Brief Reports

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Photoneutron cross section for ^{29}Si

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The ^{29}Si(γ,n) cross section has been measured from 9.6 to 18.8 MeV with monoenergetic photons. These new data resolve the discrepancies between the results of two previous measurements of this reaction cross section.

The photoneutron reaction in ^{29}Si has been studied recently by two groups.[1,2] The measurement of the University of Melbourne[1] covered the energy range from threshold 8.5 MeV to 26 MeV. At the Lawrence Livermore National Laboratory (LLNL),[2] the range was from 13 MeV to over 30 MeV, but there were gaps in the lower energy range. From 18 to 26 MeV there is excellent agreement between the results of the two measurements in both shape and absolute magnitude. However, between 13 and 16 MeV the LLNL data indicate cross-section values which are about 50% higher than those reported by the Melbourne group. Between 17 and 18 MeV, again the LLNL data give values which are significantly greater; indeed the LLNL data show strong indications of a peak here, which is not evident from the Melbourne work.

The opportunity was taken during another experiment at LLNL to remeasure the ^{29}Si(γ,n) cross section in the excitation energy range from 9.5 MeV to 18.3 MeV, in order to investigate this discrepancy. The method used was the same as that of the earlier LLNL work.[2] That is, an array of BF_3 counters detected thermalized neutrons produced when quasimonoenergetic photons from positrons annihilating in flight irradiated a SiO_2 target enriched to 95% in the ^{29}Si isotope. However, it should be noted that although the sample and technique of these two measurements were identical, the setting up, calibration, etc., were quite independent of each other. The correction for the oxygen in the SiO_2 sample was made, knowing the chemical composition of the sample and the ^{16}O(γ,n) cross section from earlier measurements. In the present energy range, the only data points significantly affected by the oxygen contamination are those between 16.8 and 18.8 MeV, for which correction has been made using the ^{16}O(γ,n) cross section of Ref. 3.

The new results are shown in Fig. 1, which also includes the earlier LLNL and Melbourne results for comparison. Between 11 and 18.3 MeV, the new data agree very well with the Melbourne data, and thus confirm that the earlier LLNL data were high.

The reason for the high cross section in the earlier results in the energy range from 13 to 16 MeV is almost certainly related to the use of a neutron-detection efficiency which was too low. The efficiency of the neutron detector used at LLNL depends on the average neutron energy in a way that has been carefully measured, and is documented in Ref. 4. Reference to Fig. 4 of Ref. 2 shows that in this region of excitation energy, the aver-

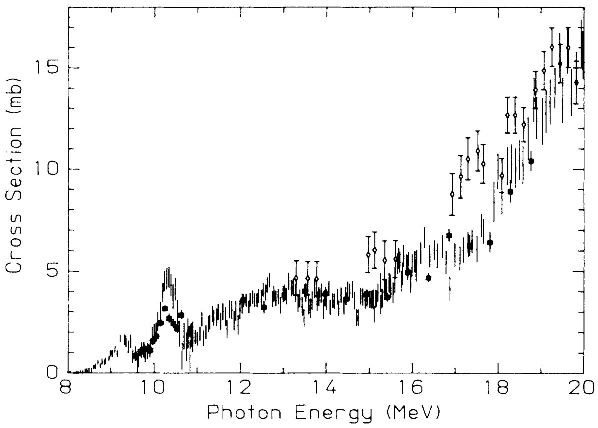

FIG. 1. Measurements of the ^{29}Si photoneutron cross section. The solid lines represent the Melbourne data (Ref. 1). The LLNL data (Ref. 2) are given by the diamonds, while the squares give the present results.

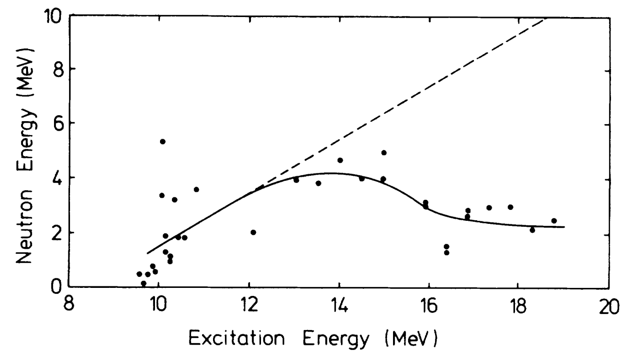

FIG. 2. The average energy of emitted neutrons as a function of excitation energy. The data points are derived from the ring ratio as described in Ref. 4. The solid line indicates the values used in this analysis, while the dashed line shows the energy expected for neutrons emitted to the ground state of ^{28}Si.

age neutron energy is consistent with all neutron decays occurring in the ground state of ^{28}Si. A recent measurement[5] of the deexcitation gamma rays emitted from ^{28}Si following the $^{29}Si(\gamma,n)$ reaction, shows that some 30% of decays are to the 1.7 MeV and 6.71 MeV states in ^{28}Si. Thus, the average neutron energy must be lower than that indicated in Ref. 2. The consequence of this is that the detection efficiency used in Ref. 2 was too low, leading to a cross-section value that was too high in this excitation-energy region.

In the present measurement, with better statistics, the average neutron energy is clearly defined, and is shown in Fig. 2. The significantly lower average neutron energy in the excitation energy range of 13 to 16 MeV, when compared to that of Ref. 2, agrees with the observations above, and leads to the smaller value of the cross section in this energy region.

The apparent peak near 17.5 MeV in the earlier LLNL data[2] is clearly not confirmed in either the present measurement or the Melbourne results. Again, in this region the average neutron energy used to determine the detection efficiency in the earlier LLNL data was too high. Figure 2 shows that the average neutron energy is significantly lower than the value of 5 MeV used in determining the efficiency in Ref. 2.

To confirm that the differences between the present results and those of Ref. 2 are purely due to detector efficiency effects, we have reanalyzed the earlier data using detector efficiencies derived from the measured average neutron energies shown in Fig. 2. The agreement is complete, with the earlier data coming into line with both the present measurement and the Melbourne results.[1]

At 10.3 MeV, the cross section measured at Melbourne shows a strong peak with a maximum height of 4.75 ± 0.25 mb. The new data reported here also show a peak at this energy, but the maximum is only 2.7 ± 0.2 mb. This discrepancy cannot be ascribed entirely to resolution effects. We recommend that at 10.3 MeV a peak value of 3.7 mb be accepted.

The discrepancy that exists between the $^{29}Si(\gamma,n)$ cross section between 13 and 16 MeV as measured at Melbourne,[1] and at LLNL,[2] has been resolved by the present measurement. We recommend that with regard to the structure at 10.3 MeV, a peak cross section of 3.7 mb be accepted. Elsewhere, up to an energy of 19 MeV, we recommend the Melbourne data[1] be accepted.

Above 19 MeV the data of Refs. 1 and 2 agree over their common energy range. It would seem that in this energy region, the higher cross section, and consequently better counting statistics, allowed the average neutron energy, and hence the detector efficiency, to be correctly determined in Ref. 2.

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