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Measurement of *K*-shell photo effect cross sections at 145.4 keV

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Abstract : Shell-wise photo effect cross sections are determined by a direct method or an indirect method. Measurements employing the direct method are available at higher photon energies only. This is due to the fact that at lower photon energies, measurements on low photon energy and low intensity photo electrons are to be carried out. This involves additional experimental complication resulting in poor accuracy On the other hand, from subtraction method, shell-wise photo effect cross sections can be obtained with better accuracy at low photon energies.

In the present investigation, the *K*-shell photo effect cross sections are evaluated by the indirect method in high-*Z* elements and in few rare earth elements at 145.4 keV. The *K*-shell photo effect cross sections so determined have been compared with the available theoretical values A reasonable agreement is observed between theory and experiment within the limits of experimental errors.

Keywords : *K*-shell photo effect, cross sections, indirect method, high-*Z* elements

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1. Introduction

The atomic photo effect cross section is obtained either by direct method or by indirect method. In the direct method, the determination of cross sections involves the detection of photo-electrons or X-rays. Particularly, at low energies the detection of photo electrons becomes difficult in the presence of auger electrons of comparable energies. Similarly, in the X-ray flourescent method it is difficult to suppress the contribution arising due to compton scattering and other secondary radiations. In addition, self-absorption becomes dominant and its correction is extremely tedious and complicated and results in over estimation of the photo effect cross section. On the other hand, in the energy region 30–200 keV, where the atomic photo effect cross section is predominant, the indirect method of estimation of atomic photo effect cross section by subtracting a relatively small scattering contribution from the measured total cross section is preferred [1]. This method is relatively simple and given fairly accurate results, it has received considerable attention in recent years [2–5].

Further, about 80% of the total photo effect cross section is due solely to the K-shell. A systematic study of the variation of the ratio of total photo effect cross section to K-shell cross section $\left[\sigma_\tau|\sigma_K\right]$ with atomic number and incident photon energy has been recently made [6,7] and it has been found that it varies between the limits 1.25 to 1.30 in high-Z elements. Further, its variation with incident photon energies is negligible. Thus, these ratios can be considered practically constant at least in high-Z elements and can be used to estimate the K-shell photo effect cross sections.

2. Results and discussion

In the present report, we have made use of the total photo effect cross section data at 145.4 keV photon energy obtained from our earlier measurements on high-Z elements [8] and on few rare earth elements [9] to evaluate K-shell photo effect cross sections using the $\sigma_\tau|\sigma_K$ ratio. The results so obtained are compared with the theoretical values [10]. The agreement between the evaluated K-shell cross sections and theoretical values as is evident from the data presented in the Table 1, is satisfactory.

Table 1. Photo effect cross sections of elements [barns atom] at 145.5 keV*

Element	Total photo effect cross sectons	K-shell cross sections
Gd	265 9	218 3
	(270 0)	(220.2)
Dy	299 2	245 2
	(305 0)	(247 7)
Er	330.0	268.5
	(332.0)	(268.8)
Lu	398 8	324.2
	(395 0)	(317 7)
Ta	451.1	363.1
	(450.0)	(360.0)
W	455 0	364.0
	(463 0)	(370 4)
Au	591.4	473.1
	(600.0)	(474 6)
Hg	623.0	498 4
	(618 0)	(486.6)
Pb	672.0	525.0
	(677.0)	(528 9)
Bi	702 0	548 0
	(707.0)	(552.3)
Th	919.0	696.2
	(942 0)	(719.0)
U	1012.0	760 9
	(1015.0)	(768.9)

*Figures in brackets indicate the theoretical values [10]

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