ELECTROFISSION OF ^{235}U IN ENERGY RANGE 10–34 MeV

BY E. MARIAŃSKA, I. ŚLEDZIŃSKA AND W. ZYCH

Institute of Physics, Warsaw Technical University*

(Received March 6, 1981)

Experimental results are presented for the electrofission cross section of ^{235}U in the energy range 10–34 MeV. An analysis of the data has been performed using the concept of virtual photons.

PACS numbers: 25.85.Ge

Contrary to photofission reaction on ^{235}U which was investigated by several authors [1–4], there are no data on the electro-induced fission for this nucleus.

Electro-induced reaction, apart from the simpler experimental procedure, seems to be more useful for the analysis of the contribution of various multipoles to the reaction mechanism than the photo-induced reaction [5–7].

The measurements of the ^{235}U(e, e′f) reaction cross section have been performed with the electron beam of the 35 MeV betatron at the Institute for Nuclear Research in Świerk. The energy calibration was done with an accuracy of 2%. Mica detector target sandwiches were used to register the fission fragments in 2π geometry. The targets of ^{235}U — 350 μg/cm^2 and ^{238}U — 250 μg/cm^2 were used. The absolute values of the reaction cross section have been established using the known ^{238}U (e, e′f) cross sections [8]. The measured cross sections for ^{235}U(e, e′f) reaction are shown in Fig. 1. Only the statistical errors, not exceeding 4% in most cases, are plotted. The systematic error including the target thickness determination and the ^{238}U (e, e′f) cross section errors is 13%. More experimental details can be found in our earlier publication [7].

Results of our measurements have been analysed using the virtual photon formalism. The electro-induced fission cross section $\sigma_e(E_0)$ can be expressed as:

$$\sigma_e(E_0) = \sum_{\lambda L} \int_0^{E_0} \sigma_{\gamma,f}^{\lambda L}(E) N^{\lambda L}(E, E_0) \frac{dE}{E}, \tag{1}$$

* Address: Instytut Fizyki, Politechnika Warszawska, Koszykowa 75, 00-662 Warszawa, Poland.

where λ and L are the mode and the multipolarity of virtual photons, E_0 and E are the electron and photon energies, respectively, $\sigma_{\gamma,f}^{\lambda L}$ is the partial photofission cross section, $N^{\lambda L}(E, E_0)$ is the virtual photon spectrum, the same as was used in our previous paper [7]. It has been obtained and kindly sent to us by Profs. D. S. Onley and L. E. Wright. For the method of the calculation of the spectrum cf. Ref. [9]. The photofission cross section has been calculated as:

$$\sigma_{\gamma,f}^{\lambda L}(E) = \sigma_{\gamma}^{\lambda L}(E) P_f(E), \tag{2}$$

where $\sigma_{\gamma}^{\lambda L}$ is the photon absorption cross section and P_f is the fission probability calculated in the same way as in [7], with the neutron binding energy and fission barier values taken

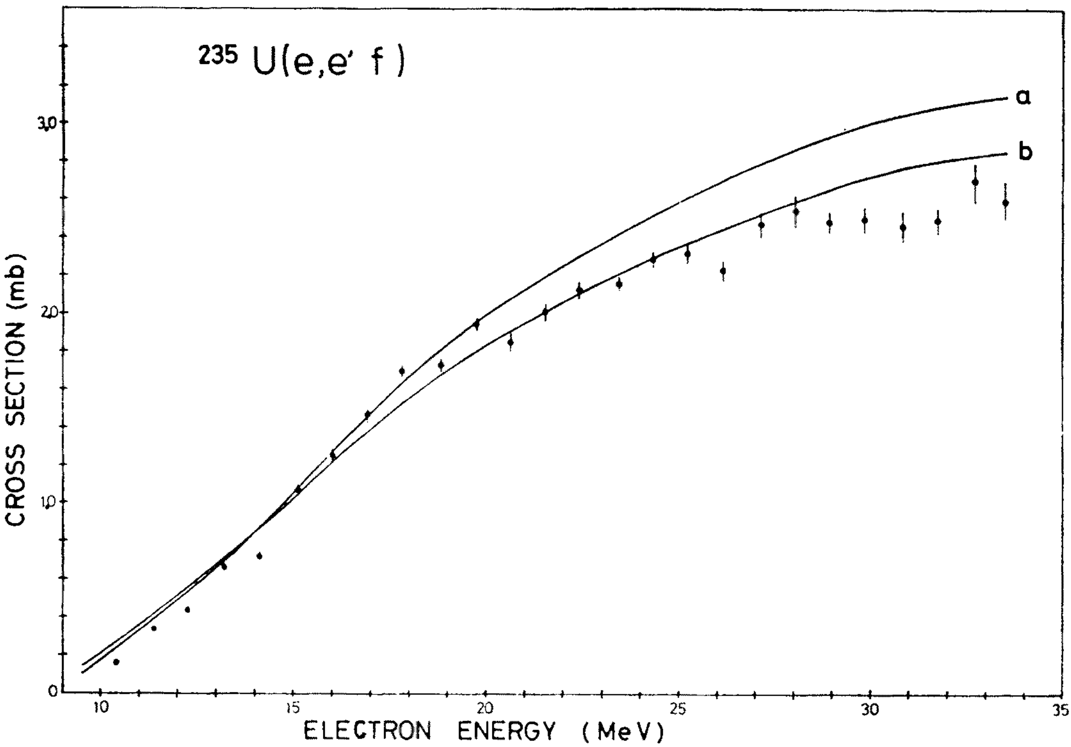

Fig. 1. Electrofission cross section for ^{235}U versus electron energy. The solid circles represent experimental results. Curves a and b show the cross sections for E1 mode calculated with the Lorentz-lines parameters of Caldwell [2] and Gurevich [3], respectively

