost constant for both cases. From the model calculation using ADAS[7] the line intensity ratios depend on electron temperature as shown in Fig. 3. The constant intensity ratios imply these lines were emitted at the same temperature region. If we assume ion density ratio n(Ne IX)/n(Ne VIII) as 1-4, the electron temperature for Ne VIII is expected as about 12-18 eV for this discharge. We need more detailed analysis to confirm their emitting region in order to estimate the effect of radiation power loss.

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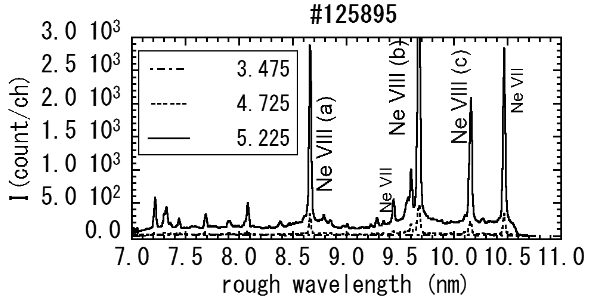

Fig. 1 EUV spectra measured with SOXMOS for the discharge #125895. N_e gas was injected at t =4.3-4.45 s.

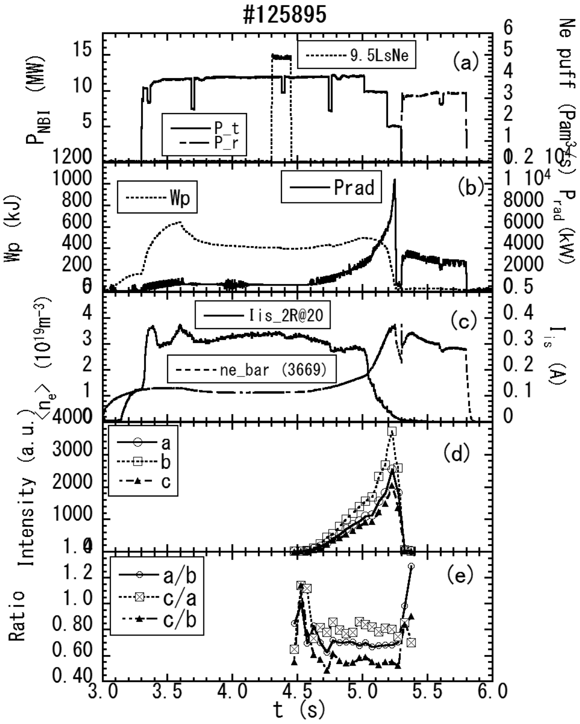

Fig. 2 Temporal distribution of (a) tangential and radial NBI input power P_t and P_r, and amount of Ne Gas puff, (b) stored energy W_p and radiation power P_{rad}, (c) line averaged electron density $<n_e>$ and ion saturation current at divertor plate I_{is}, (d) intensity of Ne VIII lines, and (e) intensity ratios of Ne VIII lines for discharge #125895.

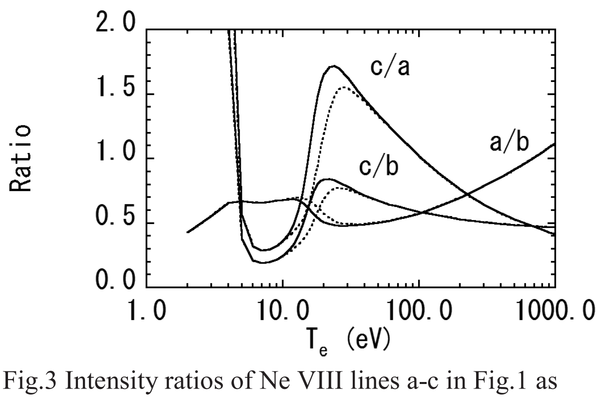

Fig.3 Intensity ratios of Ne VIII lines a-c in Fig.1 as functions of electron temperature. Ion density ratios n(Ne IX)/n(Ne VIII)=1 and 4 are assumed for solid lines and dotted lines, respectively.