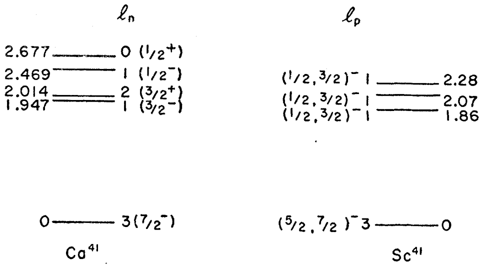

FIG. 4. Comparison of low-lying states in Sc^{41} with the more intense states of Ca^{41}.

still within the error bars indicated. If any appreciable fraction of the forward peak shown is attributable to carbon, then the interpretation as an $l_p=1$ distribution would be open to serious question.

The experimental results are summarized in Table I. Group (*a*) is assigned to the ground-state reaction $C^{12}(d,n)N^{13}$, and groups (*e*), (*f*) to the ground and first excited states of $O^{16}(d,n)F^{17}$. Groups (*b*), (*g*), (*h*), (*i*) are identified with the first four levels from $Ca^{40}(d,n)Sc^{41}$. Groups (*c*), (*d*) are very likely due to a silicon impurity, but are listed with the energies they would correspond to if they had originated in the calcium.

The level scheme of Sc^{41}, that these identifications would result in, is given in Fig. 4. This scheme is compared to the more intense low-lying states of Ca^{41} after isobaric correction. In this experiment no further attempt was made to specify the angular momentum unambiguously, so only the l_p values as determined from the respective stripping distributions are pertinent. Considering recent evidence of changes in distribution with bombarding energy, even these probably should be taken with some reservation. Nevertheless, the agreement among the low-lying levels appears to be quite reasonable.

If one considers the reaction cycle involving $Ca^{40}(d,p)Ca^{41}$ [1] and the Sc^{41}–Ca^{41} beta decay,[8] a ground-state Q value for $Ca^{40}(d,n)Sc^{41}$ of -0.60 ± 0.06 Mev would be suggested. This is in excellent agreement with the observed value of -0.57 ± 0.05 Mev. This latter value would indicate a mass difference for the Ca^{41}–Sc^{41} doublet of 5.92 ± 0.06 Mev. This may be compared with the isobaric (Coulomb and mass) correction of 6.12 Mev. The discrepancy of 0.20 Mev is quite in line with discrepancies observed in other mirror pairs.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Professor G. Breit in some phases of the analysis and of Miss E. A. McCauley in the scanning of the emulsions.

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[8] D. R. Elliot and L. D. P. King, Phys. Rev. **60**, 489 (1941).

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Resonance Fission Widths of U^{235} for Levels from 6 ev to 50 ev*

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The energy variation of the total and fission cross sections of U^{235} has been measured with the Nevis synchrocyclotron neutron velocity spectrometer. Fission widths for most of the levels up to 50 ev have been deduced from these measurements. The distribution of the 38 known fission widths shows that the number of channels available for the fission process is between one and four and is most probably two. If $\bar{\Gamma}_f$ is different for the two possible spin states of the compound nucleus, these cannot differ by more than an order of magnitude.

INTRODUCTION

THE wide variation of the fission widths of the neutron resonance levels in U^{235} has now definitely been established,[1–4] implying that the number of exit channels available for the fission process is small. The exact number of such channels, however, cannot be determined with any degree of accuracy from the available data for the following reasons: (1) The accuracy of the known fission widths is poor. (The range of the observed values of the fission widths for a particular resonance is frequently considerably larger than the stated errors of the measurements, which are fairly large in themselves). (2) The number of fission widths which have been determined is rather small. (3) The spin of the resonance level in the compound nucleus is unknown. (There are two possible spin states for the compound nucleus, and these may have

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* This work was partially supported by the U. S. Atomic Energy Commission.

[1] V. L. Sailor, *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955* (United Nations, New York, 1956), Vol. 4, p. 199.

[2] W. W. Havens, Jr., and E. Melkonian, *Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958* (United Nations, Geneva, 1958), Vol. 15, p. 99.

