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THE REACTION $^7Be(n,\alpha)^4He$ AND PARITY CONSERVATION IN STRONG INTERACTIONS

by

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The Reaction ^{7}Be(n, α)^{4}He and Parity Conservation in Strong Interactions.

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In order to understand the nature of the forces involving strange particles it is necessary to know whether parity is violated or not in strong interactions. The amount of parity violation that we reasonably expect in low energy nuclear physics is very small ($F \sim 10^{-4}$, where F is the ratio of the amplitude of the wave function components of opposite parity).

As an experimental approach to this problem, D. H. WILKINSON suggested the study of the reaction

$$(1) \qquad {}^7\text{Be} + \text{n} \to 2\alpha \, ,$$

which should not be allowed for thermal neutrons (mainly absorbed in S wave), if parity is conserved, due to the negative parity of the ^{7}Be nucleus. An experimental attempt to detect reaction (1) is described by SEGEL, KANE and WILKINSON (1) and they give an upper limit of 25 mb for the cross section.

We thought it worthwhile studying reaction (1) again, for two reasons: *a*) when ^{7}Be is bombarded with thermal neutrons another reaction is possible

$$(2) \qquad {}^7\text{Be} + \text{n} \to 2\alpha + \gamma \, ,$$

and this one is not inhibited by parity conservations laws: a γ-ray of about 2 MeV comes through an electric dipole transition to the 16.62 MeV level (and also with lower probability to the 16.92 MeV level) with an « *a priori* » estimated cross-section of several tens of millibarn, transitions to lower levels being also possible. Reaction (2) has not been observed by SEGEL *et al.*, on the other hand they could not distinguish the α-particles of reaction (1) and (2) since the resolution in energy allowed by their apparatus was probably

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(1) R. E. SEGEL, J. V. KANE and D. H. WILKINSON: *Phil. Mag.*, 3, 204 (1958).

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not sufficient. *b*) The new technique of solid state counters, which was developed after the Segel experiment, gives a new possibility both to separate α-particles from reaction (1) and (2) and to lower of some orders of magnitude the limit for the cross section of reaction (1).

However, we had as first objective to observe the α-particles from reaction (2).

The experiment has been performed in the thermal column of the Ispra I reactor the cadmium ratio being about 10 000. ^{7}Be target and counters are put into a hole cut in the graphite and are shielded by 20 cm of bismuth in order to reduce the γ-ray flux from the reactor. The ^{7}Be target (on a 30 μg/cm^2 formvar sheet) is put between two solid state counters (Hughes SD1-22; 1 cm^2 area) and is movable from outside the reactor in order to put two α sources in front of the counters when necessary for calibration. The calibration of the whole apparatus by means of the α sources is done every 20 min. The system is put under vacuum (40 μm Hg).

We have used two different experimental methods, the one provides a presentation of the coincident α pulses on a double trace oscilloscope, the other analyses the pulses which come from the addition of two coincident α pulses with a 256 channel analyser. We report the results obtained with both methods pointing out that the ones obtained with method 2 are still preliminary at present and are now used to check the results of method 1. On the other hand we hope to get in the future the highest statistics from method 2.

In the first method the pulses from each counter are transmitted outside the reactor shield by a fast cathode follower and formed with double RC to $6\cdot10^{-8}$ s; then they are amplified by two distributed amplifiers and sent, on one side to the vertical deflection plate of a double trace oscilloscope (Tektronix 551), on the other side to the coincidence circuit through another chain of distributed amplifiers. The coincidence is of the Rossi type with 125 Ω plate resistance and performs an addition of the incoming pulses. The resulting pulse goes to a fast integral discriminator which triggers the oscilloscope sweep.

The results are reported in Fig. 1. We have plotted, on the axes of a cartesian cohordinate system, the pairs of correlated pulse heights so that each event is represented by a point. The amplification of the electronic chains, corresponding to the two counters, were balanced in such a way to have on both sides pulses of the same height corresponding to particles of the same energy; events of the type (1) and (2) and chance coincidences between ^{238}Pu α particles used for calibration, indicated by α in Fig. 1, will give points around a straight line at $+45°$.

When we project all the points (P_i) recorded, on a $-45°$ straight line we obtain an histogram (A) representing almost exactly the dispersion of the difference in amplitude between correlated pulses; doing the projection at $+45°$ we get the distribution (B) of the sum. In both cases the statistical dispersions should coincide. However, it is easy to notice, looking at the oscilloscope photographs, that many pulses are due to a chance sum of an α-particle pulse and a background pulse, presumably the 1.44 MeV protons from ^{7}Be(n, p). In cases like these, we expect an asymmetrical contribution to the distribution of pulse heights and the dispersion of the histogram A will be slightly larger than that of B; in fact this difference in the dispersions is observed.

As an internal check we have measured on the oscilloscope photographs the distribution in time of the correlated α pulses. We have found a symmetric distribution *vs.* time with no correlated pair having more than $1.2\cdot10^{-8}$ s relative difference in time. As the resolving time of the coincidence is $6\cdot10^{-8}$ s, this is a good proof that we are observing really coincident events.

lines (MM; NN) corresponding to the dispersion of the histogram A.

