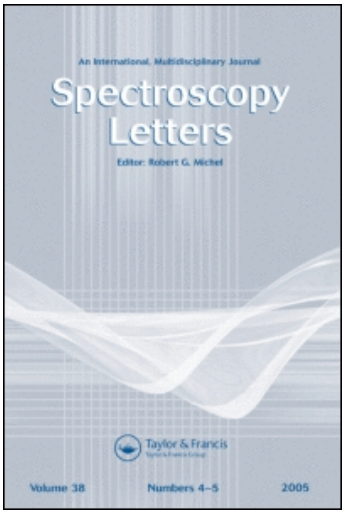

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COMPARISON OF RAYLEIGH AND COMPTON SCATTERING IN THE PHOTON-MOMENTUM TRANSFER REGION OF 2.219 × 3.814 Å^{-1}

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COMPARISON OF RAYLEIGH AND COMPTON SCATTERING IN THE PHOTON-MOMENTUM TRANSFER REGION OF $2.219 \times 3.814\,\text{Å}^{-1}$

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ABSTRACT

Rayleigh and Compton scattering differential cross sections for Mo, Ag and Sn have been measured from 55° and 105° at 59.5 keV using an Hp Ge detector. The ratios of measured cross sections are compared with ratios of theoretical scattering cross section values calculated using nonrelativistic form factors.

INTRODUCTION

Scattering of gamma rays by atoms has been a subject of substantial theoretical and experimental interest. Tabulations of theoretical coherent and incoherent scattering cross sections are available for use in calculating radiation interactions with matter. Experimental differential scattering cross

section data have been made to verify theoretical values. The data will be useful in calculating radiation attenuation transport and energy deposition in medical physics, power reactor shielding, industrial radiation processing, analysis of nuclear physics experiments and in a variety of other applications in addition to x-ray crystallography.

EXPERIMENTAL

In the experiment, a Am^{241} source, with an activity of 100 mCi (3.7×10^9 Bq), was used. The source had a distance of 32 mm from the target, which had diameters of 10 mm. Spectroscopically, pure thin elemental foils of Mo, Ag and Sn of thickness from 0.0174 to 0.1082 g/cm^2 have been used for measurements. The experiments were performed with a high purity Ge detector with a resolution of 230 eV for 5.9 keV Mn *Ka* line. The experimental arrangement was given in our earlier work[1]. Self-absorption correction was performed for all samples used in our experiments[2]. The ratio of the differential cross sections for Rayleigh and Compton scattering of gamma rays by a target atom is obtained using the relation[3,4].

$$[(d\sigma/d\Omega)^R/(d\sigma/d\Omega)^c] = (n^R T^c \varepsilon^c / n^c T \varepsilon) \quad (1)$$

where n^R and n^c are the counting rates of the Rayleigh and Compton lines, T^c and T are respectively, the transmission factors for Compton scattered gamma rays and for 59.5 keV energy, ε and ε^c are the photo peak detection efficiencies for 59.5 keV and for the energy after Compton scattering. The theoretical Rayleigh and Compton scattering differential cross sections are calculated by using the relations:

$$(d\sigma/d\Omega)^R = (1/2) r_o^2 (1 + \cos^2\theta)[F(x, Z)]^2 \quad (2)$$

and

$$(d\sigma/d\Omega)^c = (d\sigma^{KN}/d\Omega)[S(x, Z)] \quad (3)$$

where θ is the scattering angle, r_o is the classical electron radius, F(x,Z) is the atomic form factor, x is the photon-momentum transfer, Z is the atomic number, S(x,Z) is the incoherent scattering function, $(d\sigma,^{KN}/d\Omega)$ is the Klein-Nishina cross section per electron.

Table 1. Experimental and Theoretical Results for the Ratio of Rayleigh Scattering to Compton Scattering Differential Cross Section $[(d\sigma,/d\Omega)^{R}/(d\sigma,d\Omega^{c}]$ for Mo, Ag and Sn

		Mo		Ag		Sn	
θ(deg)	$X(Å)^{-1}$	Expt.	Theo.	Expt.	Theo.	Expt.	Theo.
55	2.219	1.306	0.792	1.158	0.902	1.234	0.984
60	2.403	1.151	0.695	1.009	0.754	1.084	0.815
65	2.583	0.992	0.596	0.879	0.666	0.915	0.710
70	2.757	0.902	0.523	0.780	0.594	0.796	0.636
75	2.926	0.761	0.461	0.697	0.538	0.720	0.582
80	3.090	0.695	0.406	0.656	0.690	0.640	0.536
85	3.248	0.614	0.359	0.579	0.446	0.578	0.493
90	3.399	0.559	0.320	0.530	0.407	0.539	0.443
95	3.544	0.487	0.288	0.506	0.376	0.511	0.420
100	3.682	0.445	0.268	0.460	0.355	0.497	0.398
105	3.814	0.399	0.256	0.411	0.339	0.454	0.382

