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# RADIATIVE CAPTURE OF FAST NEUTRONS BY THE $^{238}U$ NUCLEUS

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evaluated by himself and, above it, the capture cross-sections for gold as measured absolutely by him in the same study.

In the variant of the evaluation presented in the paper, the selected experimental data of the different authors are regarded as one set of points. Fitted curves were drawn through this set of points by the method of rational fractional approximation (Pade approximation) described in Ref. [12]. The functional dependence $\sigma(E)$ then takes the form:

$$\sigma(E) = \frac{P_N(E)}{Q_N(E)} \equiv const + \frac{\mathcal{P}_{N-1}(E)}{Q_N(E)} \equiv$$
$$\equiv C + \sum_{i=1}^{\ell_1} \frac{a_i}{E_i^{(o)} - E} + \sum_{K=1}^{\ell_2} \frac{\alpha_K + \beta_K (E - E_K^{(o)})}{(E - E_K^{(o)})^2 + \Gamma_K^2/4} , \tag{1}$$

where $\mathcal{P}_n$, $P_n$, $Q_n$ are polynomials of power N; $\ell_1 + 2\ell_2 = N$, and $E_i^{(o)}$ and $E_k^{(o)} \pm i\frac{\Gamma k}{2}$ are, respectively, the real and complex roots of polynomial $Q_N(E)$. The parameters a, $\alpha$, $\beta$, $E^{(o)}$ and C are chosen from the condition of minimization of the relative root-mean-square deviation of curve $\sigma(E)$ from all $N_{exp}$ experimental points used, i.e. minimum value

$$\Delta^{exp} = \sqrt{\sum_{i=1}^{N_{exp}} \frac{(\sigma(E_i) - \sigma_{exp}(E_i))^2}{\sigma_{exp}^2(E_i)} \Big/ N_{exp}} \tag{2}$$

which in itself represents the "average spread". For the qualitative characteristics of reconstructing the energy dependence of the cross-section - $\sigma(E)$ - we used another value $\Delta^{re}$ which was calculated in the following manner. The optimum $\sigma(E)$ curve chosen from the minimum $\Delta^{exp}$ was subjected to "pseudo measurements", in each of which to the value of $\sigma(E_i)$ we added random numbers from the Gaussian distribution with a dispersion corresponding to $\Delta^{exp}$ and having an average value of zero, and obtained $\sigma'_{exp}(E_i)$. The sets of cross-sections thus obtained were treated by the same algorithm as the initial set of experimental data, i.e. by minimizing expression (1) with replacement of $\sigma_{exp}(E_i)$ by $\sigma'_{exp}(E_i)$. The values of $\Delta^{re}$ were then calculated in accordance with expression (2) by substituting $\sigma'(E_i)$ for $\sigma(E_i)$, which were averaged additionally over many "pseudo measurements". In this way we determined the root-mean-square deviation of the reconstructed curves from the optimum curve. If the true cross-section is an analytical function and the measurement errors for different energies are independent (uncorrelated), $\bar{\Delta}^{re}$ gives the deviation of this curve from the true one. Because of approximate fulfilment of the two above-mentioned conditions, $\bar{\Delta}^{re}$ is only the lower estimate of this deviation (for the influence of correlations of errors on the evaluation of errors, see, for example, Ref. [13]). As a rule $\Delta^{exp}$ is always noticeably higher than $\bar{\Delta}^{re}$ (see Table 1).

In the actual fitting process, we divided the whole energy region into three intervals - 1-190, 97-530 and 390-7600 keV. Table 1 gives the quantitative approximation results obtained for these intervals, and in Fig. 1 the $\sigma(E)^{238}U$ curve for the optimum variant of fit is compared with Sowerby's evaluation [11] and with experimental data.

Table I

| Interval | 1-190 keV | 97-530 keV | 0.39-7.6 MeV |
|---|---|---|---|
| $\Delta^{exp}$ | 6.6% | 6.4% | 8.2% |
| $\bar{\Delta}^{re}$ | 3.5% | 2.3% | 7.0% |
| $\Delta^{pseu.exp}$ | 7.0% | 6.5% | 9.7% |
| Number of pseudo experiments | 25 | 34 | 49 |