from Refs. [10] and [11], respectively. The photoabsorption cross section has been taken in the analytical form as the sum of the two Lorentz curves. The results of our calculations, shown in Fig. 1, take into account only the electric dipole mode of the virtual photon spectrum. The calculations have been performed for two sets of parameters defining the photoabsorption cross sections. These parameters are given in Table I. Curve a in Fig. 1 corresponds to the parameters of Caldwell [2] and curve b to those of Gurevich [3].

As can be seen in Fig. 1, the curve *a* lies above the experimental points for the electron energy larger than 20 MeV. This may be due to the improper virtual photon spectrum or/and to the improper photofission cross sections taken in the calculations. The right results for the electrofission cross section for ^{237}Np obtained with the same virtual photon spectrum, suggest, however, the latter possibility, i.e. the improper photofission cross sections. In accordance with Eq. (2), the photofission cross section is a product of the photoabsorption cross section $\sigma_\gamma^{\lambda L}$ and the fission probability P_f. Because, as it was checked by us, the calculated electrofission cross sections are not very sensitive to the values P_f, the reason of the mentioned disagreement is expected to be in too large values of the photoabsorption cross section taken from Ref. [2].

TABLE 1

Parameters of the Lorentz-curve fits to the giant dipole resonance taken from Refs. [2] and [3]

E_1(MeV)	σ_1(mb)	Γ_1(MeV)	E_2(MeV)	σ_2(mb)	Γ_2(MeV)	Ref.
10.90±0.05	328±19	2.30±0.15	13.96±0.09	459±10	4.75±0.32	[2]
10.74±0.20	284±43	3.43±0.70	13.77±0.26	342±41	4.82±0.64	[3]

The curve *b* fits reasonably well to the experimental data up to the electron energy of about 28 MeV, but this fact cannot be an argument for the absence of the contribution of the multipolarity higher than one (dipole) to the electrofission reaction on ^{235}U. The statistical errors in the determination of Gurevich's parameters, taken to the calculation of the curve *b*, result in a 29% discrepancy in the electrofission cross section at 30 MeV electron energy. That is more than the contribution of the quadrupole mode in ^{237}Np, which amounts to about 22% at the same electron energy. For these reasons, it is impossible to draw a quantitative conclusion on the contribution of the electric quadrupole admixture into the electrofission of ^{235}U. We expect that the analysis of the angular distributions for this reaction, which is in preparation now, will allow us to obtain more information on the problem.

We would like to thank Profs. D. S. Onley and L. E. Wright for kindly supplying us with the calculated virtual photon spectra. We also wish to express our sincere gratitude to Dr J. Kiełsznia and the INR betatron staff for their able operation of the betatron, and to Dr hab. M. Jaskóła for the help in the target-thickness measurements.

REFERENCES

[1] C. D. Bowman, G. F Auchampaugh, S. C. Fultz, *Phys. Rev.* **B133**, 676 (1974).
[2] J. T. Caldwell, E. J. Dowdy, B. L Berman, *Phys. Rev.* **C21**, 1215 (1980).
[3] G. M. Gurevich, L. E. Lazareva, V. M. Mazur, G. V. Solodukhov, B. A. Tulupov, *Nucl. Phys.* **A273**, 326 (1976).
[4] K. J. Ivanov, Ju A. Solovyev, K. A. Petrzak, *JETP Lett.* **17**, 610 (1973).
[5] A. C. Shotter, D. Branford, J. C. Mc George, J M Reid, *Nucl. Phys* **A290**, 55 (1977).

[6] U. Kneissl, G. Kuhl, K. M. Leister, A. Weller, *Nucl. Phys* **A256**, 11 (1976).
[7] E. Mariańska, I. Śledzińska, W. Zych, *Acta Phys. Pol.* **B11**, 691 (1980).
[8] J. Aschenbach, Ph. D. Thesis II, Phys. Institut der Universität Giessen, 1978.
[9] C. W. Soto Vargas, D. S. Onley, L. E. Wright, *Nucl. Phys.* **A288**, 45 (1977).
[10] K. A. Keller, J. Lange, H. Munzel, *Landolt-Bornstein*, gr. I, Vol. 5a, 1973.
[11] B. B. Back, H. C. Britt, O. Hansen, B. Leroux, *Phys. Rev.* **C10**, 1948 (1974).