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PHYSICS III COMMITTEE

LETTER OF INTENTION: INVESTIGATION OF HYPERNUCLEAR γ RAYS

by

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Recently K-mesic X rays have been observed in He[1], Li, Be, B, and C[2] with stopped K^- of order of 15 K^-/pulse. In CERN a slow K^- beam of more than 100 stopped K^-/pulse is possible to obtain. The interest for such a slow K^- beam has been emphasized in connection with the plans to extend the present study of μ- and π-mesic X rays to K^--mesic X rays. It is the aim of this note to point out that with 100 stopped K^-/pulse beam the hypernuclear γ rays could be observed. The experimental set-up required for these measurements is very similar to the one used for K^--mesic rays. Actually both experiments can be done simultaneously with the same apparatus, the only difference being in the γ-detecting system.

So far information on Λ's bound in nuclei has been obtained by studying the decay of the hypernuclei from their ground state or isomeric state ($_\Lambda He^7$). Observation of the γ rays would yield information on the excited states of hypernuclei and thus the splitting and rearranging of nuclear states in the presence of a bound Λ hyperon. This information is of great interest for understanding the Λ-N interaction as well as nuclear structure. Both points have been discussed extensively by Dalitz[3].

Let us consider $_\Lambda Li^7$, one of the simplest systems, where we can expect hypernuclear γ rays. In Fig. 1 the level scheme predicted[3] for $_\Lambda Li^7$ and its relation with that for Li^6 is shown. The splitting of the ground state and first excited state gives direct information about the spin dependence of the Λ-N interaction, in particular for Λ in s state and nucleons in p state. The width of the γ line gives information about the lifetime of the state (Doppler smearing depends on the ratio lifetime/stopping time) being proportional to $(g_N - g_\Lambda)^2$ in the case of M1 transitions. For the nuclear structure the incorporation of a nonidentical particle into the nucleus gives a sensitive test for the correctness of the present interpretation of the pattern of excited states in nuclear systems (change of coupling scheme in p-shell nuclei).

A possible set-up for detecting the hypernuclear γ rays is shown in Fig. 2. The yield and background estimate has been done for 100 stopped K^-/pulse and $\pi^-/K^- = 10^3$. As target material Li, Be and C have been considered.

For the NaI counter of 5" x 3" at 15 cm distance grom the target a total efficiency of 2% for 1-MeV γ rays can be assumed. From the present information[4] about 5% of stopped K^- produce a hypernucleus. This results in 0.1 γ/pulse for one counter.

The main source of background are γ rays following π^0 decay from the reactions $K^- + p \rightarrow \Sigma^0 + \pi^0$, $K^- + n \rightarrow \Sigma^- + \pi^0$ and $K^- + p \rightarrow \Lambda^0 + \pi^0$. The total counting rate of these γ rays is 0.7 counts/pulse, but they are spread over a large energy interval. In comparison with the upper estimate for hypernuclear γ's a number 0.007 counts/pulse MeV should be taken as a relevant estimate.

The accidental coincidences produced by γ rays following the inelastic scattering of pions in the target are small (σ = 100 mb, target thickness = 10 g/cm^2, coincidence resolution 2τ = 10 ns).

$$N = 100 \times 10^{-27} \times 10^5 \times 10^{24} \times \frac{10^{-8}}{0.1} = 10^{-3} \text{ counts/pulse.}$$

The background from uncorrelated γ's in the experimental hall is not considered here. The order of magnitude of this background can be determined without any machine-time request.

From the upper estimate one can conclude that a 24-hour run (30 000 effective bursts/day have been assumed) with the target and a 24-hour background run should yield 3000 hypernuclear γ counts, 1500 of these in the photopeak. In the case of ${}_\Lambda Li^7$ with 4 particle-stable states at least three γ's with energies between 0.5 and 2 MeV should be observed. At least for the transition to the ground state from the first excited state, being fed directly and though the γ decay the upper estimate should be reasonably good. Therefore we can conclude that with a beam of 100 stopped K^-/pulse the hypernuclear γ's can be observed.

