6.5. A check of the existence of the ternary fission of ^{235}U induced by thermal neutrons

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An investigation of the ternary fission of ^{235}U has been carried out with nuclear emulsions and solid state track detectors sensitive to particles of $A > 4$ and $A > 16$. The uranium target was homogeneously distributed throughout the emulsion, or vacuum evaporated on the two foils of the solid state detector (polycarbonate). In the solid state detector, the following three types of events have been found:

a) events with two collinear tracks (binary fission),
b) events with two tracks making an angle less than 180° and
c) events with three tracks.

Events b) and c) may be accidental (T^-), due to coincidence of binary events, and T^+, which represent cases of binary fission fragments scattering on target and detector nuclei, or ternary fission.

A computer program has been devised to calculate all elements of T^+ events and to discriminate cases of scattering from the ternary fission. On the basis of this a comparison is made of the results obtained by means of the two detectors. The yield of ternary fission relative to binary fission is determined.

6.6. Activation measurements of fast neutron radiative capture

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The existing differences in fast neutron capture cross sections obtained by the activation[1,2] and integration methods[3,4] are presently the subject of considerable interest. In principle, σ_{int} should be smaller than σ_{act}, since the former quantity measures only the decay to the bound states of the final nucleus (target + neutron), i. e. the prompt gamma spectra, while the latter includes the decays to the bound and the unbound states. However, this difference should not be too large, since the decay to the unbound states leads normally to the emission of particles and gamma rays compete favourably with particle emission only in the region just around the binding energy where the available neutron energy might be too small to overcome the centripetal barrier.

As the present experimental evidence shows (Fig. 1), the integration cross sections follow a smooth path. The activation cross sections vary considerably as a function of A, but also σ_{act} measured by different authors yield results which differ by more than a factor of two (see, e. g. the case of ^{127}I in the Table).

For all these reasons and unanswered questions our group in Zagreb started a systematic survey of 14 MeV (n, γ) reactions by the activation method. A standard Ge(Li) detector of 20 cm^3 active volume in connection with a 256-channel analyser was used. At the beginning we measured (n, γ) cross sections on ^{23}Na, ^{27}Al, ^{37}Cl, ^{55}Mn, ^{41}K and ^{127}I. For ^{37}Cl it is the first measurement of σ_{act} around 14 MeV.

The results are shown in the Table. The reactions $^{56}Fe(n, p)$, $^{27}Al(n, p)$ and $^{27}Al(n, \alpha)$ were used as monitoring reactions. Corrections were made for nonpoint geometry. We also used samples, such as $FeCl_3 \times 6H_2O$, where both the reaction in question and the monitoring reaction were simultaneously induced. This, then, eliminated geometrical corrections.

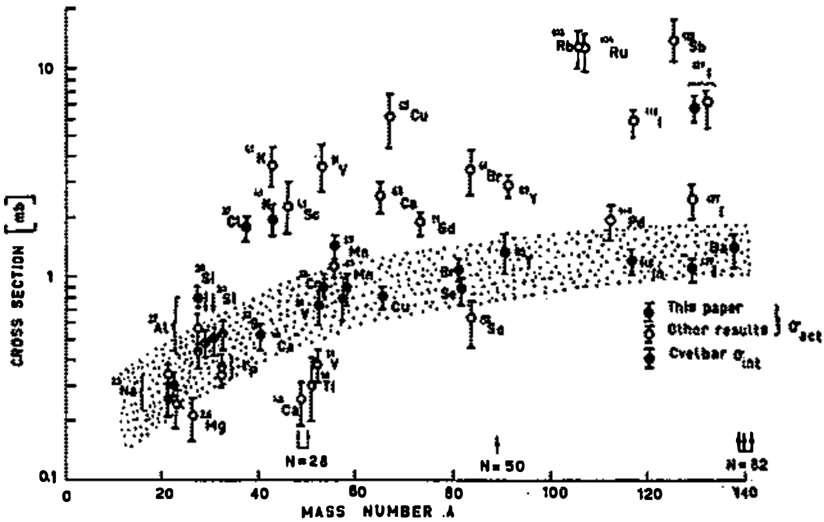

Fig. 1.

The obtained results show a difference in behaviour of σ_{act} and σ_{int} by varying the number A. σ_{act} appears to be always larger than σ_{int}. This difference is small around the closed neutron shells, but the difference between the closed neutron shells could be as large as an order of magnitude.

TABLE

Isotope	Sample	Activation cross section this paper (mb)	Activation cross section others (mb)	Ref.
^{23}Na	NaCl	0.25±0.04	0.24±0.06 0.33±0.03	1) 7)
^{27}Al	Al natural	0.8±0.1	0.56±0.10	1)
^{37}Cl	NaCl $FeCl_3 \times 6H_2O$	1.8±0.2		
^{55}Mn	MnO_2	1.4±0.2	1.2 ±0.3 0.76±0.08	1) 7)
^{41}K	KIO_3	2.0±0.3	3.5±0.7	7)
^{127}I	KIO_3	7.0±0.5	7.2±1.2 2.5±0.5	6) 7)

A possible explanation is that activation measurements are influenced by the presence of ~1 MeV neutrons produced by the (n, 2n) reaction in the target. Preliminary calculations[5], made for holmium indicate that up to 25% of the measured activation could be accounted for by this interpretation. It is not likely that reactions of the type (n, nX) could explain the rest of the order of magnitude difference between σ_{act} and σ_{int}.

Our results thus present the beginning of a systematic measurement of 14 MeV (n, γ) cross sections by the activation method with the double aim to reduce the scattering of various experimental results and to look for the systematic differences with σ_{int}. So far the results in the $d_{3/2} - f_{7/2}$ region have confirmed the earlier prediction in the sense that σ_{act} is consistently larger than σ_{int}.

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6.7. Isomeric cross section ratios for (n, p) reactions induced by 14.6 MeV neutrons in Te isotopes

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Introduction. Measurement of the ratio of the yield of isomeric pairs as a function of energy is a useful tool for the investigation of the mechanisms of the nuclear reactions. Huizenga and Vandenboch[1] have developed a method for calculating the theoretical isomeric ratio in (x, n) reactions on the basis of the statistical theory.

Although the isomerism in isotopes of tellurium is well established, the available data on the yield ratio for the isomeric pair formation of tellurium isotopes is surprisingly small, particularly for the 14—15 MeV neutrons. In this work we have measured the (n, p) cross sections for the metastable and ground states of all unstable tellurium isotopes. The choice was, moreover, influenced by the desire to investigate further the effect known from the works of Ľevkovski[2,3], Gardner[4] and others[5,6,7,8]. This effect consists in a regular decrease of the (n, p) cross sections of isotopes of the same element with the increase of the mass number.

Experimental. Natural tellurium was used in the form of chemically pure and specpure powders. Enriched $^{120,122,124,126,128,130}Te$ used in the work were obtained from the Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Irradiations were performed at 14.6 ± 0.2 MeV with neutrons obtained from the $^{2}H + {}^{3}H$ reaction using 200 keV Cockcroft-Walton generator of the Institute »Ruđer Bošković«. The neutron flux was about 2×10^{9}n/sec, and the total neutron yield was monitored by the associated α-particles. The duration of irradiation time was varied from several minutes to several hours depending on the half-live of the products. Gamma-ray spectra were measured using 25 cm^3 Ge(Li) detector coupled to the 400-channels analyser.