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 Mg^+Ar/Ca^+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***).

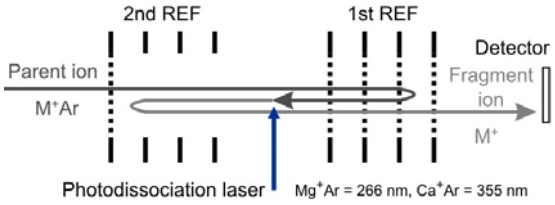

Figure 1: View of the imaging apparatus.

The electronic transition of Mg^+Ar at 266 nm has a localized nature of 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 ± 100 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].

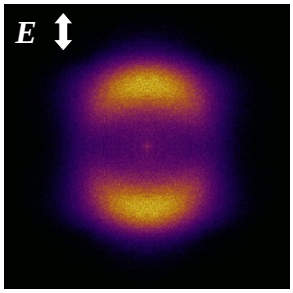

Figure 2: An observed image of the Ca^+ fragment ion from Ca^+Ar at 355 nm with $\boldsymbol{E} \perp \boldsymbol{Z}$.

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 Ca^+ $4p_z \leftarrow 4s$. The velocity and angular distributions of the produced 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 ± 210 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).