ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

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P.S.Isaev

DOES GEIGER-NUTTAL RULE EXIST FOR HYPERON DECAYS?

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The work has been reported at the Session of the
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Experimental data on the hyperon decays indicate a rather interesting regularity.

The main modes for hyperon decays are the following[1]:

Table I.

Name, mass (MeV)	Partial decay mode	Q_i (MeV) (Energy released in every decay mode)	Fraction (%)	Mean-time (sec) T
Λ 1115,6	$p+\pi^-$	37,7	65,3 ± 1,3	$(2,51 \pm 0,3) \cdot 10^{-10}$
	$n+\pi^0$	41,0	34,7 ± 1,3	
Σ^+ 1189,4	$p+\pi^0$	116,1	51,7 ± 0,8	$(0,802 \pm 0,007) \times 10^{-10}$
	$n+\pi^+$	110,2	48,3 ± 0,8	
Σ^0 1192,5	$\Lambda\gamma$	76,9	100	$< 1,0 \; 10^{-14}$
Σ^- 1197,3	$n+\pi^-$	118,1	100	$(1,49 \pm 0,3) \cdot 10^{-10}$
Ξ^0 1314,7	$\Lambda+\pi^0$	64,6	100	$(3,03 \pm 0,18) \cdot 10^{-10}$
Ξ^- 1321,3	$\Lambda+\pi^-$	66,6	100	$(1,66 \pm 0,04) \cdot 10^{-10}$
Ω^- 1672,5	$\Lambda+K^-$	73,1	16 events	$\left(1,3^{+0,4}_{-0,3}\right) \times 10^{-10}$
	$\Xi^0+\pi^-$	218,2	9 events	
	$\Xi^-+\pi^0$	216,2	2 events	

The most studied are decays of Λ, Σ and Ξ particles. Therefore in formulating the regularity we will rest on data on these particles only. We assume that a law of decay of the unstable particle beam is of the exponential form:

$$\mathcal{N} = \mathcal{N}_0 \cdot e^{-\lambda t}, \qquad (1)$$

where $\lambda = \lambda_1 + \lambda_2 + \ldots$, i.e. the decay constant λ is a sum of the decay constants for separate modes.

Now let us form the table of the products $T \cdot \Sigma Q_i$, where ΣQ_i is a sum of kinetic energies released in separate decay modes of a given particle (see Table 2)

Table 2

Particle	ΣQ_i (MeV)	$T \cdot \Sigma Q_i \cdot 10^{10}$ (MeV.sec)	
Λ	78,7	197	23,6o
Σ^+	226,3	182	1,6
Σ^0	76,9	76,9	$1o^{-4}$
Σ^-	118,1	176	35,4o
Ξ^0	64,6	194	11,6
Ξ^-	66,6	1o8	2,6
$\Omega^- \to \Lambda^0 + K^-$	73,1	95	22,2
$\to \Xi^0 + \pi^-$	218,2	285	65,4
$\to \Xi^- + \pi^0$	216,2	284	65,4

Σ^0 particle is out of the consideration because of the electromagnetic nature of its decay.

For $\Lambda, \Sigma^+, \Sigma^-, \Xi^0$ - particles the values of $T \cdot \sum Q_i \times 10^{10}$ are grouped near (180 - 190) $sec \times$ MeV. For Ξ^- hyperon this value is around twice smaller. For Ω^- hyperon the Table gives the products $T \cdot \sum Q_i$ for each partial mode. Subsequently the data on Ω^- hyperon decay will not be analyzed because of poor statistics. Thus, we have

$$T \cdot \sum Q_i \simeq \varkappa \cdot n \,, \tag{2}$$

where n is an integer and $\varkappa$ is some constant equal to around $0.95 \cdot 10^{-8}$ MeV sec . The equality (2) holds for all particles within 10%. Eq.(2) can be rewritten in the form:

$$\frac{\ln 2}{n \cdot \varkappa} \cdot T \cdot \sum Q_i = \ln 2 \,. \tag{3}$$

By comparing (3) with the definition of the decay constant

$$\lambda T = \ln 2 \,. \tag{4}$$

we obtain

$$\lambda = \sum \lambda_i = \frac{\ln 2}{n \varkappa} \cdot \sum Q_i \,. \tag{5}$$

The regularity (5) consists in that the decay constant of any hyperon is a quantity proportional to the kinetic energy which is released in the hyperon decay into the strongly interacting particles in all modes and is multiple of an integer.

The regularity (5) can be written in a different manner:

$$\ln \lambda = \ln a + \ln \left(\Sigma Q_i \right), \tag{6}$$

where

$$a = \frac{\ln 2}{n \varkappa} .$$

This form of the above regularity coincides with that of the Geiger-Nuttal rule for decay of the radioactive families. (The Geiger-Nuttal rule contains $\ln R$, where R is the range of α-particle, instead of $\ln (\Sigma Q_i)$). The physical content of the decay laws for elementary particles and radioactive elements turns out to be the same.

The regularity (5) contradicts the experimental data listed in Table I, since this regularity necessarily provides the fraction of decays $\Lambda \to n + \pi^0$ 41/33 times as large as that of decays $\Lambda \to p + \pi^-$ (in Table I the ratio of the decays $\frac{\Lambda \to n + \pi^0}{\Lambda \to p + \pi^-} = \frac{1}{2}$). This contradiction could be understood if assuming that two, very close by mass Λ -particles do exist and one of them can decay in the mode

$$\Lambda \rightarrow N + \pi + \mu .$$

One can also suppose the existence of other hyperons (in addition to Λ particles) decaying in the mode:

$$\text{hyperon} \longrightarrow \text{baryon (hyperon)} + \pi\text{-meson} + \mu \text{ quantum} \qquad (7)$$

Besides, these particles should have very close values of masses. Such an assumption does not contradict the regularity (5).

The discovery of the hyperon decay modes accompanied with μ -emission of the type of (7) and confirmation of the above considered regularity would correct essentially our knowledge about the microworld nature.

REFERENCES

1 Physics Letters, v.33b, No.1 (1970)
"Review of particle properties"

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