§10. Dielectronic Recombination Rate Coefficients to Excited States of *He* from He^{+}

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Helium is one of the most common species in laboratory and astrophysical plasmas. It played an important role in the development of plasma spectroscopy and spectroscopic diagnostics. Helium is also the ion with lowest atomic number which DR is possible, compared to the eletron-nucleus interaction between the free eletron and ion, the relative strength of electron-electron interaction (which mediates the dielectronic recombination process) is larger for Helium than any other ion. This fact makes the calculation of DR more difficult for helium. We have developed a Simplified Relativistic Configuration Interaction (SRCI) method to study the dielectronic recombination processes. As a stringent test, we have calculated the DR processes of helium for $\Delta N = 1$ transitions[1]. In present paper, we calculate the DR processes of helium for $\Delta N = 2$ transitions, and the cross sections are compared with the experimental measurements[2]. The past thereotical and experimental works on He^{+} are focused on the total dielectronic recombination rate coefficients or corss sections. But now, if individual line intesities have to be evaluated for the plasma cooling or spectroscopic diagnostic, the partial DR rate coefficients to the excited states must be known. So we calculate the partial DR rate coefficients to the excited states of He from He^{+}, and then for applied convenience, the rate coefficients are fitted to an analytical formula and the n-dependence of the fitting parameters are discussed.

The DR processes through the $\Delta n = 2$ resonance states are more challenging theoretically because the electron-electron interaction is expect to be stronger than through the $\Delta n = 1$ resonance states, and meantimes for these $\Delta n = 2$ resonance states, there are more Auger channel, while only one contributes to the capture processes. Our convoluted cross sections are compared with the experimental measurements[2], as shown in Fig.1. In the convolution, we only include the doubly excited states $3l_r nl$ with $3 \leq n \leq 6$. The thereotical peaks for $n = 3$ and $n = 4$ show a good agreements with measurements. But the thereotical peaks for $n = 5$ and $n = 6$ are higher than experimental measurements. This is because the contributions of high-n resonaces with $n \geq 5$ haven't been fully included in the experimets due to field ionization effects[2]. Meanwhile, the contributions of high-n resonaces with $n \geq 7$ are observed partially in the experiments, which are located in the higher energy range than our thereotical value in Fig.1. In the calculation on rate coefficients, the contributions of all high-n resonances are included.

In order to use the rate coefficients conveniently, we fit them into a formula with two fitting parameters as following:

$$\alpha_{fit} = 6.68167 \times 10^{-13} (\kappa T)^{-3/2} \cdot E_{av} \cdot S_t \cdot e^{-\frac{E_{av}}{\kappa T}}$$

Here, the fitting parameters E_{av} and S_t are according to the average incident electron energy and total integrated cross sections, respectively. The units of α_{fit}, κT, E_{av} and S_t are $cm^3 \cdot s^{-1}$, eV, eV and $10^{-20} cm^2 \cdot eV$, respectively. The n-dependences of E_{av} and S_t are discussed.

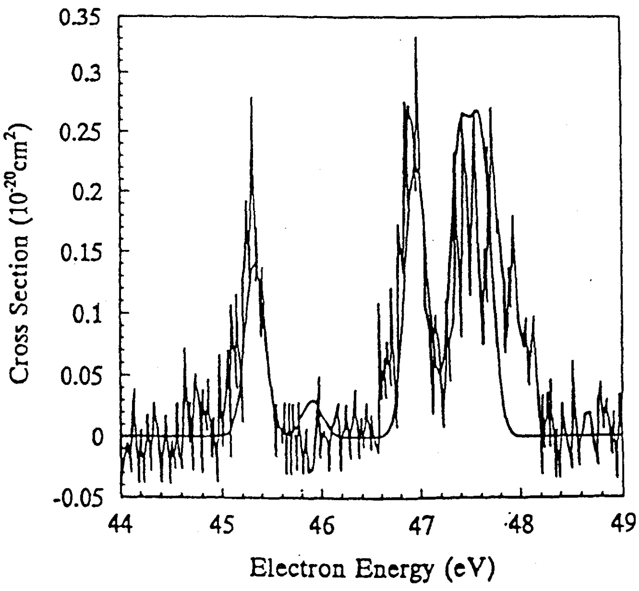

Fig.1 DR cross section for the $\Delta n = 2$ resonances. Solid line: Present theoretical results; Grey line: Experimental measurements[2]

References

[1]. J.G. Wang et al., Phys. Rev. A **52**, 4274(1995);

[2]. D.R. DeWitt et al, J. Phys. B: At. Mol. Opt. Phys. 28, L147(1995).