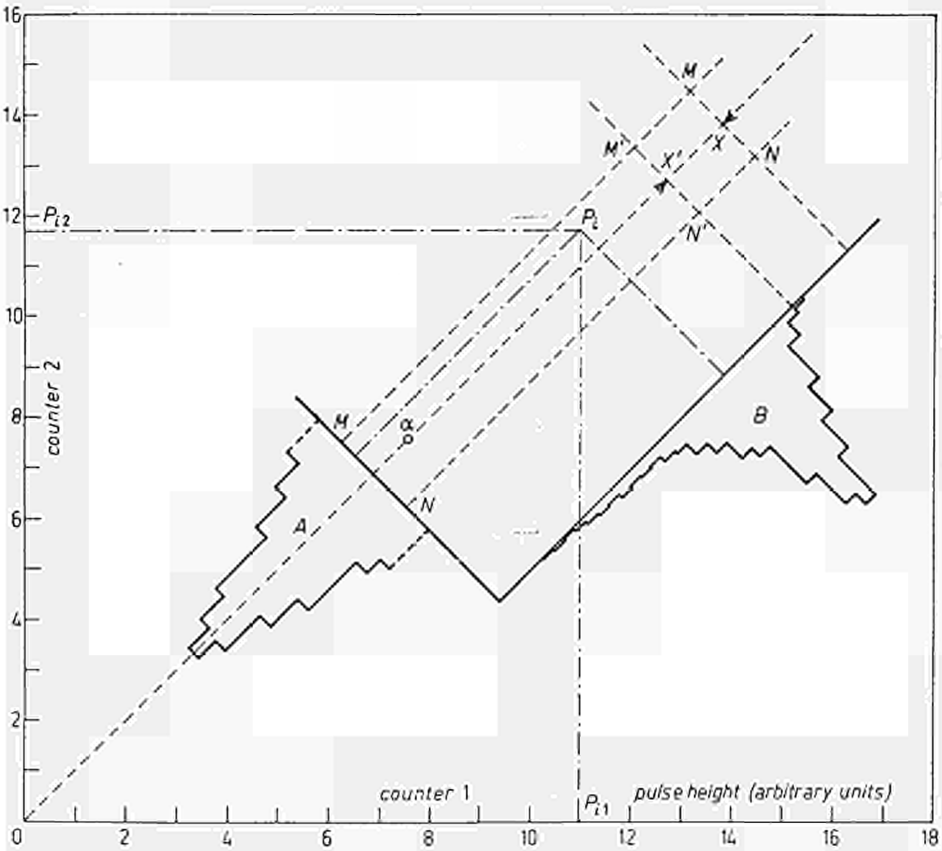

Fig. 1.

In the α spectrum given by the histogram B we observe a group of α-particles which can be interpreted as coming through a reaction of type (2) from the level 16.62 (2^+) MeV. In order to estimate the probability of α decay from the 18.9 MeV level (reaction (1)) we should select those pairs of pulses of right amplitude which do not result in chance addition of an α-particle of lower energy and a background pulse. This selection, when done on single photographs, is rather subjective and we prefer to select all pulses which, in Fig 1 lay between two $+45°$

Using as calibration the α's of two ^{238}Pu sources and those from reaction (2) corresponding to the level 16.62 MeV, it is possible to establish the position of the 18.9 MeV level on the graph. To this level we have attributed the same dispersion of level 16.62 MeV (XX'). By counting the few events (five) contained in the rectangle $MM'N'N$, which are anyhow on the side of the 16.62 MeV tail, we can get an upper limit for the cross-section of reaction (1).

From the neutron flux ($7.5 \cdot 10^9$ thermal n/cm² s) and the ^{7}Be amount (7.6 mc)

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we can evaluate the cross sections for the various reactions. For reaction (1) we find an upper limit $\sigma_1 \leqslant 0.16 \cdot 10^{-27}$ cm², for reaction (2) to the level 16.62 MeV $\sigma_2 = 115 \cdot 10^{-27}$ cm² over 3 500 events.

In the second method the pulses from each counter are transmitted to an addition channel and to a coincidence channel by two cathode followers. The addition pulse is formed to $6 \cdot 10^{-8}$ s, amplified by a chain of three distributed amplifiers (40 db) and sent through a bias circuit which accepts only pulses corresponding to more than 4 MeV. The total rise-time, due mainly to the characteristics of the counter, is $2 \cdot 10^{-8}$ s. The pulses, after the bias circuit, are lengthened, amplified and fed to a 256 channel analyser which can accept them only if it is triggered by a pulse from the coincidence channel. The coincidence has $4 \cdot 10^{-8}$ s resolving time. With 5.94 mc ^{7}Be and a neutron flux of $2 \cdot 10^9$ n/cm² s we find $\sigma_2 = 148 \cdot 10^{-27}$ cm² (on about 700 events) in agreement with the other measurements.

To conclude we can observed that, accepting the usual attribution of spin (2) to the state in which the thermal neutron is captured by ^{7}Be, the upper limit found ($\sigma_1 \leqslant 0.16 \cdot 10^{-27}$ cm²) for the cross section of reaction (1) corresponds to a limit of $F \leqslant 2.5 \cdot 10^{-5}$. We could not get any conclusion in this sense if the neutron is captured in a state of spin 1 in disagreement with the usual point of view (²).

(²) R. L. MACKLIN and J. H. GIBBON: *Phys. Rev.*, **109**, 105 (1958).

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