This experiment, if approved, would be done in the frame of CERN-Heidelberg collaboration.

REFERENCES

(1) Burleson, Cohen, Lamb, Michael and Schluter, Phys. Rev. Letter **15**, 70 (1965);

(2) Wiegand and Mack,(to be published);

(3) Dalitz, Hypernuclear Physics, Lectures given at the International School of Physics "Enrico Fermi", Varenna in July 1966;

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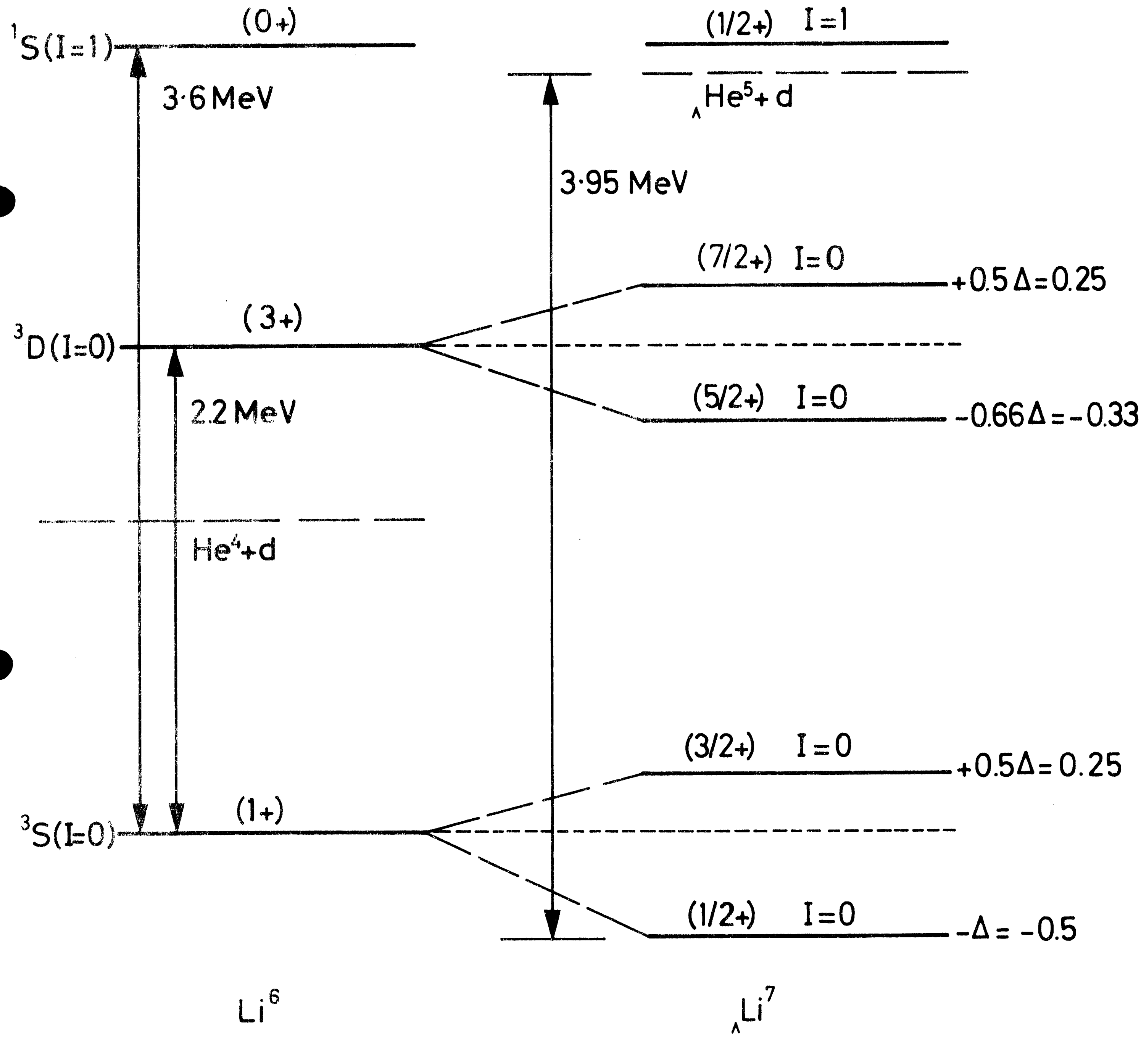