[3] F. J. Shore and V. L. Sailor, Phys. Rev. **112**, 191 (1958).

[4] E. Vogt, Phys. Rev. **112**, 203 (1958).

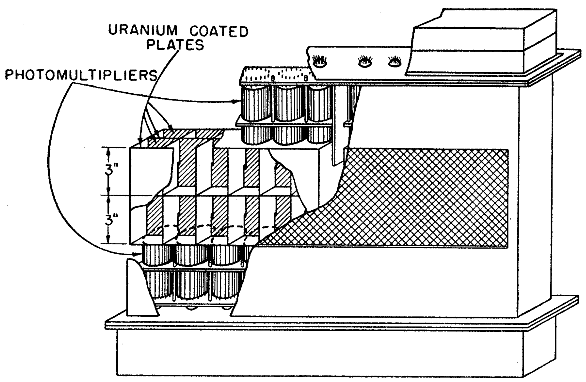

FIG. 1. Diagram of gas scintillation fission chamber.

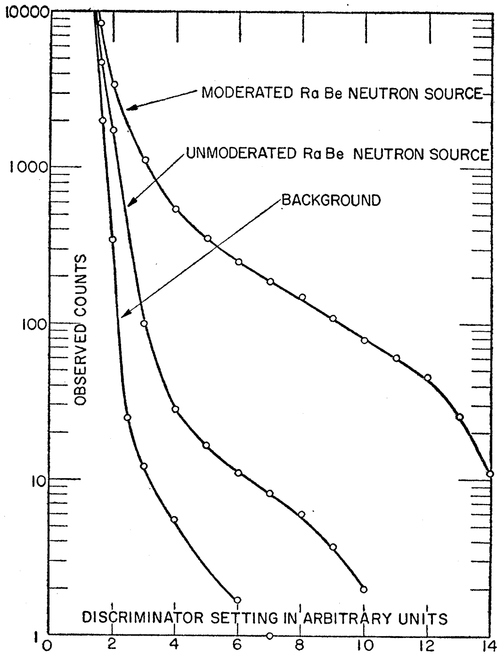

FIG. 2. Integral bias discriminator curves for gas scintillation fission detector for (1) moderated RaBe neutron source, (2) unmoderated RaBe neutron source, and (3) background (no source).

completely different average fission widths.[5,6]) These difficulties have recently been reviewed by Havens and Melkonian[2] and are well illustrated in the papers recently published by Shore and Sailor,[3] who used the many-level formulation of Reich and Moore[7] to obtain a good fit of a theoretical curve to their data. Vogt[4] also obtained a good fit to the data of Shore and Sailor using a different many-level formulation but deduced parameters which are significantly different from those of Shore and Sailor.

Because knowledge of the resonance properties of U^{235} is important to the theory of the fission process, it is desirable to have as much experimental information as possible. Consequently the Nevis synchrocyclotron neutron velocity spectrometer, because it has especially good resolution, was used to measure the total cross section and the shape of the fission cross section of U^{235} as a function of energy. Fission widths for most of the levels up to 50 ev have been deduced from these measurements.

APPARATUS

The spectrometer has been described previously.[8] The total cross-section measurements were made using a detector system in which the neutrons were absorbed in a slab of B^{10}, and the 477-kev gamma ray subsequently emitted in the $B^{10}(n,\alpha)Li^7$ reaction was detected with an NaI crystal.[9] The source detector distance for these measurements was 36.66 meters and the detector timing gates were 0.4 μsec.

