TABLE III. Center frequency of $F=2$ to $F=1$ transition in $4P_{\frac{1}{2}}$ state of K^{39}.

Run	Observed frequency in Mc/sec	Average in Mc/sec
1, 2, 3	57.5, 58.3, 57.4	57.7±0.5

"scramble" the populations in the $F=2$, $m_F=-2$ and $F=2$, $m_F=-1$ ground-state levels (as well as the other ground-state levels) and by slight adjustments of current and frequency of the low-frequency oscillator, 50% of the atoms in the $F=2$, $m_F=-2$ level were transferred to the $F=2$, $m_F=-1$ level and vice versa. Since the effect was already at maximum, the high-power rf could not produce any additional refocused signal. Consequently the ground-state rf effect was zero.

Another resonance was observed at a frequency of 57.7±0.6 Mc/sec and this we assign to the transition $F=2$ to $F=1$ in the $4P_{\frac{1}{2}}$ state. Three runs were taken and the results are shown in Table III. From this, the value of $a_{\frac{1}{2}}$ is 28.85±0.3 Mc/sec. The value of $a_{\frac{3}{2}}$ is then 5.77±0.06 Mc/sec, because the ratio $a_{\frac{1}{2}}/a_{\frac{3}{2}}$ is theoretically 5 to within a few percent.[3,4] This was found to be true experimentally in the case of sodium[2] and rubidium.[1]

In the $4P_{\frac{3}{2}}$ state of K^{39}, the three hyperfine level separations are

$$3a+b \quad \text{for} \quad F=3 \text{ to } F=2,$$
$$2a-b \quad \text{for} \quad F=2 \text{ to } F=1,$$
$$a-b \quad \text{for} \quad F=1 \text{ to } F=0.$$

We assign the 20.1-Mc/sec resonance to the $F=3$ to $F=2$ transition. This gives a value for b of 2.8±0.4 Mc/sec, where the error quoted is taken to be the extreme of the deviation from the average. Because of the difficulty of fitting curves to an incompletely resolved resonance, we feel this error should be increased to ±0.8 Mc/sec.

The value of Q is $(0.07\pm0.02)\times10^{-24}$ cm^2.

Full details of this experiment will be published later.

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[1] B. Senitzky and I. I. Rabi, Phys. Rev. **103**, 315 (1956).
[2] Perl, Rabi, and Senitzky, Phys. Rev. **98**, 611 (1955).
[3] H. Kopfermann, *Kernmomente* (Edwards Brothers, Inc., Ann Arbor, 1945), p. 22.
[4] Davis, Feld, Zabel, and Zacharias, Phys. Rev. **76**, 1076 (1949).

$C^{13}(\gamma,p)B^{12}$ Cross Section*

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RECENT work[1] at this laboratory showed the $C^{13}(\gamma,n)C^{12}$ cross section to have a small peak near 13.5 Mev in addition to the "giant resonance" peak near 25 Mev. Although energy considerations seem sufficient to exclude competition with the $C^{13}(\gamma,p)B^{12}$ reaction as the reason for the decrease of the (γ,n) cross section above 13.5 Mev, the (γ,p) cross section has now been measured to confirm this conclusion. These two measurements together yield a total absorption cross section that can be interpreted less ambiguously than the partial cross section for the production of neutrons.

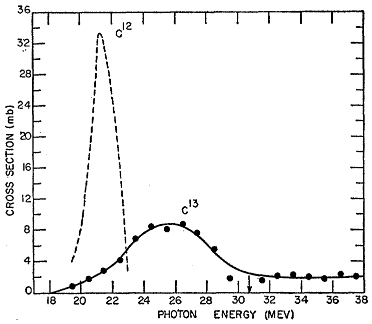

FIG. 1. The $C^{13}(\gamma,p)B^{12}$ cross section. The $C^{12}(\gamma,p)B^{11}$ cross section is that of Halpern and Mann.[4]

B^{12} was detected by the $\beta^-(E_{max}=13.43$ Mev) decay, and a yield function obtained up to 45 Mev. The yield at 30 Mev is 1.3×10^7 protons/100 r mole, compared to 3.6×10^7 neutrons/100 r mole at the same energy for total neutron production. The half-life of B^{12} was redetermined to be $(18_{-1.3}^{+1.5})$ msec, compared to the 22 msec or 27 msec previously reported.[2] Over 5×10^6 disintegrations were recorded to obtain the complete yield curve and used for making this half-life determination.

The (γ,p) cross section (Fig. 1) was derived from the yield curve by using the tables of Leiss and Penfold[3] for the inverted bremsstrahlung spectrum; it shows a broad maximum of 8.8 mb near 25.5 Mev. In contrast, the cross section[4] for $C^{12}(\gamma,p)B^{11}$ is much narrower with a peak value of 34 mb at 21.5 Mev. Although the shapes of the two cross sections differ, the integrated cross sections are the same. For C^{13} the cross section integrated over the resonance (to 30 Mev) is 55 mb Mev, while the corresponding quantity (to 25 Mev) for C^{12} is 63 mb Mev.

