A. Piazzoli: A SEARCH FOR THE TETRANEUTRON

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INTRODUCTION -

The aims of this relation is to resume the experimental and theoretical basis of our hypothesis of the tetra neutron's existence and also to describe an experimental research (unsuccesfull) of this nucleus.

The Part 1 is devoted to the first aim, but in a schematic way, because these arguments are treated in greater details in two papers[1,2] by our group. Only one argument will be pointed out: some experimental data on the $2\pi^+$ and $2\pi^-$ photoproduction on ^{4}He. These data are not published because they are very preliminar and stathistically very poor.

The Part 2 is devoted to the second aim.

PART 1

The analysis of 96 events in cloud diffusion chamber, (C. D. C.) due to the reaction ^{4}He(γ, π^+)N, ^{3}H has shown some features, as the tendency of the π^+, ^{3}H and γ directions to be coplanar and a bump in the Q-value distribution of N and ^{3}H, that one can't understand in the impulse approximation scheme.

The existence of an ^{4}H state (hydrogen four) could explain the features of the reaction ^{4}He(γ, π^+)N, ^{3}H we have seen.

2.

1.   We deduced the following properties for the ^{4}H state: $E_B \simeq 4$ MeV,
$T = 1$. In order to compare the ^{4}H hypothesis with the previous experimental results, we can make two remarks:

a) - The possible existence of an isotriplet of the 4-nucleon system could be deduced on the basis of the existence of one or more ^{4}He excited states with excitation energy of about 20-24 MeV and with I-spin not determined up to now.

b) - The experimental study of the N-^{3}H scattering, shows a bump in the total cross section at $E_N \simeq 4$ MeV[3]. A phase-shift analysis[4] seems to point out that this bump is not a resonance.

2.   The not published experimental data we have spoken about, is the following:

in the C.D.C. we have found 10 two-prongs events. Both prongs are positive and at minimum of ionization. These events are very probably due to the reaction: ^{4}He(γ, $2\pi^+$) 4 N. We have found also 1 six-prongs event, two prongs are negative and at minimum of ionization, four prongs are positive and with a large ionization. This event is very probably due to the reaction He^4(γ, $2\pi^-$) 4 P.

3.   If we don't consider the stathistical errors, we can make the following remark:

the ratio, larger than 10, between the cross section of the $2\pi^+$ photoproduction (we said "larger" because, of course, the scanning efficiency for the $2\pi^-$ events is 1, but certainly smaller than 1 for the $2\pi^+$ events) is not easily understable.
After our experiment, Nefkens[5] by irradiating a ^{7}Li target with a high-energy bremsstrahlung beam ($E_\gamma{}^{max} = 310$ MeV) found a β^- activity with $E_\beta{}^{max} \gtrsim 19$ MeV, which, in his opinion, should be due to the presence of the channel:

$$\gamma + {}^7\text{Li} \rightarrow 2\,\text{p} + {}^5\text{H}$$
$$\hookrightarrow \nu + e^- + {}^5\text{He}$$
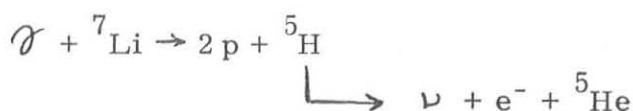
with a ^{5}H lifetime $\tau \simeq 110$ msec.

4.   The points 1. and 3. are in contradiction for the following reason:

the ^{5}H pairing-energy must be smaller than the ^{6}He pairing-energy that is 2.86 MeV. Therefore the energy difference between ^{4}H and ^{5}H must be ≤ 1.4 MeV(this is clear if we think to build up ^{5}H by adding neutrons

to ^{3}H) while from the two experiments we have described, one can deduce $E_{4H} - E_{5H} \gtrsim 4.5\,MeV.$

5.　　　In order to remove this contradiction, we have proposed the value T = 2 for the I-spin for ^{4}H. The value T = 2 would seem likely also for two other reasons:

a) - The fact that the experimental study of the N - ^{3}H scattering[3] don't show clearly the ^{4}H state is now understable because a T = 2 state is not visible in the scattering between two T = 1/2 particles.

b) - The dissociation of a T = 2 state has a lifetime much larger than that of a T = 1 state.

