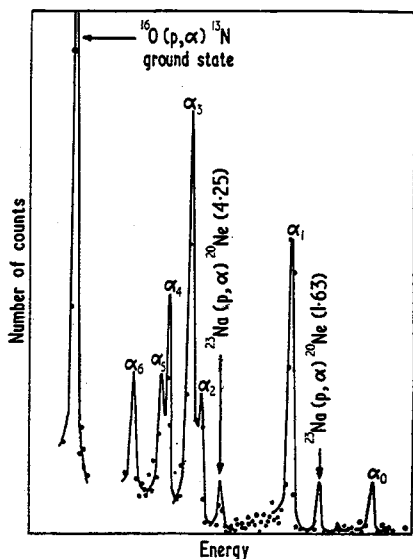Figure 1. Energy spectrum of alpha particles from the reaction $^{39}K(p, \alpha)^{36}Ar$ observed at the laboratory angle of 60°. The number against each impurity peak indicates the excitation in MeV of the residual nucleus.

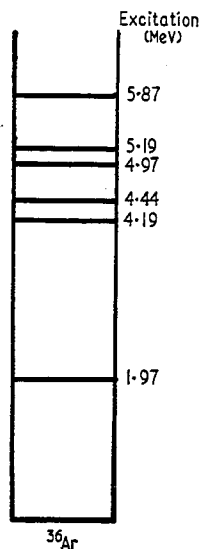Figure 2. Observed level scheme of ^{36}Ar from the reaction $^{39}K(p, \alpha)^{36}Ar$.

It was concluded that no other resolved levels in ^{36}Ar below 6·0 MeV reaction $^{39}K(p, \alpha)^{36}Ar$ had an intensity greater than 10% of that of the first excited state when observed at 60° in the laboratory.

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Gamma ray absorption coefficients

Abstract. The experimental and theoretical values of scattering cross sections of gamma radiation, reported by Lakshminarayana and Jnanananda in 1961, have been extended to cover a wider range of atomic numbers and photon energies.

In a paper on the scattering cross sections of gamma radiation (Lakshminarayana and Jnanananda 1961) cross sections of gamma rays from absorption coefficients for graphite, aluminium and copper for photon energies between 1·332 MeV and 0·145 MeV were presented. The purpose of this letter is to present the experimental mass absorption coefficients for carbon, aluminium and copper over a range of photon energies 1·2526 MeV to 0·0843 MeV and for mercury over a range of energies 1·2526 MeV to

Comparison of mass absorption coefficients (cm² g⁻¹)

Energy (Mev)		Absorber			
		Carbon $Z = 6$	Aluminium $Z = 13$	Copper $Z = 29$	Mercury $Z = 80$
1·2526 (⁶⁰Co mean)	(i)	0·0568	0·0555	0·0521	0·0587
	(ii)	0·0567 ±0·25%	0·0553 ±0·3%	0·0525 ±0·38%	0·0581 ±0·68%
	(iii)	−0·18	−0·36	0·76	−1·03
1·119 (⁶⁵Zn)	(i)	0·0601	0·0579	0·0554	0·0654
	(ii)	0·0600 ±0·3%	0·0582 ±0·17%	0·0545 ±0·55%	0·0648 ±0·46%
	(iii)	−0·17	0·52	−1·6	−0·93
0·662 (¹³⁷Cs)	(i)	0·0773	0·0742	0·0725	0·0927
	(ii)	0·0771 ±0·26%	0·0738 ±0·41%	0·0727 ±0·52%	0·0901 ±0·3%
	(iii)	−0·26	−0·54	0·3	−2·88
0·511 (⁶⁵Zn annihilation)	(i)	0·0862	0·0831	0·0814	0·1514
	(ii)	0·0864 ±0·45%	0·0825 ±0·5%	0·0820 ±0·61%	0·1451 ±0·4%
	(iii)	0·23	−0·73	0·73	−4·34
0·1344 (¹⁴⁴Ce)	(i)	0·1380	0·1422	0·2584	
	(ii)	0·1370 ±0·6%	0·1483 ±0·61%	0·2645 ±0·6%	
	(iii)	−0·73	+4	+2·31	
0·0843 (¹⁷⁰Tm)	(i)	0·1566	0·1831	0·6238	
	(ii)	0·1517 ±1·7%	0·1940 ±1·4%	0·5834 ±0·6%	
	(iii)	−3·2	+6·13	−7	

(i) Theoretical μ, (ii) experimental μ, (iii) % difference between (i) and (ii).

0·511 mev, and to compare these values with those obtained from theoretical calculations. For a discussion of the theory reference should be made to the original paper.

In our experiments a narrow beam geometry apparatus was used together with a 3 in. × 3 in. NaI scintillation crystal as a detector. This arrangement was similar to that of Davisson and Evans (1952), but modified to reduce the solid angle so that the positioning of the absorber had no effect on the scattering cross section. The apparatus was checked for proper collimation and the electronic equipment for stability. Test runs were made using ^{60}Co, ^{65}Zn, ^{137}Cs and ^{226}Ra gamma ray sources to check the linearity so that the base voltage of the pulse height analyser could be directly correlated with the gamma ray energy. The gamma ray sources used for the determination of absorption coefficients were ^{60}Co, ^{65}Zn, ^{137}Cs, ^{144}Ce and ^{170}Tm; the absorbers were carbon, aluminium, copper and mercury (purity greater than 99%). The absorbers were cut into thin disks of varying thicknesses to enable flexibility in the thickness of the absorber placed in the path of the gamma ray beam.

Observations were taken without any absorber in the path of the collimated gamma ray beam and repeated with absorbers of varying thicknesses. The gamma ray spectra were obtained using a pulse height analyser. The counting rate was varied depending on the thickness and type of the absorber to keep the statistical error to a minimum (<1%). The mass absorption coefficients obtained from the observations are given in the table.

Theoretical absorption coefficients (bn/atom) for the absorbers and the gamma ray energies under consideration were obtained by using the Klein–Nishina (1929) formula and by extrapolation from graphs drawn using Davisson and Evans' tables. These were converted to mass absorption coefficients and are given in the table.

It can be observed from the data given in the table that there is good agreement between theoretical and experimental values of absorption coefficients for carbon, aluminium and copper for energies greater than 0·511 mev. We conclude that the Klein–Nishina equation gives accurate values for scattering cross sections for energies above 0·511 mev. At low energies there is considerable difference between the theoretical and experimental values. It may be that coherent scattering contributions have to be taken into consideration at these energies. The difference between theoretical and experimental values of absorption coefficients for mercury between 0·511 and 1·2526 mev can be ascribed to errors in pair production and photoelectric coefficients. However, the contribution of pair production at 1·119 and 1·2526 mev is much less then 1% of the total coefficient, and zero below 1·022 mev. As the rigorous dependence of the photoelectric effect on the atomic number of the element and on the energy of the photons cannot be described by a simple power law, we conclude that the deviations observed in the values of absorption coefficients for mercury are due to the approximations made in the equations for photoelectric coefficients.

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