The fission cross section was measured relative to of B^{10} using a U^{235} gas scintillation chamber and a thin BF_3 proportional counter. The gas scintillation fission detector is shown schematically in Fig. 1. It has an active volume 27 in. wide by 6 in. high by $1\frac{1}{4}$ in. deep which is viewed by 24 2-in. Dumont 6292 photomultipliers. Each photomultiplier tube views a front and rear "box" having front and rear surfaces (four total), each coated with approximately 0.5 mg/cm^2 of 99.7% U^{235}. In order to obtain the maximum signal from the chamber, the photomulitpliers were completely enclosed in the gas volume, electrical connections being made through a multilead kovar seal. The 24 phototubes were run from separate high-voltage supplies with divider chains and adjusting potentiometers for each tube. The background counting rate and the counting rates with neutrons from an unmoderated and a moderated $\frac{1}{2}$ g RaBe source are shown in Fig. 2 as a function of the discriminator bias. This curve shows that the bias on the gas scintillator can be set to detect fission pulses with very little α-particle background.

The fission cross-section measurements were taken with a source detector distance of 14.21 instead of the usual 35.2 meters in order to have increased intensity.

The background was determined at specific energies by placing thick silver and thick tantalum at the transmission position.

RESULTS

The results of both the transmission measurements and the fission measurements up to 65 ev are shown in Fig. 3 on the same energy scale to permit detailed comparison of the resonance structure. Both transmission and fission measurements extend to much higher

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[5] A. Bohr, *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955* (United Nations, New York, 1956), Vol. 2, p. 151.

[6] J. A. Wheeler, Physica **22**, 1103 (1956); J. A. Wheeler, Oak Ridge National Laboratory Report ORNL-2309, 1956 (unpublished), p. 165.

[7] C. W. Reich and M. S. Moore, Phys. Rev. **111**, 929 (1958).

[8] L. J. Rainwater, *Handbuch der Physik*, edited by S. Flügge (Springer-Verlag, Berlin, 1957), Vol. 40.

[9] E. R. Rae and E. M. Bowey, Proc. Phys. Soc. (London) **A66**, 1073 (1953).

energies than is shown, but the plot is only given to 65 ev because of the inability to resolve levels at higher energies.

