DISINTEGRATION OF $_{\Lambda}H^3$ IN A COULOMB FIELD AND PICKUP OF Λ PARTICLES BY HEAVY NUCLEI

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A preliminary study of the disintegration of $_{\Lambda}H^3$ in the Coulomb field of heavy nuclei is carried out. It is shown that the cross section for the process may be very large. The hyperons released may be captured by the nuclei with an appreciable probability.

THE binding energies B_{Λ} of the light hypernuclei $_{\Lambda}H^4$, $_{\Lambda}He^4$, and $_{\Lambda}He^5$ are small (~ 2–3 MeV), so that their interaction with nuclei (stripping, Coulomb disintegration) should be quite similar to the behavior of a deuteron. Special interest is attached to the case of $_{\Lambda}H^3$, where B_{Λ} is so small (~ 0.2 MeV[1]), that in practice the $_{\Lambda}H^3$ cannot approach a heavy nucleus without being destroyed in the Coulomb field and without emitting a Λ particle[1)]. Inasmuch as B_{Λ} is much smaller than the binding energy of the core (deuteron), it is natural that the dimensions of $_{\Lambda}H^3$ are much larger than the dimensions of the core, as confirmed also by direct calculations in the three-body problem (see, for example, [2], p. 597). This means that the Coulomb disintegration of $_{\Lambda}H^3$ occurs principally when the hyperon is located at large distances from the core. But in this case the two-body approximation is applicable[2], and the deuteron can be regarded as pointlike.

If $\xi = Ze^2/\hbar v \gg 1$ (v —the velocity of $_{\Lambda}H^3$) but on the other hand the characteristic time $\tau = \hbar/B_{\Lambda}$ is much larger than the collision time p/v[3,4] (p —impact parameter), then in the classical approximation the cross section of Coulomb stripping, in analogy with the ionization of an atom, is given by the formula[4]

$$\sigma = 2\pi Z^2 e^4 / mv^2 B_{\Lambda}, \tag{1}$$

where m —deuteron mass[2)]. On the other hand, in accordance with [6], in the region of low hypernucleus energy E (up to ~ 2 MeV), the following approximate formula holds true

$$\sigma = 0.23 \cdot 10^{-0.76 (B_{\Lambda}/E)^2} \left(\frac{E}{B_{\Lambda}}\right)^{3/2} Z^{1/2} \text{ b}. \tag{2}$$

Either (1) or (2) leads to a large value of σ, which according to (2) increases rapidly in the region of small E, and according to (1) decreases in the region of large E, thus obviously indicating the presence of a maximum. By extrapolating (1) and (2) until they coincide we obtain for the order of magnitude of σ at the maximum the crude estimate $\sigma_{max} = 150$ b for Ag at E = 4.5 MeV. For comparison we indicate that in the region of applicability of the formula (1) we have σ ~ 33 b at E = 20 MeV and σ ~ 17 b at E = 40 MeV, while for E = 2 MeV, according to (2), σ ~ 17 b[3)]. The Coulomb disintegration should also greatly hinder the formation of hypertritium of medium energies from heavy nuclei in primary processes.

The Λ particles released as a result of the Coulomb stripping should be picked up by the heavy nucleus. In view of the large value of B_{Λ} for heavy hypernuclei (~ 20–25 MeV[7]), the capture of the Λ particles should be accompanied by strong heating of the nucleus. Consequently, assuming the nucleus to be absolutely black, we obtain in analogy with [8],

$$\sigma_r = \pi (R + \lambda)^2 \frac{4kK}{(k+K)^2}$$

(k —wave number of the Λ particle in vacuum, K —the same in the nucleus), corresponding to ~ 1.5 b for Ag at a primary $_{\Lambda}H^3$ energy 15 MeV.

1 W. G. James, Nuovo cimento Suppl. 23, 285 (1962).

1)The less probable disintegration of $_{\Lambda}H^3$ with an emission of nucleons is not considered here.

2)Formula (1) agrees with the expression obtained in the Born approximation for $\xi \ll 1$[5].

3)To estimate σ we chose $B_{\Lambda} = 0.21$ MeV in accordance with the maximum value $B_{\Lambda} = 0.04 \pm 0.17$ MeV (within the limits of experimental error)[1]. The choice of a smaller B_{Λ} strengthens the effect even more.

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249