Determination of collisional quenching rate coefficients of metastable excited atoms Ar($^3P_2$) by Ar and H_2O

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We observed the transient current after turning off the UV light illuminating a cathode used to supply the photoemission current in a Townsend discharge to measure the effective lifetime of the metastable excited atoms Ar($^3P_2$). The diffusion coefficient of Ar($^3P_2$) in argon, the reflection coefficient of Ar($^3P_2$) at the electrode surface and the collisional quenching rate coefficient of Ar($^3P_2$) by ground-state atoms Ar($^1S_0$) were determined from the observed effective lifetime of Ar($^3P_2$). Moreover, the collisional quenching rate coefficient of Ar($^3P_2$) by H_2O was also determined.

1. Introduction

In this study, the three fundamental coefficients of metastable excited atoms Ar($^3P_2$) were determined by a non-spectroscopic measurement and curve fitting to theoretical values of the effective lifetime derived from the solution of the diffusion equation.

2. Experimental apparatus and method

Details of the experimental apparatus and the procedure used for numerical analysis have already been reported [1,2]. The purity of Ar gas used in the experiment was 99.999%.

3. Experimental results and discussion

In figure 1, the four solid lines show the observed effective lifetime τ_1 of Ar($^3P_2$) in Ar plotted against the gas pressure for different gap lengths. From the results, we determined the diffusion coefficient D_{m1} of Ar($^3P_2$), the collisional quenching rate coefficient k of Ar($^3P_2$) by Ar($^1S_0$) and the reflection coefficient R of Ar($^3P_2$) at the electrode to be 42.2±1.4 cm^2/s, (2.96±0.05)×10^{-15} cm^3/s and 0.13±0.02, respectively. The value of k is consistent with that reported by Molnar [3] and also with values previously obtained by spectroscopic measurement [4-7]. The temperature dependence of $k(T)$ was also derived as

k=3.9×10^{-7}exp(-5700/T) [300≦T≦343 K].

On the basis of the results, the experiments were extended to an Ar/H_2O(112 ppm) mixture and the preliminary results are shown in Fig. 1. The collisional quenching rate coefficient k' of Ar($^3P_2$) by H_2O was determined to be 2.3×10^{-10} cm^3/s, which is 10^5 times larger than the value of k. Our value k' was consistent with those reported by Bourene and Le Calvè [8] and Balamuta and coworkers [9, 10] of 1.84×10^{-10} cm^3/s and 2.16×10^{-10} cm^3/s, respectively, who described the generation of O, H and OH as the by-products of H_2O.

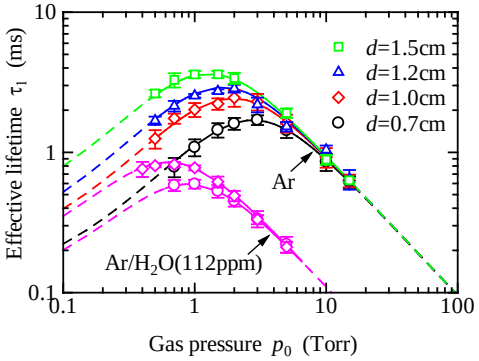

Fig. 1 Effective lifetime of metastable excited atoms Ar($^3P_2$) in Ar.

4. References

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