Total gamma-ray cross sections in C, Sn, W and Pt in the energy region 84-662 kev

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Abstract. Experimental total gamma-ray cross sections in the energy region 84–662 kev in the elements C, Sn, W and Pt are recalculated, using most of the available data with their appropriate errors, because of the inconsistencies in the existing experimental data. These values are found to be in agreement with the theoretical total gamma-ray cross sections reported by Grodstein within the range of errors. Using these values, studies are made on the scattering cross sections, and within the range of errors agreement is observed between theory and experiment. More accurate and consistent remeasurements of total gamma-ray cross sections are suggested, in order to have a better understanding of the existing discrepancies between theory and experiment in the present region of energy.

In table 1 the gamma-ray experimental cross sections in C, Sn, W and Pt measured by various workers are given. It can be seen from these values that the total cross sections are not in agreement, even after the errors quoted by the respective authors have been taken into consideration. Because of the variations in the measured cross sections, the conclusions drawn on the basis of these values may, however, vary from worker to worker, depending on their results of measurement. The inconsistencies in the results of cross-section measurements by various workers are either due to an underestimate of errors or due to fluctuations in the value itself. Thus it is of real interest to recalculate only one

Table 1. Total gamma-ray cross sections in barns per atom

Element \ Energy (kev)		84	145	411	662
C		2.93 ± 0.03 (Ra) 3.16 ± 0.03 (†Wi) 3.15 ± 0.02 (†Mc)	2.62 ± 0.02 (La) 2.71 ± 0.03 (Ra)		
	RV	3.08 ± 0.13	2.67 ± 0.06		
	Theor.	3.14 ± 0.09	2.73 ± 0.08		
Sn					14.07 (Co) 14.58 ± 0.02 (Col)
	RV				14.33 ± 0.36
	Theor.				14.70 ± 0.45
W				55.58 ± 1.12 (Wi) 53.89 ± 0.02 (Ho)	
	RV			54.7 ± 1.2	
	Theor.			54.7 ± 1.6	
Pt				63.95 ± 0.12 (Col) 62.52 ± 1.25 (Wi)	32.77 ± 0.03 (Col) 32.00 ± 0.20 (†La)
	RV			63.24 ± 1.00	32.40 ± 0.60
	Theor.			63.20 ± 1.90	33.00 ± 1.00

Ra, Ramana Rao *et al.* 1965; La, Lakshminarayana 1960; Wi, Wiedenbeck 1962; Mc, McCrary *et al.* 1967; Co, Cowan 1948; Col, Colgate 1952; Ho, Howland and Krager 1954; RV recalculated value; Theor., theoretical value; † interpolated values.

cross-section value from the available data at a particular energy in the same element. The conclusions drawn on the basis of these values are more likely to be realistic.

The mean of the cross sections measured by various workers at each energy and in each element is taken as the recalculated value†. The standard deviation from these values is taken as the error in it. The recalculated values in C, Sn, W and Pt in the energy range 84–662 kev are also given in table 1, together with the theoretical values reported by Grodstein (1957). It can be seen from table 1 that the agreement among the recalculated values, values of the different workers and the theoretical values is satisfactory within the range of errors. Using the recalculated values, scattering cross sections (with coherent) in carbon and tin are calculated by subtracting the photoelectric cross sections evaluated, using Nagel's (1960) expressions in the case of carbon and those recently reported by Schmickley and Pratt (1967) in tin. These values, together with the theoretical values reported by Grodstein (1957), are given in table 2. To study the effect of electron binding,

Table 2. Scattering cross sections (with coherent) in C and Sn in barns per atom

Element \ Energy (kev)		84	145	662
C	Exp.	3·05 ±0·13	2·67 ±0·06	
	Theor.	3·11 ±0·03	2·71 ±0·03	
Sn	Exp.			12·72 ±0·38
	Theor.			13·00 ±0·13

Table 3. Ratios of bound- to free-electron scattering cross sections in carbon

(1)	(2)	(3)	(4)
84	0·91 ±0·04	0·86 ±0·01	0·94 ±0·03
145	0·94 ±0·02	0·96 ±0·01	0·96 ±0·03

(1) Energy (kev); (2) present values; (3) values of Ramana Rao *et al.* (1965); (4) theoretical values based on Thomas–Fermi model.

the ratios of the experimental incoherent scattering cross sections to the free-electron scattering cross sections, using the procedure employed by Ramana Rao *et al.* (1965) in the case of carbon at gamma-ray energies of 84–145 kev, are determined, and these values, together with the theoretical ratios of Ramana Rao *et al.* (1965) based on the Thomas–Fermi model, are given in table 3.

It can be seen from tables 2 and 3 that there is satisfactory agreement between the present values and the theoretical values within the range of errors at all energies. But deviations are observed at some energies in the previous investigations of Lakshminarayana and Jnanananda (1961) and Ramana Rao *et al.* (1965) based on their total cross-section measurements. However, from the present investigations it may be concluded that the previously observed discrepancies may be ignored for the present in the energy region under consideration until the existing inconsistencies in the total cross-section measurements are eliminated. It is therefore suggested that there should be a systematic measurement of the total experimental gamma-ray cross sections in the energy region under consideration, in order to eliminate inconsistencies and for there to be reproducibility of the experimental results within the specified accuracy by any worker. Only then can one draw meaningful conclusions on the accuracy of the theoretical estimates.

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† Since each experimental value at the same energy and in the same element is accurate, this method of recalculating a unique value is supposed to be based on a sound background.

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Escape of photons from infinite cylinders

Abstract. It is found that photons emitted from the surface of an infinitely long cylindrical mass distribution and moving in a plane perpendicular to its axis are allowed to escape to infinity only when the mass per unit length of the cylinder is below a certain critical limit. In all other cases they will be recaptured by the cylinder, with the exception of those moving radially.

In a recent communication Synge (1966) has shown that for 'gravitationally intense stars' only those photons which are emitted within a slender critical cone can escape to infinity. But in the limit when the surface of the star approaches the Schwarzschild radius only the radially moving photons can escape. In a corresponding problem involving a cylindrically symmetric mass distribution it is found that, for photons moving in a plane normal to the cylindrical axis, there exists a critical value for the mass per unit length of the cylinder below which the photons escape to infinity for all angles of emergence. In other cases they have to turn back somewhere in their courses, the only exception being those moving radially.

The well-known metric (Marder 1958) in vacuum outside an indefinitely long static cylinder is given by

$$ds^2 = r^{2C}dt^2 - r^{2(1-C)}d\phi^2 - A^2 r^{-2C(1-C)}(dr^2 + dz^2) \tag{1}$$

where C and A are constants. $\frac{1}{2}C$ is interpreted as the mass per unit length of the cylinder. Now the equations for the null geodesics along which the z coordinate is fixed may be expressed by

$$r^{2C}\dot{t}^2 - r^{2(1-C)}\dot{\phi}^2 - A^2 r^{-2C(1-C)}\dot{r}^2 = 0 \tag{2}$$

$$\ddot{t} + \frac{2C}{r}\dot{t}\dot{r} = 0 \tag{3}$$

$$\ddot{\phi} + \frac{2(1-C)}{r}\dot{r}\dot{\phi} = 0 \tag{4}$$

where the dots denote differentiation with respect to some affine parameter. The equations (3) and (4) after integration give

$$\dot{t} = \alpha r^{-2C} \quad \text{and} \quad \dot{\phi} = \beta r^{-2(1-C)}$$

where α and β are constants. After combining the above two relations one can directly