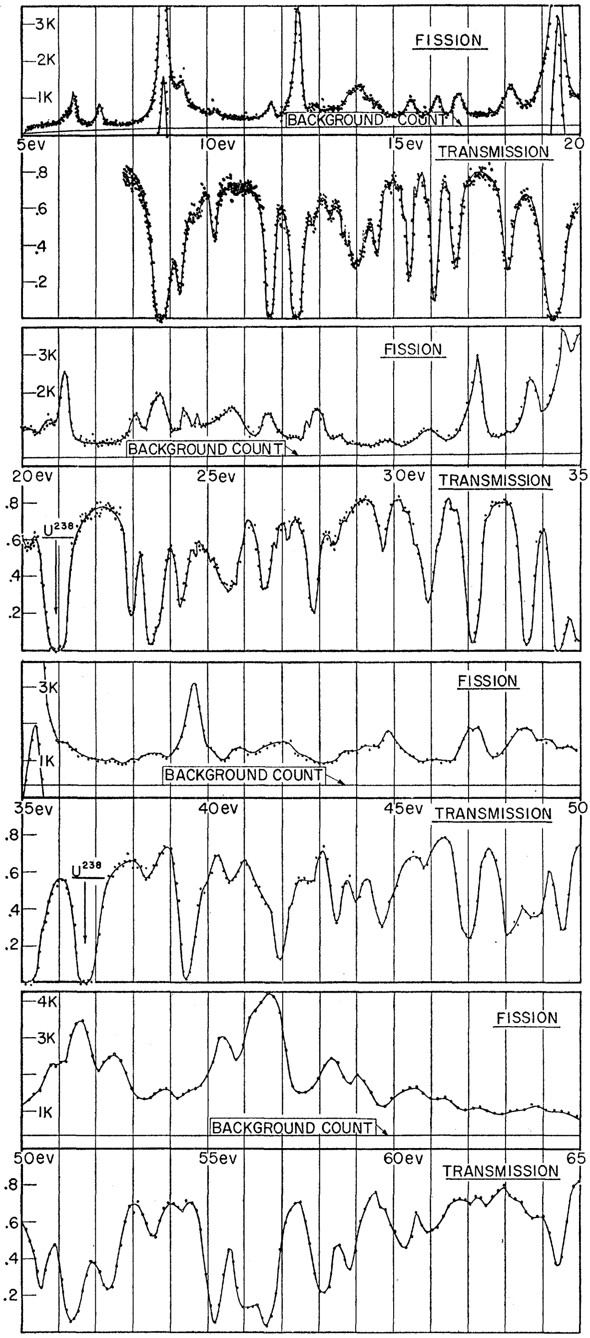

FIG. 3. Results of measurements of the transmission of 3.114 g/cm^2 of U^{235} contained in 3.757 g/cm^2 of uranium, together with the results of the measurements of the fission cross section of U^{235}. The solid curve shown in the fission results is the background to be subtracted. Another set of data of the fission measurements of equivalent statistical accuracy was also taken and used for the determination of the fission parameters. The transmission results have been corrected for the potential scattering of U^{238} assuming $\sigma_p = 11$ barns. The resonances in U^{238} are indicated.

The transmission measurements were made with a sample containing 3.757 g/cm^2 of uranium, of which 3.11 g/cm^2 was U^{235}. The transmission results have been corrected for the potential scattering of U^{238} assuming $\sigma_p = 11$ barns, so the results plotted (except for the resonances in U^{238}) are for the transmission of the U^{235}. One of the two sets of data of the observed fission counts as a function of energy is shown. The resolution of both the transmission and fission below 65 ev is limited by the time required to slow down the neutrons in the moderator and the detector thickness, and not by the time gates of the velocity spectrometer system used for these measurements.

To obtain the fission cross section from the observed counts, the background (shown by the solid straight line in Fig. 3) was first subtracted from the data. The calibrations for the effective thickness of the detector and the efficiency of the chamber were determined by comparing the areas under the resonances at 6.38, 7.10, and 8.79 ev with the results of Shore and Sailor for these resonances.[3] The internal consistency of the ratio of these areas to the areas obtained from Shore and Sailor's data under these resonances was about 10%, and the average of the three was used for normalization.

The data were examined to determine whether there was detailed agreement between the positions of the peaks observed in the fission measurements and the position of the dips observed in the transmission measurements. For the smaller levels, it was sometimes difficult to observe in the fission measurements the levels which had been seen in the transmission measurements, e.g., the 9.7-ev level. However, it was always possible to correlate a level in the transmission measurements with some structure in the fission cross-section measurements. There is a systematic shift of about one part in 300 between the positions of the fission peaks and the positions of the transmission dips. This is probably caused by a 0.2% error in the effective path length used to determine the energy scale for the fission measurements. The energy determination for the transmission measurements is much more reliable, so the positions of the levels have been determined from the transmission measurements. The positions of the observed levels, with a code letter qualitatively indicating the observed strength and therefore the significance to be attached to the result, are given in Table I.

When a curve is drawn through the experimental points to show as many levels as possible, the number of levels becomes excessively large. For example, it is possible to interpret the data to show five levels between 13.0 and 14.3 ev. Therefore, clusters of levels are indicated in Table I rather than the position of each possible level.

The transmission measurements were made with a thick sample specifically to determine the positions of the levels. Reliable values of Γ_n^0 could not be obtained from these transmission data because the sample was

TABLE I. Resonances and parameters of the levels in U^{235}, assuming $\Gamma_\gamma = 0.033$ ev.

