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THE REACTIONS $Si^{28}(\gamma, p)Al^{27}$ AND $Si^{28}(\gamma, \alpha)Mg^{24}$

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The development of solid state detectors offers special possibilities for the investigation of nuclear reactions in silicon. By using the detector as target simultaneously, energy resolution is not impaired by target thickness and measurements can be made with very high detection efficiency.

Measurements made in this [1,2] and some other [3-5] laboratories have shown this method to be useful in the detection of photo particles. In this paper cross section curves for both the (γ, p)- and (γ, α)-reaction as derived from such measurements are presented for the first time.

The experimental arrangement used has been described previously [1]. For the present measurements a 0.4 mm dE-detector * has been used. The betatron bremsstrahlung was hardened by 50 cm graphite absorbers. A fast preamplifier and a special electronic unit for pile-up rejection made it possible to measure the spectra of photo particles down to 1.5 MeV without essential distortion caused by electrons. The energy resolution was 60 keV during the gamma burst.

Besides the photoprotons the measured spectra contain also some photoalphas. Identification of the alpha particles can be made at the high energy end of each measured spectrum, due to the fact that the alpha particles can have higher energies than the protons, since the (γ, α) reaction in Si^{28} has a Q-value 1.6 MeV lower than the Q-value of the (γ, p)-reaction.

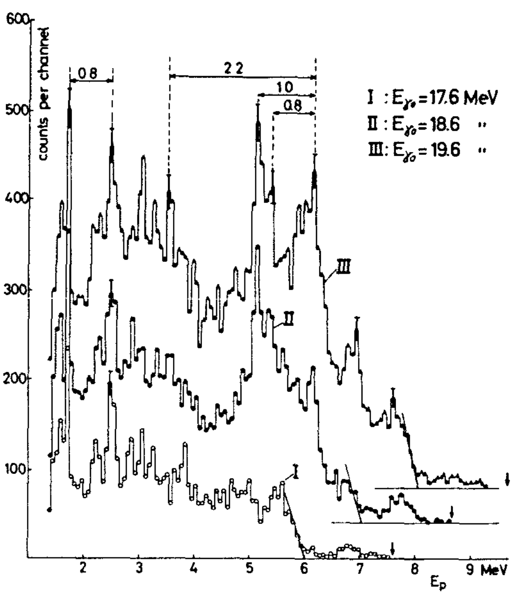

Fig. 1

Fig. 1 shows 3 measured spectra for different end point energies. For each spectrum the highest possible alpha energy is indicated by an arrow, the straight line 1.6 MeV below, indicates the end of the proton distribution. The measured points in the region in between must be attributed to alpha particles **. As the number of observed particles at the proton limits rises considerably, and since the alpha yields in general are small, below these limits the measured distributions should be mainly due to protons.

The observed proton peaks in the spectra clearly indicate the presence of narrow resonances in the excited silicon nucleus. As from each excited state proton transitions to several discrete state in the residual nucleus are possible, identification of the peaks is only possible from a series of measurements. As for instance the proton peaks at 6.2, 5.4, 5.2 and 4.0 MeV are present in curve III and II but not in curve I of fig. 1, they all must be attributed to a resonance between 18.6 and 17.6 MeV excitation energy. Thus the peak at 6.2 MeV must be due to ground state transitions since adding the Q-value of 11.6 MeV one obtains the right excitation energy. The other peaks are associated with transitions into excited states of the residual nucleus. Indeed, the distances between these peaks correspond well to the excitation energies of the first three excited states in Al^{27} with 0.8, 1.0 and 2.2 MeV.

Branching ratios for the transitions mentioned here are given in the table. These values have been derived from the difference of curve II and I. The errors are due to statistical uncertainties. At the high energy limit the proton (and alpha) spectra contain only contributions from ground state transitions. Thus together with the knowledge of the bremsstrahlung spectrum, cross section curves for reactions leading to the ground state can be derived within a certain energy range for each spectrum.

Table 1
Branching ratio for the 17.8 MeV resonance.

Transition	Branching ratio relative to p_0
p_0	1.0
p_1	1.2 ± 0.6
p_2	1.5 ± 0.8
p_3	0.75 ± 0.4
o	0.08 ± 0.04

In this way, from a series of 6 measurements with different endpoint energies the cross section curves for the (γ, p_0) and (γ, α_0) reactions have been derived. The results are given in fig. 2. Both curves are given in the same arbitrary units. Only statistical errors are indicated. Corrections for particles leaving the detector have been made [1].

* Ortec RMCJ 050/400.

** Protons from the small admixtures of Si^{29} (4.4%) and Si^{30} (3.1%) can not be responsible. as the Q-values of these (γ, p)-reactions are still higher than that in Si^{28}.

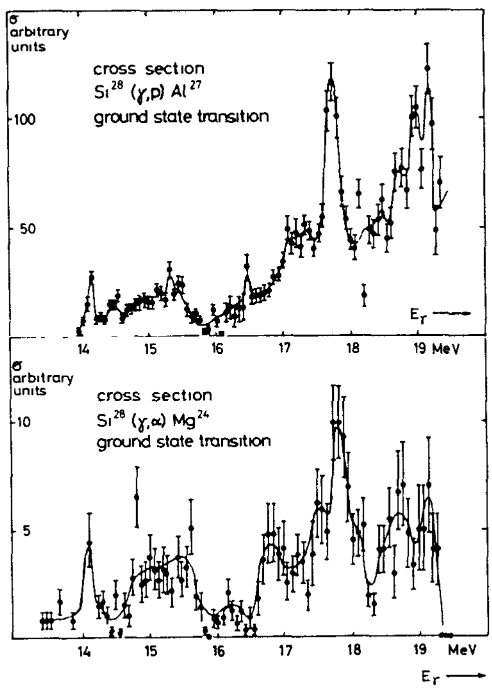

Fig. 2

The (γ, p_0) cross section has been corrected for the α_0 particles.

It can be seen that both cross section curves follow the same trend. They seem to have some common resonances, especially the pronounced one at 17.8 MeV. The relatively high branching ratio for alpha particles as compared with isotopic spin selection rules [6] could be an indication of the presence of transitions other than E1.

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