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Double-to-Single Photoionization Ratios of Mg and Ca Atoms near the Double Ionization Limit

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Introduction

The double photoionization of valence-shell elec- trons of an atom near its double ionization limit is due to the electron correlation among the electrons and provides useful means for investigating the electron correlation [1, 2]. We have measured the cross-section ratios σ^{2+}/σ^{+} for Mg and Ca atoms in the photon energy range from the double ionization threshold E_{th} (= 22.7 eV for Mg and 17.9 eV for Ca) to just below the lowest excited state of the np subvalence electron E_{ex} (= 57.5.eV for Mg and 30 eV for Ca).

Experiment and data analysis

The experiment was carried out at Beam-line BL- 20A. This beam line is equipped with a 3m normal incidence monochromator and provides SR in the range 15~50 eV. We used a time-of-flight mass spectrometer combined with an atomic beam oven. One of difficulties in the measurements in such low energy regions is the existence of second-order light. This effect was eliminated by referring to the TOF spectra recorded in the $2E_{th}$ to $2E_{ex}$ regions.

When there is no second-order-light, the double-to-single photoionization ratio σ^{2+}/σ^{+} at photon energy E is simply given by

$$\frac{\sigma_{2+}(E)}{\sigma_{+}(E)} = \frac{N_{2+}(E)}{N_{+}(E)}, \qquad (1)$$

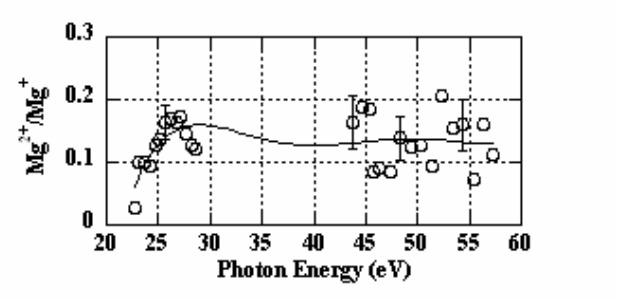
where $N_{2+}(E)$ and $N_{+}(E)$ are the numbers of doubly-charged and singly-charged ions counted at photon energy E, respectively, after corrected for the difference in counting efficiencies. When the second- order light ($2E$) is mixed in the light of energy E, the ratio must be calculated using

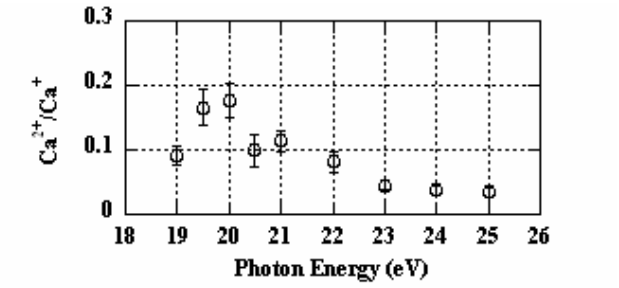
$$\frac{\sigma_{2+}(E)}{\sigma_{+}(E)} = \frac{N_{2+}(E) - F \cdot N_{2+}(2E))}{N_{+}(E)}. \qquad (2)$$

The counts $N_{2+}(E)$ in this case includes the doubly-charged ions due to the second order light. The quantity F is the fraction of the second-order light mixing in the light at E. The fraction F was deter- mined previously using M^{n+} (= He^{+}, Ca^{2+}, Sr^{2+}, and Kr^{2+}) ions from the intensity ratio $M^{n+}(E)/M^{n+}(2E)$ with E being below the appearance potential of M^{n+}. The fraction F was 0.012 at 17.5 eV and 0.0026 at 24 eV, decreasing with E.

Results and conclusion

The results obtained for Mg and Ca atoms are shown in Figures below. In the case of Mg, the data points in the 28.5 ~ 43 eV region are lacking. Although the second-order light is very weak in this region, it was not possible to remove its effect sufficiently with eq.(2) mainly because of very strong and very complex n*p* photoabsorption spectrum.





Experimental double-to-single photoionization ratio for He atom has been reported to be 4.2 % around 180 eV, the peak of the ratio curve. Although the experimental uncertainties in the present study are considerably large, it is certain that the ratios in Mg and Ca atoms exceed 10% at the maxima of their ratio curves.

References

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