E_0 (ev)	$(\sigma_0\Gamma_f)_1$ (ev b)	$(\sigma_0\Gamma_f)_2$ (ev b)	$\langle\sigma_0\Gamma_f\rangle_{\text{Av}}$ (ev b)	Γ_n^0 (mv)	Γ_f (mv)	Strength[a]
6.20	3.9	3.6	3.8	0.011		*VW*
6.38	11.2	8.4	9.8	0.117	6.4	*W-M*
7.09	6.9	6.4	6.6	0.041	16	*W-M*
8.79	93.3	86.1	89.7	0.430	30	*VS*
9.28	26	13	20	0.040	4.4	
9.7				0.013		*VW*
10.16	3.5	6.9	5.2	0.020		*W-M*
11.64	7.7	3.3	5.5	0.20	2.6	*S*
12.38	44.9	32.7	38.8	0.39	12	*VS*
12.85						*VW*
13.26						*VW*
13.6–14.3	not separated					*M, A*
14.53	8.5	6.4	7.4	0.040	40	*M*
15.39	6.8	6.7	6.8	0.059	18	*M*
16.07	5.5	6.4	5.9	0.084	9.2	*MS*
16.64	9.4	7.9	8.7	0.067	23	*M*
18.07	12.7	15.8	14.2	0.080	46	*M*
19.27	114	100	107	0.66	40	*VS*
20.2						*VW*
20.65	6.0	11.1	8.6	0.08	20	*W, B*
21.1	38	27	32.5	0.24	30	*B*
22.94	14	11	12.5	0.14	16	*M*
23.45						*S*
23.7	33.8	27.6	30.7	0.33	18	*M*
24.3	15.4	12.5	14.0	0.10	38	*M*
24.65						*VW*
24.9–26.0	not separated					*M, C*
26.53	21.3	14.6	18.0	0.10	82	*M*
27.15	4.5	5.1	4.8	0.021		*W*
27.82	15.4	14.5	15.0	0.14	25	*M*
28.4	4.2	4.2	4.2	0.07	11	*W*
28.7						*VW*
29.70	1.5	4.4	3.0	0.07	7.3	*W-M*
30.6						*W*
30.9	6.9	7.1	7.0	0.12	11	*M*
31.2						*W, U*
31.6						*W, U*
32.1	40.0	18.7	29.3	0.30	25	*S*
33.57	37.4	25.0	31.2	0.36	21	*S*
34.40	60.0	47.6	53.8	0.60	23	*S*
35.3	123	98	111	1.0	34	*VS*
38.4	9.4	17.5	13.5	0.026		*W*
39.5	57.5	26.2	41.9	0.40	34	*S*
39.8						*W*
40.6						*W, D*
41.5						*W*
41.9	41.5	13.8	27.6	0.35	21	*M*
42.3						*W, U*
43.45	10.7	5.0	7.9	0.15	12	*M*
44.0						*W-M*
44.7	24.9	19.4	22.2	0.27	24	*M*
45.0						*W*
45.85						*W*
47.0	29.9	16.9	23.4	0.18	72	*M, D*
48–49	not separated					

Other levels observed at

49.52	*M*	54.3	*W*	58.8	*M*	62.5	*W, U*
50.55	*M*	55.18	*S*	59.8	*W, U*	63.2	*W, U*
51.37	*S*	56.0	*M-S*	60.3	*W-M*	63.8	*W-M*
52.35	*M*	56.55	*S*	61.0	*W*	64.4	*M*
53.55	*W-M*	58.1	*M*	62.0	*W, U*		

[a] The meaning of the symbols is as follows: *VW*, very weak; *W*, weak; *M*, medium; *S*, strong; *VS*, very strong; *U*, uncertain; *A*, a multiple level structure having 3 to 5 levels; *B*, the transmission shows a strong broad dip at 20.7–21.2 ev, while the fission shows a weak level at 20.65 ev and a medium level at 21.1 ev; *C*, this structure, peaked near its center, has unresolved levels; *D*, may be two levels; *E*, many levels.

too thick. It is necessary to have consistent results on several different sample thicknesses if one is to have confidence in the results.

To analyze the results of the fission measurements, resonance level curves were drawn through the fission data points at the positions of the levels observed in the transmission measurements. For the strong levels, e.g., the 8.79-ev level, the curve to be drawn was obvious, but for the weaker levels some judicious guessing was sometimes necessary. The areas A_E under the fission resonances were measured, and the quantity $\sigma_0\Gamma_f$ was calculated from the formula[10] $\sigma_0\Gamma_f = 2A_E/\pi\eta$, where η is the number of atoms/cm^2. Two independent sets of data with about the same statistical accuracy, one of which is shown in Fig. 3, were taken and the values of $\sigma_0\Gamma_f$ determined from each set.

