Yield of Photoprotons from Some Light Elements

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IT is well known that the cross sections for the (γ,n) reactions in heavy elements agree well with the predictions of the sum rule. For light elements the cross sections are considerably lower than the sum rule limit. In the latter case a contribution from (γ,p) reactions is expected. Recent calculations by Morinaga[1] on the proton-to-neutron yield ratios indicate that the emission of protons is the predominant mode of decay for nuclei of the type $A=4n$. However, little is known about the cross sections for (γ,p) reactions. In order to get more experimental data, the proton yields for Mg, Si, S, and Ca were determined. The measurements were made relative to Al, the yield of which is known.

Thin foils (30 mg/cm^2) of the elements in question were exposed to the collimated beam from the University of Lund synchrotron. The maximum bremsstrahlung energy was 28 Mev. The foils were mounted in an evacuated nuclear plate camera and given the same dose of radiation. The number of proton tracks in a certain part of the plates was determined for the five elements. The number of background tracks was determined and subtracted. No attempt was made to distinguish protons from deuterons. However, the number of deuterons must be small, since most of them are absorbed in the target. The protons from the (γ,np) reaction are of fairly low energy and are also absorbed in the target to a great extent. Hence the photoproton yields determined are essentially due to the (γ,p) reaction.

With certain simplifying assumptions the integrated cross sections can be calculated from the yield values. Let us assume that the shape and position of the cross-section curves of the elements investigated are similar. By using the value reported by Halpern and Mann[2] for the integrated cross section of Al, the cross sections of the other elements were calculated. It is true that the range of error of this procedure is fairly wide but since the maximum bremsstrahlung energy is well above the resonances, the error will probably have no appreciable influence on the validity of the conclusions drawn. Table I shows the values calculated in this way. For Mg and Si the contributions by the less abundant isotopes was subtracted, using the values reported by Katz *et al.*[3] Table I also contains the (γ,n) integrated cross sections[4] and the sum rule limit with $x=0$.

TABLE I. Integrated cross sections.

Element	Integrated σ (Mev-barns) (γ,p)	(γ,n)	Sum rule limit $x=0$
Mg^{24}	0.16	0.057	0.36
Si^{28}	0.27	0.070	0.42
S	0.32	0.069	0.48
Ca	0.44	0.065	0.60

It is clear from the table that proton emission is the predominant mode of decay. A comparison with the theoretical values of Morinaga shows a good agreement, the experimental values being about 20 percent lower than the theoretical. Considering the experimental errors and the simplifications in the theoretical calculations, this agreement must be considered satisfactory. Since the calculations are based on the compound nucleus model, this agreement is an indication of the validity of this model. The sum of the proton and neutron cross sections gives a value for the photonuclear dipole absorption coming close to the sum rule limit. Addition of the $(\gamma,2n)$, (γ,d), (γ,np), (γ,α), and (γ,γ) cross sections will increase the absorption cross section still more, probably above the sum rule limit for $x=0$. This experiment thus suggests the conclusion that the sum rule is valid also for the lighter elements.

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[1] H. Morinaga (private communication); see preceding Letter [Phys. Rev. **97**, 1185 (1955)].
[2] J. Halpern and A. K. Mann, Phys. Rev. **83**, 370 (1951).
[3] Katz, Haslam, Goldemberg, and Taylor, Can. J. Phys. **32**, 580 (1954).
[4] Montalbetti, Katz, and Goldemberg, Phys. Rev. **91**, 659 (1953).

Elastic p-p Angular Distribution 440–1000 Mev*

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PRELIMINARY measurements of the angular distribution of elastic p-p scattering have been made at incident proton energies of 440, 590, 800, and 1000 Mev. The circulating beam of the Cosmotron struck a $\frac{1}{4}$ in.$\times\frac{1}{4}$ in.$\times$0.514 in. CH_2 target placed inside a straight section. The two recoil protons passed through thin aluminum walls of the vacuum chamber and were detected in two scintillation counter telescopes as indicated schematically in Fig. 1. Elastic p-p events were selected by requiring coincidence of the two telescopes when set at proper kinematic angles and with appropriate time delay. A typical plot of coincidence counting rate *vs* telescope angle is shown in Fig. 1. The scattering angle was defined to $\pm\frac{1}{4}°$ by a $\frac{1}{2}$-in. square counter at 57-in. distance in the small-angle telescope, with a 3 in.$\times$4 in. counter in the large-angle telescope. The