§9. Effective Emission and Ionization Rate Coefficients of Helium Atom in a Plasma

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Effective rate coefficients for ionization, S^{eff}, line emissions, $C_{em}^{eff}(\lambda)$'s, and line radiation power, P_{rad}^{eff}, of helium atom are obtained with the collisional radiative (C.R.) model in the ionizing plasma condition. Population densities, $n(i)$'s, in the C.R. model are obtained from a numerical code developed by Fujimoto [1], with substituting new recommended atomic data [2,3,4]. The effective rate coefficients, S^{eff}, $C_{em}^{eff}(\lambda)$'s and P_{rad}^{eff}, are defined as,

$$S^{eff} = \Sigma_i n(i) S_i / n_{He},$$
$$C_{em}^{eff}(\lambda) = n(i) A_{ij} / n_e n_{He},$$
$$P_{rad}^{eff} = \Sigma_{i>j} E_{ij} n(i) A_{ij} / n_e n_{He},$$

where A_{ij}, S_i, E_{ij} and n_{He} are the transition probability, the ionization rate coefficient, the photon energy, and the density of helium atom, respectively. The n_e dependences of $n(i)$'s, S^{eff}, $C_{em}^{eff}(\lambda)$'s and P_{rad}^{eff} are shown in Fig. 1. In the low n_e region, $n_e \leq 10^4$ cm^{-3}, $n(i)$'s are negligibly small and proportional to n_e, which results in constant S^{eff}, $C_{em}^{eff}(\lambda)$'s and P_{rad}^{eff}. As n_e exceeds 10^4 - 10^5 cm^{-3}, $n(i)$'s of the 2^1S and 2^3S metastable states become large and constant to n_e, which enlarges S^{eff} and $C_{em}^{eff}(\lambda)$'s for the triplet lines such as 471.3 nm. In the high n_e plasma corresponding to the edge/divertor region, $n_e \geq 10^{11}$ - 10^{12} cm^{-3}, S^{eff} increases toward higher n_e due to the increase of $n(i)$'s for higher energy level than 2^1S and 2^3S, e.g. 3^1P, 3^1S, etc. In such high n_e plasma, $C_{em}^{eff}(\lambda)$'s and P_{rad}^{eff} decrease toward higher n_e since $n(i)$'s are saturated to n_e.

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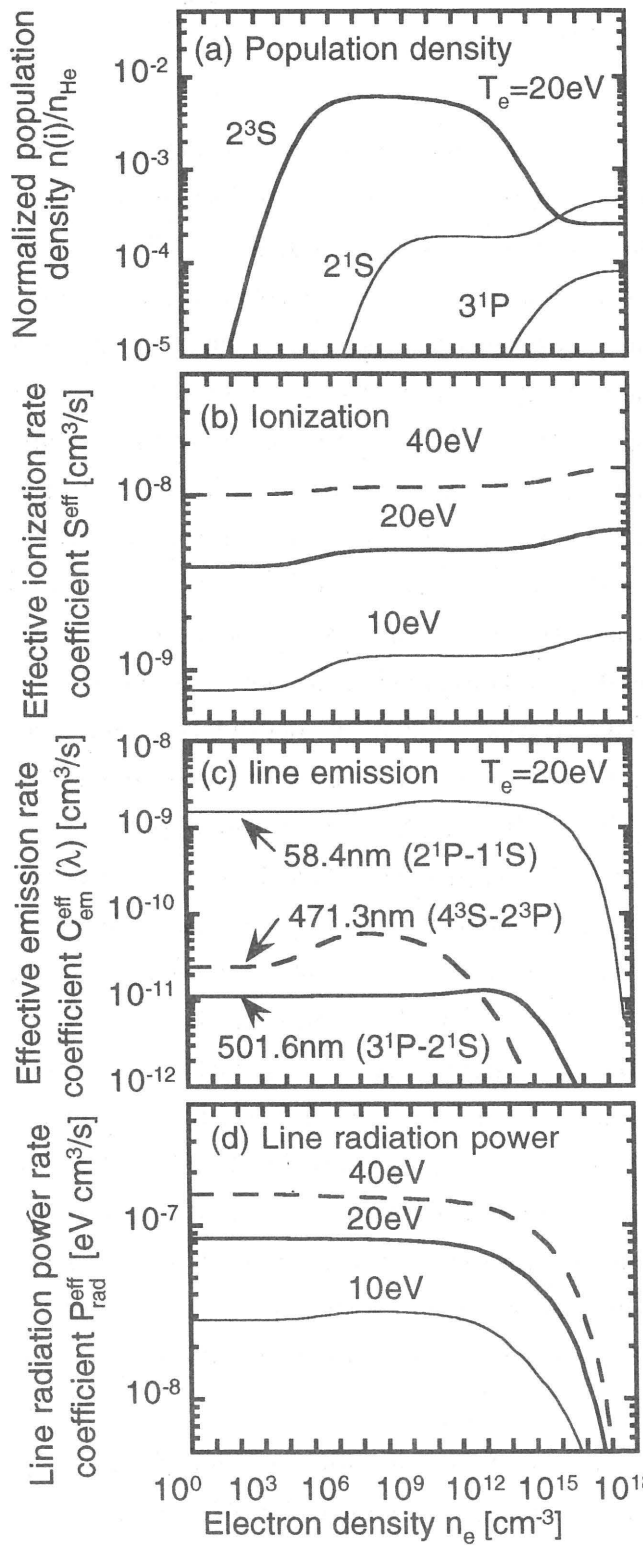

Fig. 1 (a) Population density of the excited state. (b),(c),(d) Effective rate coefficients for ionization, line emission, and line radiation power.