In some cases, it was found almost impossible to determine the area under certain resonance levels, e.g., the 9.7-ev level, which were known to exist from total cross-section measurements. A criterion was sought which would systematically eliminate small levels without biasing the results of the fission width distribution. Since the fission and neutron widths are independent of each other, the criterion used to reject small levels was based on the neutron width, and therefore the fission width distribution should not be biased. Only those levels having values of $\Gamma_n^0/E^{\frac{1}{2}}$ (proportional to the area under a level) greater than 0.009, where Γ_n^0 is in millivolts and E is in ev, were analyzed.

The above criterion alone did not eliminate all the levels for which unique areas could not be obtained. Since the cluster of levels previously reported between 13.0 and 14.3 ev and the cluster of levels between 24.9 and 26.0 ev could not be separated well enough even in the transmission measurements, parameters for these levels also are excluded from the results shown in Table I.

In addition to the usual uncertainties in measuring the areas, another source of error was introduced by the large amount of aluminum used in the structure of the fission chamber. Consequently some spurious additional fission cross section was introduced at energies immediately above resonance levels by neutrons losing energy through elastic collision with aluminum nuclei and scattering into the uranium at energies corresponding to the resonance levels. This difficulty is inherent in this particular chamber design and can be only partially alleviated by reducing the amount of aluminum. Attempts were made to correct the data for this scattering, but the correction varied so markedly from level to level that no simple method of performing this correction could be found. This effect makes it difficult to separate a small level on the high-energy side of a large level from the large level itself. This is best illustrated by examining the data on the high-energy side of the 8.79-ev level, where the level at

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[10] W. W. Havens, Jr., and T. I. Taylor, Nucleonics **6**, No. 2, 66 (1950).

9.26 ev is masked by the scattering from the 8.79-ev level. Because of this scattering effect, the criterion for eliminating small levels was set higher than would otherwise have been necessary, but the results should not be biased because of this scattering, although the uncertainty in the determination of the parameters is increased.

The quantity $\sigma_0\Gamma_f$ is the primary result of these measurements. The values of $\sigma_0\Gamma_f$ determined from each set of data, together with the average, are listed in Table I to illustrate the consistency of the results obtained. It is not, however, the quantity $\sigma_0\Gamma_f$ which is of primary interest to the theory of the fission process, but the quantity Γ_f. In order to deduce values of Γ_f from $\sigma_0\Gamma_f$, it is necessary to have values of Γ_γ and Γ_n^0 for the resonance. The value of Γ_γ for all resonances was assumed to be 33 millivolts. The values of Γ_n^0, obtained from the total cross section measurements,[11] which were used to calculate Γ_f, and the calculated values of Γ_f are also listed in Table I.

The accuracy of the fission widths cannot be determined in the usual manner because the errors are not random. The accuracy depends on such imponderables as (1) the subtraction of the background, (2) the use of the one-level approximation when interference between levels is known to be important, (3) the determination of the areas under each of two resonances which are not clearly separated, (4) the assumption of a constant $\Gamma_\gamma = 33$ mv, and (5) the accuracy of the Γ_n^0 used to determine Γ_f. The accuracy must therefore be estimated from the consistency of the parameters obtained from the two sets of data.

The consistency of the results was usually better than a factor of two; therefore, except for levels in which Γ_n^0 is small and in which Γ_f is large, a standard deviation of 30% is a reasonable error to assign. The error in Γ_f is large for the case in which Γ_f is large, because Γ_f is determined from $\sigma_0\Gamma_f$ by the formula

