4 - 21 M X-ray Emission of Hollow Xe^{q+} Atoms above Metallic Surfaces

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A highly charged ion (HCI) has a large potential energy, which is equal to the binding energies of all the electrons removed to create the ion. When such a slow HCI approaches and then enters into a solid surface, an "above the surface" and a "below the surface" hollow atom will be formed, respectively, by capturing electrons from the surface into its empty levels. Not only new aspects of atom physics has been introduced by hollow atoms, but also HCI applications in material science has promising prospects, such as surface analysis, the synthesis of materials with new properties, and the formation of nanostructure that have been an active area of research in recent years[1−6].

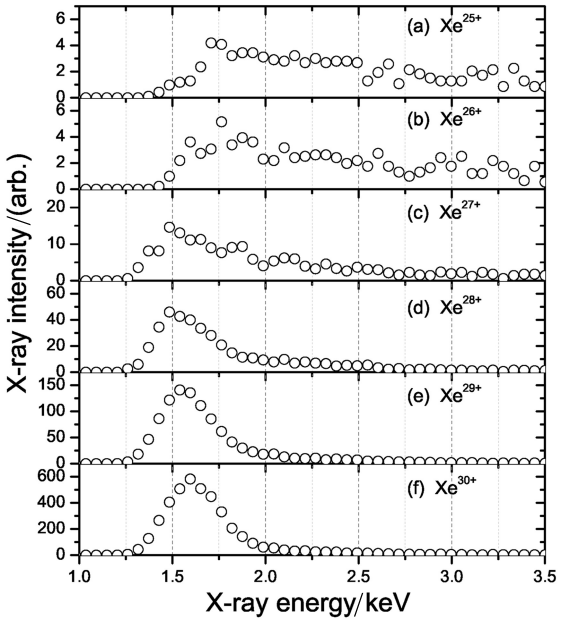

Fig. 1 X-ray spectra emitted in the interaction of 450 keV Xe^{q+}(q=25 ∼ 30) ions with Al surface. For initial charge state q=25 and 26 only lower-intensity backgrounds primarily from Si escape X-rays are observed and, for q=27 to 30 higher-intensity Rydberg M X-rays are observed and shifts in energies.

In order to obtain detailed understanding of the exotic hollow atom, the M X-rays have been measured in the interaction of Xe^{q+} (q=27 ∼ 30) ions with Aluminum, Molybdenum and Beryllium surfaces in the energy range of 350 ∼ 600 keV, by using a Si(Li) detector. Rydberg M-shell X-ray emission of Xenon was found when the projectiles have the initial M-shell vacancies and, equivalently, the charge state of incident Xenon ions is over 27. The calculated results by Cowan's program with relativistic correlation indicate that such X-rays are emitted as filling the initial M vacancies directly from highly excited states with principal quantum number ranging from 6 to 30. We found that the X-ray yield per vacancy in M-shell decreases slightly with the increase of incident energies and is inversely proportional to the work functions of surfaces used. However, it increases rapidly with the increase of the projectile charge states. This is accordance with the calculation of the transition rates, which are strongly related with the initial number of vacancies in M shell of the Xenon ions/atoms. These experimental facts indicate that such X-rays are emitted primarily above the surface, and at the time of transitions there are fewer spectator electrons in N, O shells present, *i.e.*, these shells are not filled completely.

Fig. 1 shows the X-ray spectra observed as 450 keV Xe^{q+}(q=25 ∼ 30) ions impinging on Al surface. The X-ray intensity is normalized to 10^{13} incident projectile and to the energy width corresponding to one channel of the MCA.

References

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