The most important consequence of the T = 2 hypothesis is, of course, the tetra neutron's (^{4}n) existence.
Our data on the 2 π^+ and 2 π^- photoproduction on ^{4}He, are more understable if ^{4}n does exist, because the existence of ^{4}n and the absence of $^4\bar{p}$ (on account of the coulomb interaction) can grow up the cross section of the 2 π^+ photoproduction and not the 2 π^- photoproduction.
We will point out that, also if it may be striking, theoretical principles against the existence of nuclei built up by neutrons only, don't exist.
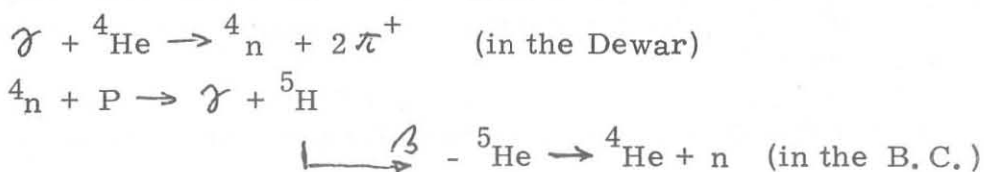
PART 2

　　　In order to reveal the ^{4}n state we have tried to make an experiment showing many difficulties (that we shall describe). On the other hand the experimental apparatus was already set up for another experiment and the number of runs seemed small.
The experimental apparatus was the following:

on the 1000 MeV γ beam of the Frascati elettronsyncrotron there was a dewar empty with liquid ^{4}He. At 90° degrees and at $\sim$ 15 cm, there was a bubble chamber (B. C.), at ethane and propane, of 20 1. The dewar's walls were 4 gr/cm^2 glass thick and the liquid ^{4}He was 0.3 gr/cm^2 thick. The B. C. saw a 0.1 steradiant solid angle. The expansion ($\sim$ 10 msec.) was 30 $\div$ 100 msec. later than the beam time and the picture was taken at the end of the expansion time.
The aim was that to reveal the following reactions chain:

$$\gamma + {}^4He \rightarrow {}^4n + 2\pi^+ \quad \text{(in the Dewar)}$$
$$^4n + P \rightarrow \gamma + {}^5H$$
$$\underset{\longrightarrow}{\rule{0pt}{0pt}} \beta - {}^5He \rightarrow {}^4He + n \quad \text{(in the B. C.)}$$

4.

by revealing the ^{5}H β^- decay that, as shown in Nefkens' paper[5], should
have the following properties: $E_\beta^{max} \simeq 19$ MeV, $\tau = 0.1$ sec.
In order to reveal this β^- decay, we have used the method of the differen
ce between electron energetic spectrum of the runs "with" and "without"
^{4}He, with the same number of equivalent quanta.
The range-energy relation for the electrons in the B.C. was: 1 cm $\simeq$ 1 MeV.
The total time of expansion was calculated by the number of cosmic rays
and the background with the syncrotron turned off was subctracted by any
spectrum.
The difficulties of this experiment were:

a) - The delay between B.C. expansion and the beam time excludes every
   reaction happening at the same time of the beam but not the activity
   induced in the B.C. by the reactions of the following type:

$$\left.\begin{array}{c} n \\ p \\ \pi^+ \end{array}\right\} + C^{12} \longrightarrow \text{ radioactive nucleus}$$

   It is very difficult to calculate this background.

b) - The root mean square radius of the ^{4}n state could be about 20 f (the
   n - n scattering lenghth). If this is true, the cross section of the
   $P(^4n, \gamma)^5$H reaction could be very small.

c) - The experimental stability conditions between the "with" and "without"
   runs are not good.

The results have been completely negative: that is both electron spectra
and the total counting rates were at random distributed between "with" and
"without" runs.
The same was happening also for different runs of the same type.

CONCLUSION. -

   Of course, the described experiment isn't neither in favour nor
against the existence of the ^{4}n state. After our experiment, Schiffer
and Vandenbosh[6] were looking for ^{4}n among the fission yields of a reac
tor, by revealing the capture reactions: ^{14}N $(^4n, n)$ ^{17}N and ^{27}Al $(^4n, T)^{28}$Mg
$(^{17}$N and ^{28}Mg are radioactive nuclei).
By assuming for the cross sections of the two reactions about the same va-
lue of the cross section for the similar α particles captures, one finds
that the ^{4}n number produced in the fission is smaller than the α particle
number by a factor $\geq 10^5$.
In our opinion the capture cross sections for ^{4}n could be overexistimated
very much, for the same reasons we have spoken about for our experiment.

REFERENCES. -

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