1S(I=1)
(0+)
3·6 MeV
3D(I=0)
(3+)
2.2 MeV
He4+d
3S(I=0)
(1+)
Li6
(1/2+) I=1
ΛHe5+d
3·95 MeV
(7/2+) I=0
+0.5Δ=0.25
(5/2+) I=0
-0.66Δ=-0.33
(3/2+) I=0
+0.5Δ=0.25
(1/2+) I=0
-Δ= -0.5
ΛLi7

FIG.1

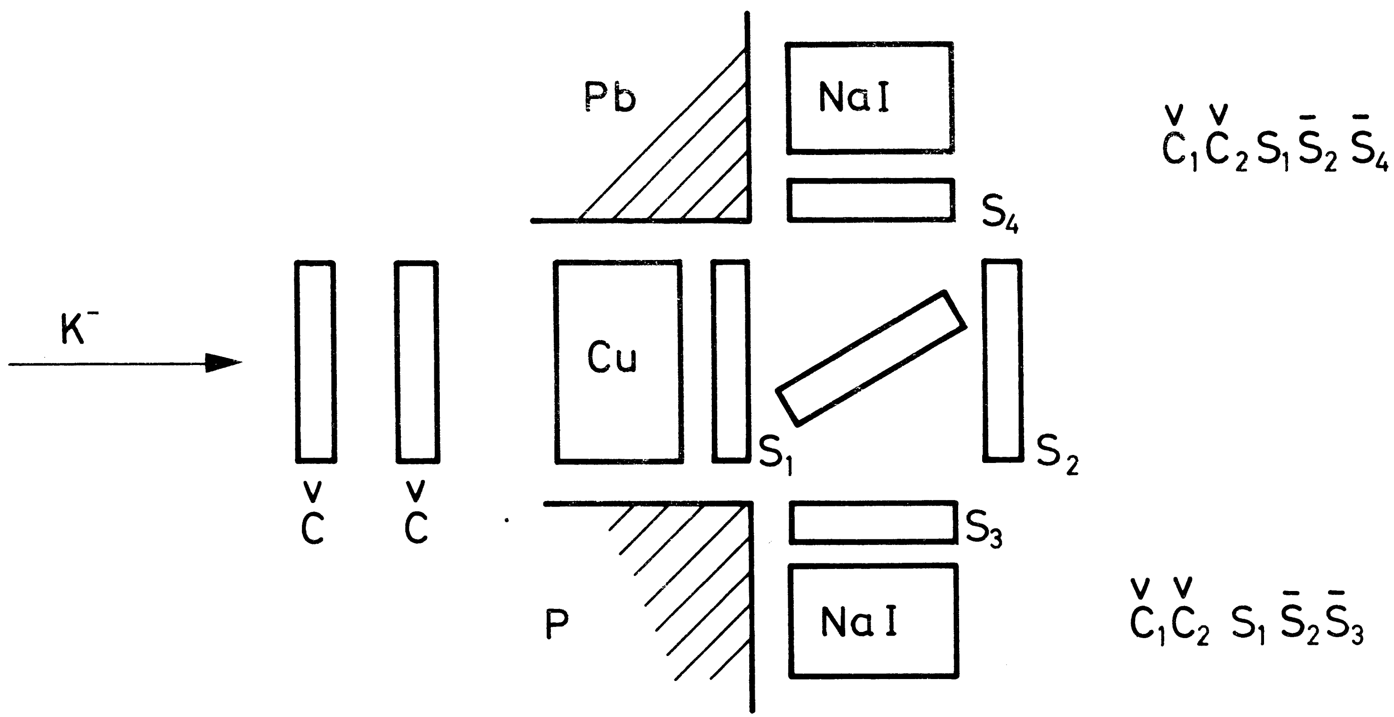

FIG. 2