THE CROSS SECTION FOR THE $^{16}O(\gamma,n)^{15}O$ REACTION*

By B. M. Spicer†

There have been a number of attempts to account for the nature of the giant resonance of nuclear photodisintegration (e.g. Goldhaber and Teller 1948; Steinwedel and Jensen 1950; Wilkinson 1955; and others). Levinger and Bethe (1950) believe that a "many-level" theory of the giant resonance is more satisfactory than a single-level theory. The existence of fine structure in the

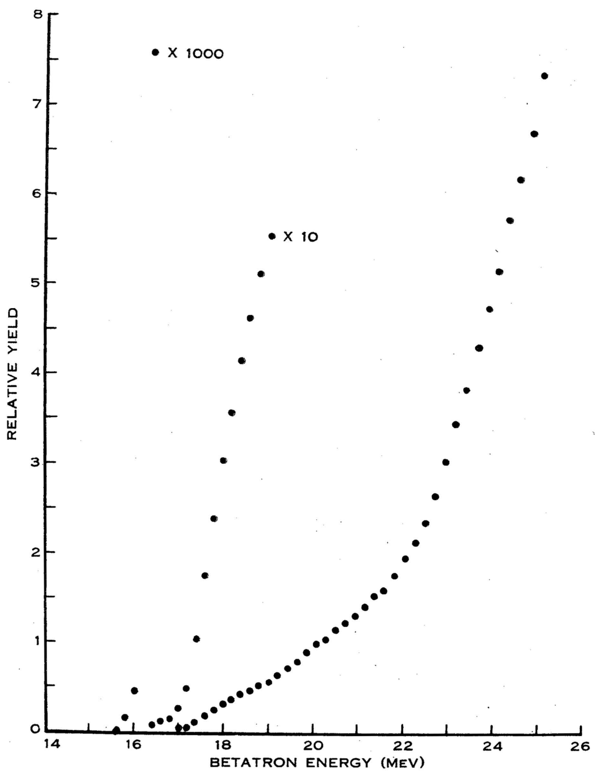

Fig. 1.—The measured yield curve for the $^{16}O(\gamma,n)^{15}O$ reaction.

yield curve of the $^{16}O(\gamma,n)$ reaction at energies near the giant resonance (Penfold and Spicer 1955) supports this conclusion. The purpose of the present note is to show that the existence of structure within the giant resonance may be demonstrated more simply than by the tedious study of fine structure in yield curves.

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The yield curve for the reaction $^{16}O(\gamma,n)^{15}O$ has been measured as a function of betatron energy by counting of the 2-min ^{15}O β^{+}-activity. The apparatus and technique used was that used previously by Penfold and Spicer (1955). The measurement was made in steps of approximately 0·2 MeV from threshold to 25·1 MeV. The results are shown in Figure 1. Each point above 16·5 MeV was measured to a statistical accuracy of better than 1 per cent. The yield curve is similar in shape to that found by Penfold and Spicer in a more detailed study, and has been extended to 25·1 MeV.

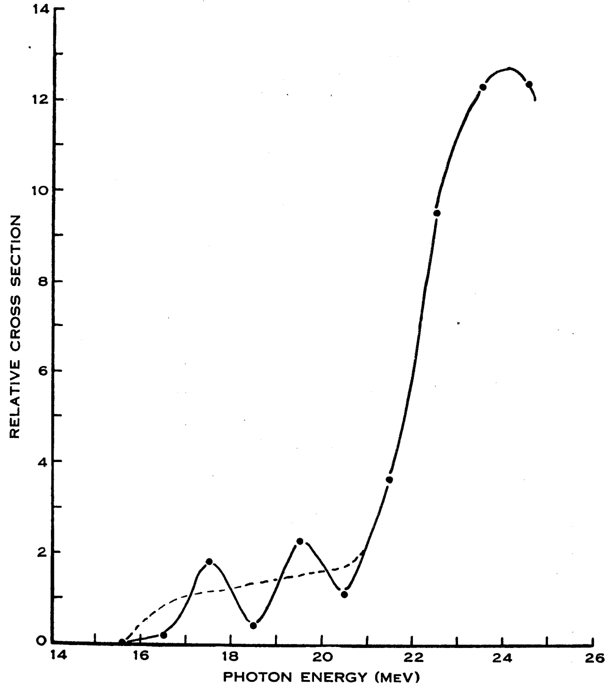

Fig. 2.—The cross section for the $^{16}O(\gamma,n)$ reaction, calculated in 1 MeV steps. A calculation using the smoothing procedure of Katz and Cameron (1951) gives the dashed curve.