$$\Gamma_f = \frac{33\text{mv}}{(\sigma_0\Gamma/\sigma_0\Gamma_f - 1)}.$$

If $\Gamma_f \approx \Gamma$, then $\sigma_0\Gamma/\sigma_0\Gamma_f \approx 1$ and Γ_f becomes very sensitive to small errors in $\sigma_0\Gamma$ and $\sigma_0\Gamma_f$. Thus the large values of Γ_f are the most unreliable, which is contrary to the usual situation. In those cases where two or more levels were counted as one level in the transmission measurements, the deduced value of Γ_f will be about the same as the Γ_f for the strongest level in the cluster. This occurs because the value of $\sigma_0\Gamma$ obtained from transmission measurements would be too large for any of the individual levels in a cluster, and $\sigma_0\Gamma_f$ would also be too large. Thus, the ratio $\sigma_0\Gamma/\sigma_0\Gamma_f$ will give some unknown weighted average of the Γ_f values of the resonances in the structure.

The data given in Fig. 3 and the values of $\sigma_0\Gamma_f$ given in Table I in general agree very well with the results given by Michaudon, Genin, Joly, and Vendryes,[12] who made similar measurements using an electron linear accelerator as a pulsed neutron source and a fission ionization chamber as detector. The positions of the levels in most cases agree to one part in 500 or better with random signs for the differences. The values they deduce for Γ_f do not agree with our values of Γ_f as well as do their values for $\sigma_0\Gamma_f$ because of a different choice of Γ_n^0.

CONCLUSIONS

In order to determine the number of exit channels for fission, the number of levels with $(\Gamma_f/\bar{\Gamma}_f)^{\frac{1}{2}}$ greater than the abscissa was plotted *versus* $(\Gamma_f/\bar{\Gamma}_f)^{\frac{1}{2}}$ for the 38 observed fission widths including the Γ_f's below 6.0 ev.[3] (See Fig. 4.) Porter-Thomas[13] distribution curves normalized to the 38 observed levels for $\nu = 1$, 2, and 4 are included and indicate a best fit for $\nu = 2$.

It is interesting to note that there are no values of Γ_f between 0.046 ev and 0.072 ev as shown by the long step in the curve at $N = 7$. The levels with $\Gamma_f > 0.046$ ev, in order of increasing Γ_f, are at 47.0, 26.53, -0.02, 0.282, 1.138, 3.14, and -1.45 ev. Detailed examination of the data in Fig. 3 shows that the levels at 47.0 and

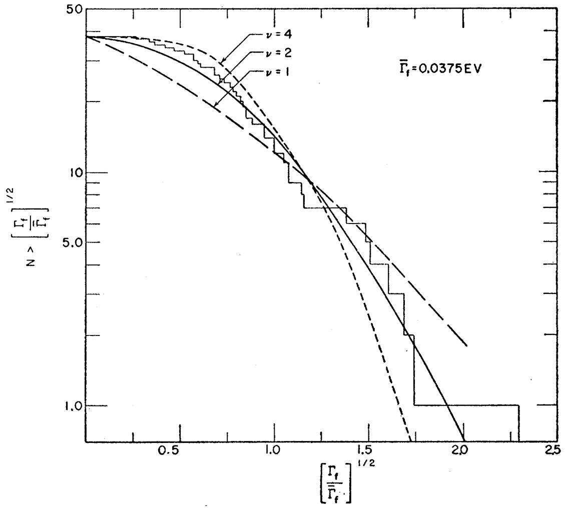

FIG. 4. A plot of the number of levels with $(\Gamma_f/\bar{\Gamma}_f)^{\frac{1}{2}}$ greater than the abscissa *versus* $(\Gamma_f/\bar{\Gamma}_f)^{\frac{1}{2}}$. The histogram gives the experimental values of $(\Gamma_f/\bar{\Gamma}_f)^{\frac{1}{2}}$. The solid curves are theoretical Porter-Thomas[13] distributions for the number of channels available for the fission process $\nu = 1$, 2, and 4.

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[11] Simpson, Fluharty, and Simpson, Phys. Rev. **103**, 971 (1956); Pilcher, Harvey, and Hughes, Phys. Rev. **103**, 1342 (1956); D. J. Hughes, *Neutron Cross Sections* (Pergamon Press, New York, 1957); W. W. Havens, Jr., and E. Melkonian, *Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958* (United Nations, Geneva, 1958), Vol. 15, p. 99.

