NEUTRONS OF TERNARY FISSION OF ^{252}Cf AND THE PROBLEM OF OBSERVING ^{5}He

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A time-of-flight spectrometer was used to measure the spectra of the neutrons of ternary fission of ^{252}Cf at angles 0, 90, and 180° to the emission direction of the long-range α particle. A difference was found between the spectra at 0° and 180°, and can be interpreted as a group of neutrons from the decay of ^{5}He. The neutron spectrum at 90° indicates that the mechanisms in binary and ternary fission of ^{252}Cf are identical.

Intensive research aimed at determining the nature of the long-range particles accompanying ternary fission of nuclei has been going on recently. Some information on this question can be obtained by studying the spectra of the fission neutrons in correlation with the emission of a long-range particle. The work performed in this direction to date consists of two measurements of the spectra of the neutrons of spontaneous ternary fission of ^{252}Cf [1, 2] and one study of the fission of ^{235}U by thermal neutrons [3]. However, the studies of the ^{252}Cf fission were performed with poor angular resolution; this, first, excluded from consideration the group of highest-energy evaporation neutrons from the fragments and, second, could smear out the effects connected with the emission of neutrons moving in the α-particle direction and genetically connected with this particle. This, however, did not prevent the authors of [2] from observing a difference between the spectra of the neutrons moving with and against the direction of the α particle, and to attribute the neutrons to the decay of ^{5}He into ^{4}He and n^{0}. To avoid the shortcomings indicated above and to obtain additional information, we measured the spectra of the neutrons from ternary-fission ^{252}Cf at angles 0, 90, and 180° to the emission direction of the long-range α particle.

The measurements were performed with the same setup as in [1]. A ^{252}Cf source of intensity 10^{6} neut/sec on a platinum substrate was placed in a vacuum chamber 27 mm away from the semiconductor-particle detector measuring 20 × 20 mm. The detector was covered with aluminum foil 8 mg/cm thick to exclude the count of the fragments and 6.11 MeV α particles from the α decay of ^{252}Cf. The neutrons were registered with a plastic scintillator of 150 mm diameter and 150 thickness. The signals from the semiconductor detector and from the neutron counter were fed to the "start" and "stop" inputs, respectively, of a time-amplitude converter. The spectrum was recorded with an AI-256 analyzer. We registered altogether 5.2×10^{4} neutrons.

The neutron spectra referred to the same number of α particles are shown in Fig. 1, which contains also the (0 - 180°) difference spectrum. Attention is called to the fact that the difference spectrum lies at higher energies than the mean values of the neutron energies, and its mean energy is $\bar{E}_{diff} = 4.6 \pm 0.2$ MeV. If this

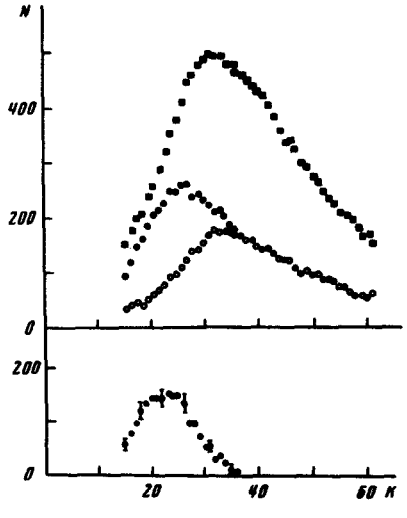

Fig. 1. Time-of-flight spectra of neutrons at angles 0° (dark circles), 90° (squares), and 180° (light circles). Below - (0 - 180°) difference spectrum. Value of each analyzer channel Δt = 1.42 nsec.

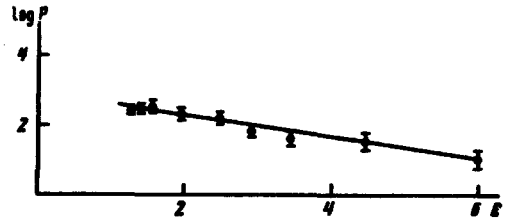

Fig. 2. Spectrum of neutrons at 90°, in the form $\log(N/\sqrt{E}) = f(E)$, where N is the number of neutrons and E is the neutron energy.

group of neutrons is produced by decay of ^{5}He into ^{4}He and n^0, then it is easy to show that the average energy of the decaying ^{5}He is equal to 7.9 ± 0.5 MeV. The disparity with the data of [2] can be attributed to geometric factors. The fact that the lifetime of ^{5}He is quite small ($\sim 8 \times 10^{-22}$ sec) gives grounds for hoping that in processes of this kind it can be used as a "clock" of sorts for the investigation of the pecularities of processes occurring in ternary fission.

The neutron spectrum at 90° agrees well with a Maxwellian spectrum with mean energy $\bar{E}$ = 1.96 ± 0.08 MeV (Fig. 2). This indicates that the ternary-fission process is similar in many respects to binary fission, and in a plane perpendicular to the α-particle emission direction the difference between the neutron spectra lies only in the difference between the mean energies. For binary fission, $\bar{E}$ = 2.1 ± 0.8 MeV [1]. We have thus confirmed the fact that in ternary fission of ^{252}Cf there exists a group of neutrons that is genetically connected with emission of a third particle, which can be regarded as ^{5}He decaying into ^{4}He and n^0 in a time $\sim 8 \times 10^{-22}$ sec during the course of acceleration in the Coulomb field of the fragments.

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[1] A.P. Graevskii, B.A. Bochagov, and L.N. Kupriyanova, ZhETF Pis. Red. 15, 572 (1972) [JETP Lett. 15, 407 (1972)].
[2] Z. Fruenkel et al., Phys. Rev. Lett. 29, 805 (1972).
[3] V.I. Nefedov et al., Yad. Fiz. 3, 465 (1966) [Sov. J. Nuc. Phys. 3, 337 (1966)].

PARAMAGNETIC RESONANCE OF MIXED TRIADS OF CHROMIUM AND IRON

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The parametric resonance of three-nucleus clusters of the type $[Me_3O(CH_3COO)_6(H_2O)]NO_3CH_3COOH$, where Me = Cr_2Fe (A) or $CrFe_2$ (B) was investigated. It is shown that the exchange integral $J_{Cr-Fe} > J_{Cr-Cr}$ in the triad Cr-Cr-Fe and $J_{Cr-Fe} < J_{Fe-Fe}$ in the triad Cr-Fe-Fe.

One of the pressing problems in the physics of magnetic phenomena is the study of the simplest systems capable of simulating to a certain degree the phenomena of anti- and ferromagnetism. Among various systems of this kind, undoubted interest attaches to mixed triads of Cr^{3+} and Fe^{3+}, which are produced in joint synthesis of isostructural acetates of chromium and iron [1, 2], and which can be described by the formula

$$[Me_3O(CH_3COO)_6(H_2O)_3]NO_3 \cdot CH_3COOH, \quad (1)$$

where Me_3 = Cr_2Fe (A) and $CrFe_2$ (B). The complicated extended EPR spectrum of