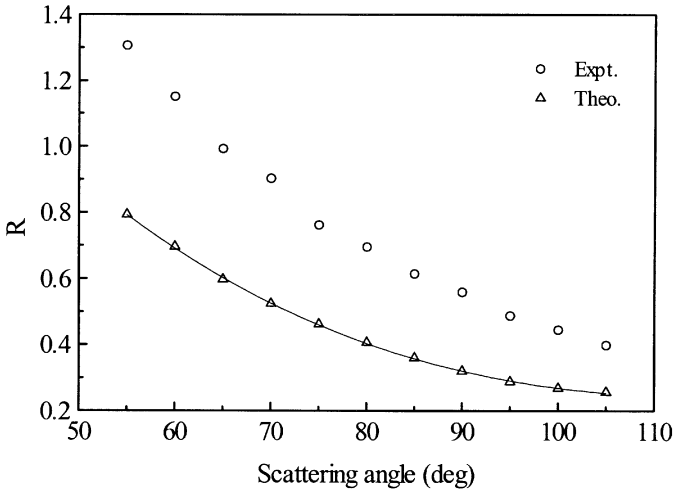

Figure 1. Ratio (R) of Rayleigh scattering to Compton scattering differential cross sections against scattering angle for Mo.

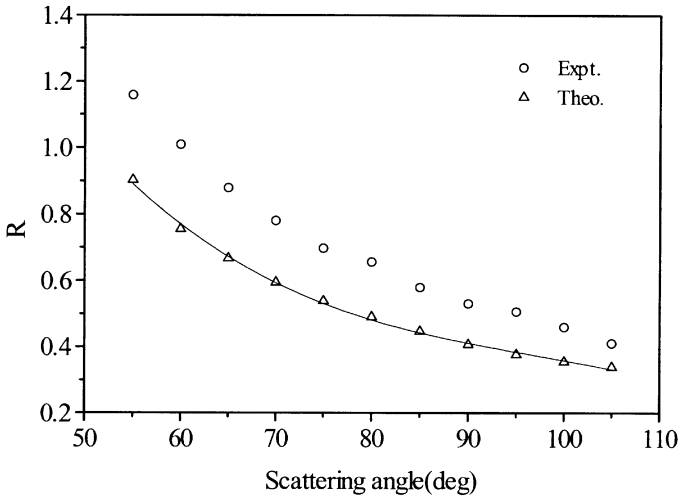

Figure 2. Ratio (R) of Rayleigh scattering to Compton scattering differential cross sections against scattering angle for Ag.

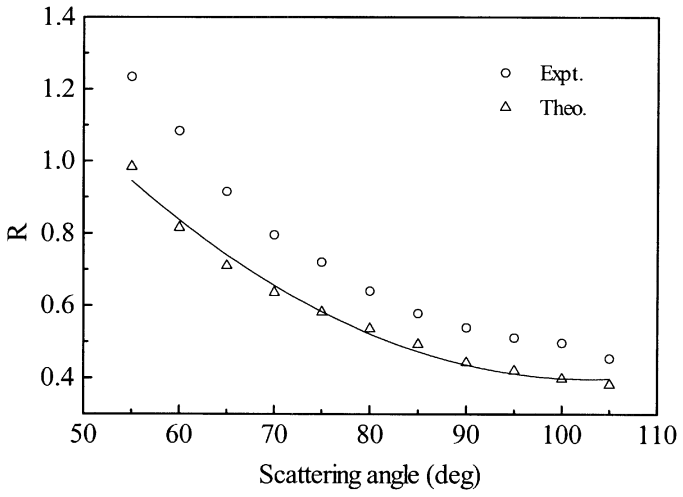

Figure 3. Ratio (R) of Rayleigh scattering to Compton scattering differential cross sections against scattering angle for Sn.

RESULTS AND DISCUSSION

The experimental and theoretical results for the ratio of Rayleigh scattering to Compton scattering differential cross section are presented in Table 1. Experimental results are also graphically compared with theoretical results calculated using nonrelativistic form factors[5] in Figures 1 through 3. Many authors[6–12] have measured Rayleigh and Compton scattering differential cross section of photons scattered at various angles. But, there are no experimental data on the ratio of differential cross sections in literature for 59.5 keV by Mo, Ag and Sn at these angles except for 145 keV by Cu, Cd and Pb for angles from 25° to 80° ;[13] As seen from Figures 1 through 3, there is reasonable agreement between experimental and theoretical results for the differential cross section ratios. All experimental points lie above theoretical curve. These deviations are probably caused by small differences in the values of parameters employed in the calculations. The error associated in the evaluation of the photo peak area is less than 1.06%. The precision in scattering angle is about $\pm 4\%$. The uncertainty in thickness determination is about $\pm 2\%$.

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