The yield curve was solved for cross section by the method of Penfold and Leiss (1954) in steps of 1 MeV. It is to be noted that in most papers on the systematics of giant resonances either the first differences of the yield curve were smoothed before solution for cross section or the cross section was smoothed after solution. Here no smoothing was done. In this case, if the yield curve was recalculated after smoothing the first differences as prescribed by Katz and Cameron (1951), there would be changes averaging 40 per cent. in the yield value in the energy range 16–18 MeV, and the difference between the smoothed curve and the measured curve was still greater than 10 per cent. at 20 MeV. This was considered unwarranted in view of the statistics of the measurement.

Figure 2 shows the cross section, calculated in 1 MeV steps. The dashed curve from threshold to 21 MeV is readily obtained if the smoothing procedure of Katz and Cameron is adopted. This result is in agreement with that of Horsley, Haslam, and Johns (1952), who also detected the ^{15}O activity.

The cross-section solution in steps of 0·5 MeV is shown in Figure 3. It was calculated from the same yield curve, and again no smoothing was done. The general features of this curve below 20 MeV are identical with those of Figure 2. Above 20 MeV, the smooth curve of the 1 MeV solution now exhibits structure. It is estimated that the probable error of the cross-section solution is not greater than 10 per cent. above 20 MeV energy in either Figure 2 or Figure 3.

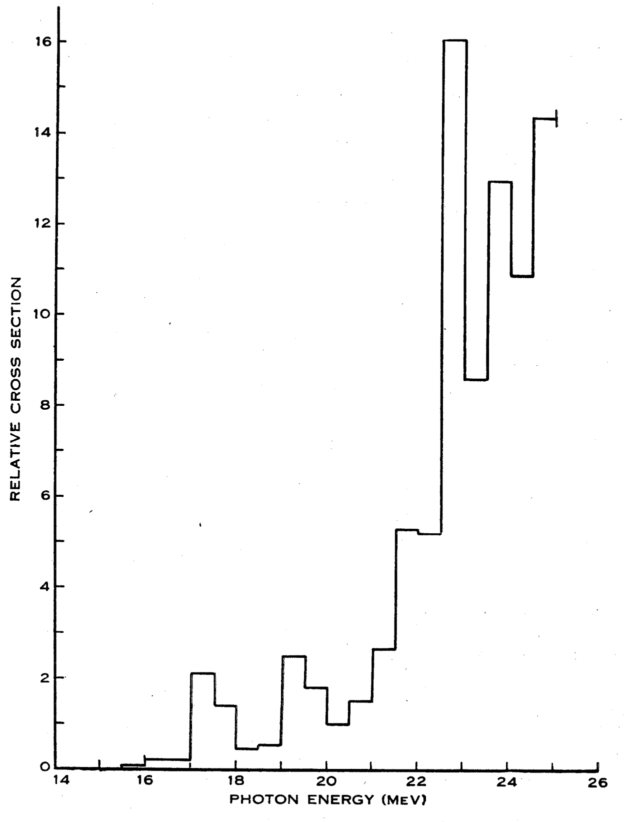

Fig. 3.—The cross section for the $^{16}O(\gamma,n)$ reaction, calculated in 0·5 MeV steps.

The small peak at 17 MeV is compatible with the bunching of levels at that energy, which was found in the fine structure study (Penfold and Spicer 1955). The peak at 19 MeV is also consistent with a less certain assignment of a strong level at 19·2 MeV. The gradual rise of the cross section between 20 and 21·5 MeV, as shown in fine structure study, is reproduced in this work.

The integrated cross section between 22 and 22·5 MeV is approximately three times that between 22·5 and 23 MeV. This is substantiated from the fine structure work, although one cannot say for certain into which interval the integrated cross section of the 23·0 MeV level should be put.

It is therefore concluded that a many-level theory for the giant resonance of photodisintegration is indicated, and that at least semi-quantitative support is given to the results of the fine structure measurements.

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