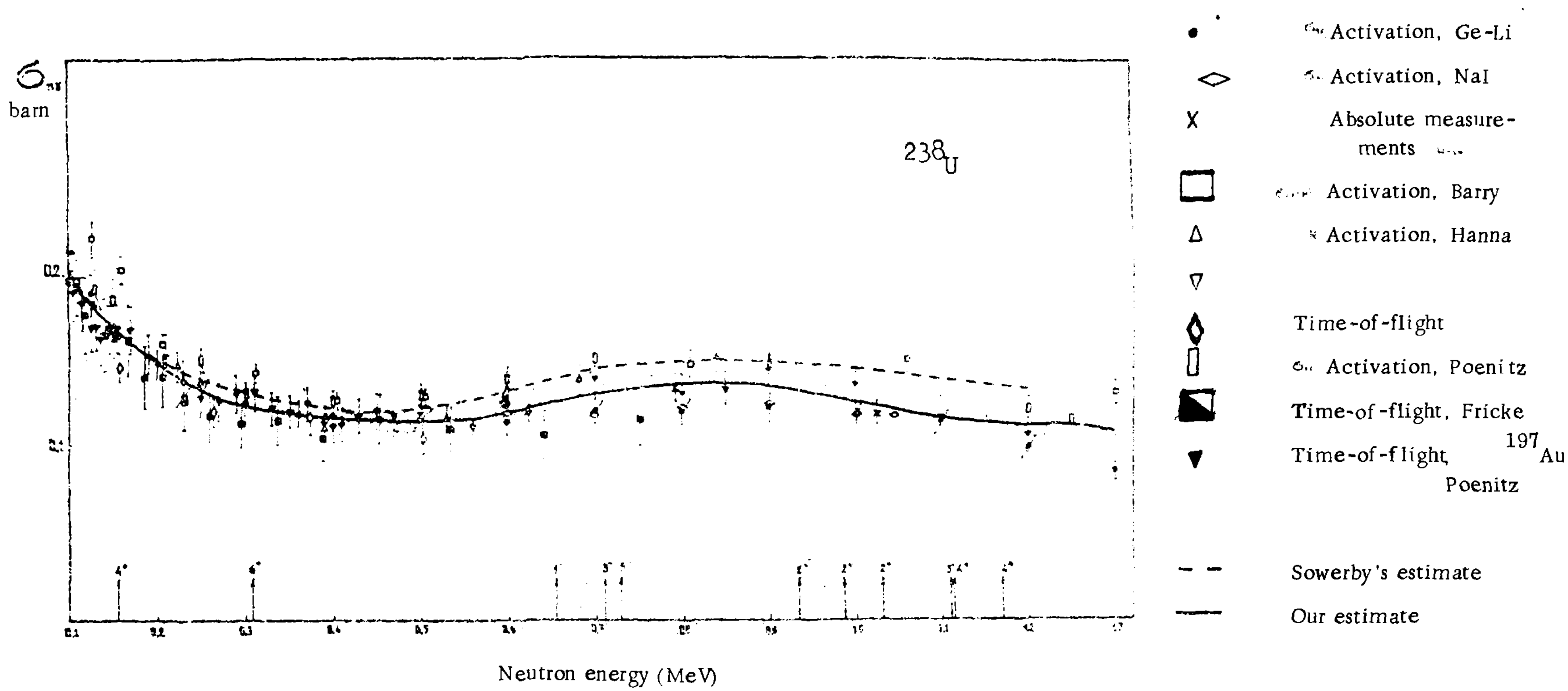


__Fig. 1__ The experimental data on $\sigma_{n,\gamma}$ $^{238}U$ used for the 0.1-1.3 MeV region and a comparison of these data with the evaluation of Sowerby [11] and that performed in the present work*/

*/ Translator's note: Some words occurring in the Figure are illegible and have not been translated.

REFERENCES

[1] PANITKIN, Yu.G., TOLSTIKOV, V.A., STAVISSKIJ, Yu.Ya., Materialy Vsesoyuznogo Soveshchaniya po nejtronnoj fizike (Proceedings of the All-Union Conference on Neutron Physics), part I, Naukova Dumka, Kiev (1972) 321.

[2] TOLSTIKOV, V.A. ABRAMOV, A.I., Soobshchenie vo vremya tematicheskoj diskussii na 2 - m Soveshchanii MKYaD v BNL (Communication presented during a discussion period at the second meeting of the International Nuclear Data Committee held at BNL (1968)).

[3] DAVLETSHIN, A.N., TIPUNKOV, A.O., TOLSTIKOV, V.A., "Secheniya radiatsionnogo zakhvata nejtronov s ehnergiej 0.6-1 MeV yadrom $^{238}U$" (Cross-sections of radiative capture of 0.6-1 MeV neutrons by the $^{238}U$ nucleus). Paper presented at the second INDC meeting.

4. J.F.Barry, J.Bunce, P.H.White. J.Nucl. Energy. A/B, 18, 461 (1964).

5. R.C.Hanna, B.Rose, J.Nucl. Energy, 8, p.197 (1959).

6. T.B.Ryves, J.B.Hunt, J.C.Robertson. Journ. Nucl. Energy, 27, p. 519 (1973).

7. H.O.Wenlove, W.P.Poenitz. Nucl.Sci.Eng. 33, p. 24 (1968).

8. W.P.Poenitz. Nucl.Sci. Eng. 40, p. 283 (1970).

9. M.P.Fricke et al. Nucl. Data for Reactors, vol. II, p.265, Vienna, IAEA, 1970.

10. W.P.Poenitz. "Neutron Capture Cross Section Measurements of $Au^{197}$ and $U^{238}$ from 20 ÷ 3500 keV" INDC meeting held in Australia, 1974.

11. M.G.Sowerby, B.H.Patrick, D.S.Wather, AERE-R7273, Harwell, 1973.

[12] VINOGRADOV, V.N., GAJ, E.V., RABOTNOV, N.S., Preprint FEhI-484, Obninsk (1974).

[13] USACHEV, L.N., Preprint FEhI-537, Obninsk (1974).