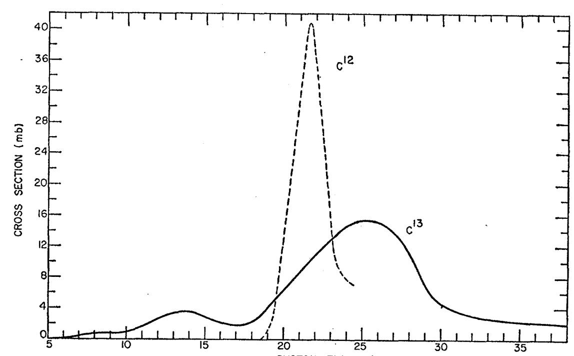

FIG. 2. The total photon absorption cross section of C^{13} and C^{12}. The latter cross section is known only from 18 to 25 Mev. An allowance for neutron multiplicity has been made.

The known $C^{13}(\gamma,xn)$ cross section (after making reasonable allowance for neutron multiplicity) can now be combined with the present results to give a good approximation to the total absorption cross section of C^{13}. This cross section (Fig. 2) exhibits peaks at 13.5 Mev and 25.5 Mev. Thus the decrease in the neutron cross section above 13.5 Mev, as anticipated, cannot be attributed to the (γ,p) competition, but represents a true decrease in the total cross section. The lower peak at 13.5 Mev has a maximum cross section of 3.7 mb and a width at half-maximum of 6 Mev, while the "giant" resonance at 25 has a maximum cross section of 17.4 mb and a width of 8.5 Mev. The integrated cross section of C^{13} from 18 to 30 Mev is 125 mb Mev as compared to 100 mb-Mev for C^{12}.

Although the integrated cross sections for the two isotopes are similar and absorption occurs mainly in the 25-Mev region in each case, the two cross sections differ drastically. Thus all their finer details (e.g., widths, etc.) appear to depend strongly upon the ground state configurations which differ in this case by only one loosely bound neutron. A report describing this work in full is in preparation and will be submitted to this Journal.

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[1] B. C. Cook and V. L. Telegdi, Bull. Am. Phys. Soc. Ser. II, **1**, 63 (1956).
[2] P. Bretonneau, Compt. rend. **236**, 913 (1953); J. V. Jelley and E. B. Paul, Proc. Cambridge Phil. Soc. **44**, 133 (1948).
[3] A. S. Penfold and J. E. Leiss, Phys. Rev. **95**, 637 (1954).
[4] J. Halpern and A. K. Mann, Phys. Rev. **83**, 370 (1951).

Neutron Cross Section of Xenon-135

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RECENTLY Bernstein *et al.*[1] have measured the total cross section of xenon-135. The total cross-section measurements were fitted to the single level Breit-Wigner formula. Since the angular momentum of the compound state could have two possible values, two sets of parameters fit the data equally well. The two sets of parameters for a ground state spin of 3/2 are the following: Set I, $J=1$, $g=\frac{3}{8}$, $E_0=0.0851\pm0.0011$ ev, $\Gamma_n{}^0=0.0305\pm0.0008$ ev, $\Gamma_\gamma=0.0828\pm0.0031$ ev; Set II, $J=2$, $g=\frac{5}{8}$, $E_0=0.0849\pm0.0010$ ev, $\Gamma_n{}^0=0.0182\pm0.0005$ ev, $\Gamma_\gamma=0.0942\pm0.0032$ ev.

In order to resolve the ambiguity, it is necessary to perform an independent measurement. Such a measurement has been made by Petruska *et al.*[2] in an experiment using the N.R.X. reactor in which they measure the relative fission product yield of Cs^{135} to Cs^{137} in a high flux and in a low flux region. The difference between the ratios measured in the two cases is attributed to the burnout of xenon-135, so that an analysis of the experiment permits the evaluation of the average xenon absorption cross section in the N.R.X. neutron spectrum. One can then calculate the average absorption cross section over the same spectrum for the two sets of parameters found by Bernstein *et al.* and so distinguish the proper set.

Using the identical procedure as Petruska *et al.* to analyze their results except to correct for the intermittent character of the sample irradiation, one arrives at the following result: $\sigma_{Xe^{135}}/\sigma_{B^{10}}=8.34\pm40$. If one assumes a Maxwellian neutron spectrum at a temperature of 57°C and a B^{10} cross section of 4000 ± 25 barns at 2200 meters/sec, the average xenon-135 absorption cross section is $(2.78\pm0.13)\times10^6$ barns.

Averaging the absorption cross section for the two sets of Breit-Wigner parameters and a 57°C Maxwillian neutron spectrum, the result for Set I is $(2.19\pm0.09)\times10^6$ barns, while for Set II the value is $(2.45\pm0.10)\times10^6$ barns. The Set II parameters appear to be the proper ones. The errors that are quoted are statistical errors and, although the absorption cross section predicted by the Set II parameters is somewhat outside the quoted error, the agreement can be considered satisfactory for this type of analysis.

There are, however, a considerable number of unknown factors in the experiment of Petruska *et al.* which could significantly influence the results. These factors are the ratio of epithermal to thermal flux, spectrum hardening, and the variation of the flux during the irradiation periods. The latter two effects would tend to reduce the difference between the absorption cross-section value derived from the experiment, and that found by averaging over Breit-Wigner parameters, while consideration of the epithermal flux would increase the difference. The estimated magnitude of these effects is such as to tend to cancel each other out so that the conclusion that Set II parameters are the proper ones is still valid.

* Operated for the U. S. Atomic Energy Commission by the General Electric Company.

[1] Bernstein, Shapiro, Stanford, Stephenson, Dial, Freed, Parker, Brossi, Herbert, and DeWitt, Phys. Rev. **102**, 823 (1956).
[2] Petruska, Melaika, and Tomlinson, Can. J. Phys. **33**, 640 (1955).