

Velocity Map Imaging of Photofragment Ions from Mass-Selected Cluster Ions Studied with A Linear-Type Double Reflectron

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Velocity and angular distributions were measured for mass-analyzed fragment ions which were produced by photodissociation of mass-selected gas-phase complex ions. Velocity-map-imaging condition of the fragment ions was achieved by using a newly developed ion imaging apparatus with two linear reflectron time-of-flight (TOF) mass spectrometers, which can enhance the resolution of images. In the present study, photofragment ion images have been examined by ultraviolet photodissociation of Mg^+Ar and Ca^+Ar complex ions.

In the experimental setup, the two linear reflectrons were placed collinearly, both of which timing-controlled, high-voltage pulses were applied (Fig. 1). The $\text{Mg}^+\text{Ar}/\text{Ca}^+\text{Ar}$ ions produced in the source first ran through a reflectron (2nd REF), and then they were reflected to the opposite direction by the next reflectron (1st REF).

The ions were next irradiated with a linearly polarized photolysis laser (266 nm for Mg^+Ar and 355 nm for Ca^+Ar) at the middle of the two reflectrons. Photofragment ions, Mg^+/Ca^+ were then reflected by the 2nd REF and ran through the 1st REF. Finally the fragment ions were detected as velocity map ion images by microchannel plates with a phosphor screen as shown in Fig. 2. The images were obtained with changing the polarization direction (E) of the photolysis laser with respect to the ion beam direction (Z).

The electronic transition of Mg^+Ar at 266 nm has a localized nature of $\text{Mg}^+ 3p_z \leftarrow 3s$ excitation, in which the transition dipole moment is parallel to the bond (z) axis [1]. The velocity and angular distributions of the Mg^+ fragment ions were obtained by reconstructed to the 3D sliced image of the ions from the obtained raw image. We have then determined a kinetic energy distribution and an anisotropy parameter. The binding energy of Mg^+Ar in the ground state, $1330 \pm 100 \text{ cm}^{-1}$, which was deduced from the most probable translational energy, was found to be in good agreement with those reported in the literature [2].

Similar processes were expected in the photodissociation of Ca^+Ar at 355 nm: The Ca^+Ar ion was excited from the $^2\Sigma^+$ ground state to repulsive $^2\Sigma^+$ state, which has a character of $\text{Ca}^+ 4p_z \leftarrow 4s$. The velocity and angular distributions of the produced $\text{Ca}^+ (4p, ^2P_{3/2})$ ion were analyzed from the obtained images. The binding energy of Ca^+Ar in the ground state was determined to be $760 \pm 210 \text{ cm}^{-1}$, which the binding energy agreed well with those reported theoretically and by spectroscopic measurements [3].

[1] H. Hoshino et al., *Chem. Phys. Lett.* **630**, 111 (2015), and references therein.

[2] S. Massick and W. H. Breckenridge, *Chem. Phys. Lett.* **257**, 465 (1996).

[3] J. G. Kaup and W. H. Breckenridge, *J. Chem. Phys.* **107**, 4451 (1997).

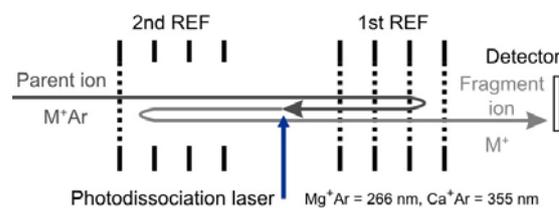


Figure 1: View of the imaging apparatus.

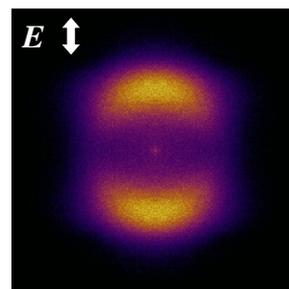


Figure 2: An observed image of the Ca^+ fragment ion from Ca^+Ar at 355 nm with $E \perp Z$.