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FINE STRUCTURE OF NUCLEAR MASSES OCCURRING IN α DECAY

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WE observed that the energy of successive α decays in nuclei with odd A > 230 satisfies, within the limits of experimental errors, the following relation:

$$Q_\alpha(A+4i,\quad Z+2i) = Q_\alpha(A,\ Z) + i\xi + m\varepsilon, \tag{1}$$

where i and m are positive or negative integers. The quantity ε, determined by the method of least squares, is equal to 0.174 ± 0.002 MeV. The quantity ξ takes on different values for nuclei with A = 4n + 1 and A = 4n + 3, namely, 0.154 and 0.049 MeV, respectively. The experimental data (mainly from [1-3], but also from [4-8]) are compared in the table with the results of calculations by formula (1).

Relation (1) expresses the phenomenon whereby not any, but only certain values of the mass difference of various nuclei occur in reality; we call this phenomenon the fine structure of nuclear masses.

Formula (1) relates the energy of the α decays within one α-active decay chain. The differences between chains can be related if we consider the quantity Q_α/ϵ. For each nucleus we could choose an integer N such that the quantity $Q_\alpha/\epsilon - N$ varies linearly, according to formula (1), with a change in A, while for constant A, the dependence on Z is nearly quadratic. In one variant constructed in this way, the parity of the number N is strongly correlated to the parity of the α tran-

Isotopes	$Q_{\alpha\,calc}$, MeV	m	$Q_{\alpha\,exp}$, MeV
	Nuclei with $A = 4n+1$		
Pu^{241}	5.121	—	5.121; 5.120 ± 5 [4] **
Cm^{245}	5.623	2	5.62 ± 0.05
Cf^{249}	6.299	5	6.296; 6.29; 6.30 [5]
Fm^{253}*	6.975	8	7.05 ± 0.04; 6.96 ± 0.04; 7.24
U^{233}	4.900	—	4.900; 4.901 ± 2 [4] **
Pu^{237}	5.750	4	5.74 ± 0.02
Cm^{241}*	6.078	5	6.05 ± 0.02
Cf^{245}*	7.276	11	7.23 ± 0.02
Bk^{249}	5.540	—	5.540 [5]; 5.53 ± 0.05; 5.55
Es^{253}	6.738	6	6.740; 6.747 ± 10 [4] **
Np^{237}	4.954	—	4.950; 4.956; 4.954 ± 3 [4] **
Am^{241}	5.630	3	5.627; 5.628; 5.633; 5.639 ± 2[4]**
Bk^{245}	6.480	7	6.48 ± 0.02
Es^{249}*	6.982	9	6.87
Np^{233}*	5.630	—	5.63
Am^{237}*	6.123	2	6.11
	Nuclei with $A = 4n+3$		
U^{235}	4.671	—	4.671[6]; 4.638; 4.66; 4.638±15[4]**
Pu^{239}	5.242	3	5.235; 5.238; 5.239 ± 2 [4]**
Cm^{243}	6.161	8	6.163; 6.159; 6.160 ± 5 [4] **
Fm^{251}*	6.955	12	7.00 ± 0.05; 7.35
U^{231}*	5.540	—	5.54
Pu^{235}*	5.937	2	5.95 ± 0.02
Am^{243}	5.428	—	5.428; 5.440 ± 7 [4] **
Bk^{247}	5.825	2	5.85
Es^{251}*	6.570	6	6.58
Md^{255}*	7.489	11	7.46 [7]
Pa^{231}	5.135	—	5.135; 5.140 ± 3 [4]**
Np^{235}	5.184	0	5.183 [8]; 5.15
Am^{239}	5.929	4	5.92; 5.90
Bk^{243}*	6.848	9	6.83

*Decay scheme unknown.
**Average (error in keV).

sitions to the ground state of the daughter nucleus. In 20 out of 23 cases for which data on the parity are discussed,[1,2,9,10] these characteristics coincide.

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SEARCH FOR THE D^+ *MESON*

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THE first experimental indication of the possible existence of a particle with strangeness $S = \pm 2$, which decays into a K meson and a π meson (the so-called D meson), was found by Wang Kang-chang.[1] An analysis of available "anomalous" strange particle decays from the point of view of the existence of such a particle was carried out by Yamanouchi.[2] Eisenberg et al[3] analyzed a 300-MeV/c K^- beam obtained from the Berkeley Bevatron. The K^- mesons slowed down and came to rest in an emulsion stack; the ranges of the stopped K^- mesons were measured. In measuring the ranges of 6000 tracks, no particle was discovered with a mass close to the conjectured value of the D meson mass. It is thus concluded in the article that the admixture of D^- mesons in this K^- beam does not exceed 1/6000. A search for the D^+ meson in a beam of positive particles was made by Cook et al,[4] who found that the number of D^+ mesons in the beam did not exceed a few thousandths of the number of K^+ mesons. It is necessary, however, to note that in the indicated experiments D mesons were sought in an extracted particle beam at a large distance from the target where they were produced. Thus, only long lived particles would have been observed in these experiments, whereas Pontecorvo[5] points out that there are no reasons for expecting the D meson to have a lifetime comparable to the lifetime of charged K mesons. This is connected with the fact that, in contrast to $K^{\pm}$ mesons, the $\Delta T = \frac{1}{2}$ rule does not lead to an additional prohibition with regard to the D meson. Consequently one can imagine that the D meson has a lifetime of the order of 10^{-10} sec, and thus we cannot observe it in K-meson beams.

In the present work, an attempt was made to observe the D^+ meson in the immediate vicinity of the place where it was produced.

Decays of K^+ mesons were looked for in an emulsion stack exposed to the internal 9 BeV proton beam from the synchrotron of the Joint Institute for Nuclear Research. The K^+ mesons (which came to rest and were found) were subsequently traced either to their place of production (star) or for a distance up to 15 mm from the decay point. With such tracking, we were in a position to observe a particle which decayed, for example, according to the scheme

$$D^+ \rightarrow K^+ + \pi^0 \qquad (1)$$

or in any other fashion with a K^+ meson among the decay particles.

At the same time we recorded particles that decayed several centimeters away from the point of production, since the dimensions of the emulsion stack, in which the particles found in this way were produced, were 20 × 10 × 5 cm. For the two-particle decay mode (1), the energy of the K^+ meson is determined by the mass of the D particle. Thus, a range of the K^+ meson in emulsion of up to 15 mm corresponds to values of the D^+ meson's mass from $M_D = 1230$ (the sum of the π^0 and K^+ masses) up