[12] Michaudon, Genin, Joly, and Vendryes, Report Commissariat al'Energre Atominique No. 1093, Nuclear Studies Center, Saclay, France (unpublished).

[13] C. E. Porter and R. G. Thomas, Phys. Rev. **104**, 483 (1956).

26.5 ev are somewhat broader than the neighboring levels, which are believed to be single. For large Γ_f the value of this parameter is particularly unreliable and this, taken together with the suspicion that these levels may be multiple, shows that limited accuracy should be attached to the absolute values given for these fission widths other than that they are greater than Γ_γ. The five remaining levels with large fission widths have resonance energies below 3.2 ev.

The fact that the fission widths of these low-lying levels are large, together with the fact that the strength function for the first ten levels in U^{235} is about $\frac{1}{10}$th the strength function determined by other methods, might be taken as evidence for the existence of two different values of $\bar{\Gamma}_n^0$ and $\bar{\Gamma}_f$ associated with the states having $J=3$ and $J=4$. If the two spin states have different average parameters, then the number of levels belonging to each group would be expected to be proportional to $(2J+1)$, which is quite different from the 31 levels in one group and 4 to 7 levels in the other group. An improvement in fit to the curve shown in Fig. 4 cannot be obtained by assuming $\nu=2$ and two different $\bar{\Gamma}_f$'s for the two spin states. Allowing both $\bar{\Gamma}_f$ and ν to be different for the two spin states can lead to an improved fit. However, considering the limited accuracy of the Γ_f's, a four-parameter fit to the data is not considered significant.

It is not possible to determine the number of fission channels available for the fission process or to determine whether the average value of Γ_f is different for the two different spin states. However, we can conclude either (a) that the average value of the fission width for either spin state is not an order of magnitude different from the observed average value of the fission width or (b) that the observed resonances are all due to one spin state.

If we assume that all the levels observed are caused by one spin state and that the other spin state has an average fission width large enough for the levels to overlap appreciably, then the optical model of the nucleus can be used to calculate the absorption cross section for the spin state with the larger $\bar{\Gamma}_f$. The strength function to be used for U^{235} has been determined by several investigators[11] and by several different methods, and it is found to be $(1.0\pm0.2)\times10^{-4}$. This value also agrees with the strength functions for neighboring nuclei. The predicted average absorption cross section for the spin state with the larger $\bar{\Gamma}_f$ is $\sigma_A=179/\sqrt{E}$, assuming $g=7/16$ the lower possible value. Thus, the absorption cross section between resonances would have to be at least this large. Since the observed cross section between levels is considerably less than the predicted absorption cross section, the assumption of a $\bar{\Gamma}_f$ for one spin state large enough for the levels to overlap is ruled out.

Suppose, on the other hand, that the average fission width for the spin state not responsible for the observed resonances is 4 mv. In this case there should be some resonances which are observed in the total cross section which would not be observed in the fission cross section, namely, those resonances which have a very small Γ_n^0 and also a small Γ_f. However, in every case where a level has been observed in the total cross section, some structure has been observed in the fission cross section. We can, therefore, conclude that the $\bar{\Gamma}_f$ of the spin state not responsible for the observed levels cannot be an order of magnitude smaller than the observed average fission width.

If the average value of α is defined as $\bar{\sigma}_\gamma/\bar{\sigma}_f$ over a region, this should be approximately $\bar{\Gamma}_\gamma/\bar{\Gamma}_f\approx1$ from these measurements. The average value of α is expected to be fairly constant up to several kev, where p levels become important. However, the average value of α determined by boron filter measurements using a broad neutron spectrum is 0.5 at both 100 and 1000 ev.[14] There is no apparent reason for this discrepancy, which indicates either that the assumptions on which the determination of an average value of α is based are not correct or that there is some process occurring in low-energy neutron fission resonances which is not understood.

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[14] Kanne, Stewart, and White, *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955* (United Nations, New York, 1956), Vol. 4, p. 315.