a small internal momentum, the principle of conservation of baryons would require at least one neutral secondary. For purposes of calculation, a single neutral secondary has been assumed and the masses of b and c have been taken to be 938 Mev and 499 Mev, respectively. From momentum and energy conservation, the mass of the neutral secondary can be derived in terms of the mass of the incident particle. If the primary is considered to be a charged hyperon of 2340 m_e,[4] and the neutral is assumed to be a neutron, the incident energy is below the threshold for reaction (4) if the target proton is at rest; a peripheral proton with internal momentum >400 Mev/c is required as the target, if the neutral mass is to be that of a neutron. We note that the probability of occurrence of an internal momentum exceeding 400 Mev/c is low.

However, if we assume a free proton target but now consider the primary to have the mass of the cascade hyperon,[5] namely 2590 m_e, it is found that the neutral secondary has mass 1820 ± 170 m_e, consistent with a neutron being the neutral secondary.

We propose that this observation is a possible example of the nucleonic absorption in flight of a charged hyperon, according to scheme IV, i.e., $Y^{\pm}+p\rightarrow p+K^{\pm}+n$, where p and n are, respectively, proton and neutron and $Y^{\pm}$ may represent either the hyperon or its heavier cascade counterpart. If the reaction has been correctly interpreted, the K-particle observed is a boson.

A recent observation of Eisenberg[6] was ascribed to the decay of a new hyperon, of mass (3200_{-500}^{+1200}) m_e, into a K^- meson. However, an alternate interpretation as a nuclear reaction of type (4), namely $Y^-+n\rightarrow K^-+n+n$, involving only known particles, might be made. The primary energy deduced from Eisenberg's data is well below threshold for the foregoing reaction if Y^- is the hyperon of mass 2340 m_e, whereas the energetics are satisfied if the incoming particle is a cascade hyperon that collides with a neutron with internal momentum $\sim$150 Mev/c.

It is of interest to note that, according to the isotopic spin assignments of Gell-Mann and Pais,[7] if the hyperon in the foregoing reactions is a Σ^-, the reaction is allowed, but is forbidden for both Σ^+ and Ξ^- hyperons.

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Deuteron Stripping and the Collective Nuclear Model

G. R. Satchler
Clarendon Laboratory, Oxford, England
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EXPRESSIONS for the reduced widths for nucleon capture into low nuclear levels reached by deuteron stripping have been derived by using the nuclear shell model.[1] We now consider the effects of collective motion in nuclei.[2]

In the weak-coupling region the contribution to the capture probability is of first order in the surface coupling only for capture into vibrational states. For other states it is of second order and contributes, at most, a few percent of the reduced width. The surface coupling will allow capture of nucleons with angular momenta (j_nl_n) other than those expected on the simple shell model,[1] but interparticle forces have the same effect, and interpretation would be difficult.

With *strong* coupling, capture into rotational levels[2] becomes possible, but, owing to the orthogonality of the single-particle states, is only "allowed" when (j_nl_n) is the same as the (jl) of the orbit the captured nucleon enters. In practice, the surface coupling[2] (and also interparticle forces) will admix other spin-orbit states $(j'l')$. That is, the shell model (jl) will not be perfectly good quantum numbers, and captures that are otherwise "forbidden" will take place with reduced probability.

We may write the reduced width $\gamma^2(j_nl_n)$ for capture with total angular momentum j_n and orbital l_n to form a compound state with n like nucleons in an unfilled shell, (jl):

$$\gamma(j_nl_n)=[n\hbar^2/MR]^{\frac{1}{2}}u_{l_n}(R)\beta(j_nl_n), \qquad (1)$$

where $u_l(R)/R$ is the single-particle radial wave function evaluated at the nuclear surface, $r=R$, and M is the nucleon reduced mass.

With an even-even spin-zero target nucleus, $J_i=K_i=0$,[2] we must have $j_n=J_e$, the spin of the compound state. Then

$$\beta(j_nl_n)=\delta(j_nJ_e)\langle\tau_i|\tau\rangle[2/(2J_e+1)]^{\frac{1}{2}}\alpha(jj_n;\tau K_e). \qquad (2)$$

When $j_n=j$, $\alpha(jj)\simeq1$, and $\tau=\tau_e$; but for $j_n\neq j$, $\alpha(jj_n)$ is the amplitude of the configuration $[(j)^{n-1}j_n]$ admixed to the "pure" state $[j^n]$ in the compound nucleus. As usual, K_e is the projection of J_e on the nuclear axis, and τ specifies the vibrational state of the nuclear surface. The $\langle\tau_i|\tau\rangle$ is an "unfavored" factor arising from the partial orthogonality of the vibrational wave functions, similar to that encountered in β and γ transitions.[2]

When the target nucleus is even-odd with spin J_i, projection $K_i=J_i$, and a rotational level of spin J_e in the even-even compound nucleus ($K_e=0$) is formed,

$$\beta(j_n l_n)=\langle\tau_i|\tau\rangle[2(2J_i+1)/(2J_e+1)]^{\frac{1}{2}} \times C(J_i j_n J_e; J_i-J_i)\alpha(jj_n;\tau J_i). \quad (3)$$

α has the same interpretation, and $C(abc;\alpha\beta)$ is the Clebsch-Gordan coefficient.[3] In strong coupling, $J_i=j-\frac{1}{2}(n-2)$.

With $j_n=j$ we now have the possibility of forming several members of the rotational family with $|J_i-j|\leqslant J_e\leqslant J_i+j$, all, to first approximation, with the same vibrational character τ_e. We can then compare their reduced widths unambiguously:

$$\frac{\gamma(jl;J_e')}{\gamma(jl;J_e)}=\left[\frac{2J_e+1}{2J_e'+1}\right]^{\frac{1}{2}}\frac{C(J_ijJ_e';J_i-J_i)}{C(J_ijJ_e;J_i-J_i)}. \quad (4)$$

Taking into account only the surface coupling, we find for the admixture of $j_n\neq j$,

$$\alpha(jj_n;\tau K)=-k(ll_n)\Delta E^{-1}i^{l-l_n}(5/4\pi)^{\frac{1}{2}} \times\langle\tau|a_0|\tau_e\rangle C(2jj_n;0K)C(j_n 2j;\tfrac{1}{2}0). \quad (5)$$

$k(ll_n)$ is the coupling strength, $=V_0Ru_l(R)u_{l_n}(R)$ if V_0 is the depth of the shell-model potential well, and ΔE is the energy separation of the unperturbed states. $\langle\tau|a_0|\tau_e\rangle$ is an off-diagonal matrix element of the nuclear shape parameter $a_0=\beta\cos\gamma$. If the surface deformation is not greatly perturbed by the change in particle orbit, its order of magnitude should be given by the diagonal element. This is related to the intrinsic quadrupole moment, Q_0,

$$\langle\tau_e|a_0|\tau_e\rangle=(5\pi)^{\frac{1}{2}}Q_0/3ZR^2,$$

which may be estimated from measured quadrupole moments, isotope shifts, etc.[2]

The interpretation of deuteron-stripping data for medium-heavy nuclei, where rotational levels have mainly been found, is obscured because the Coulomb barrier is high. Even here, however, it should be possible to test the relation (4) with deuteron energies well over the barrier, without detailed knowledge of Coulomb effects. Rotational characteristics are also to be expected in the spectra of nuclei of the $1d$ shell (such as Mg^{24}) where the Coulomb barrier is not unduly high. Further investigation of these points is under way.

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