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ANGULAR DISTRIBUTION OF THE
NEUTRON POLARIZATION FROM
 $^{11}\text{B}(\alpha, n)^{14}\text{N}$ REACTION, AT LOW
ENERGY

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ANGULAR DISTRIBUTION OF THE NEUTRON POLARIZATION
FROM $^{11}\text{B}(\alpha, n)^{14}\text{N}$ REACTION, AT LOW ENERGY.

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Abstract : The measurement of the neutron polarization from the $^{11}\text{B}(\alpha, n)^{14}\text{N}$ reaction, at the alpha particle energy of 3.6 and 3.8 MeV, has been done to investigate the reaction mechanism and the level structure of the compound-nucleus ^{15}N .

One uses a time-of-flight standard technique with improved radiation shielding and proper resolution. The preliminary analysis of the experimental data indicates the formation of the compound-nucleus ^{15}N with the participation of the $13.63(5/2, 7/2)^-$, $13.70(?)$ and $13.79(5/2)^+$ excited levels in ^{15}N . Subsequent calculation will make clear if the magnitude of the polarization is determined by the interference of these levels only, or if it will be necessary to take into account a ground term of the R-matrix, as well as a direct contribution, which is slowly changing with incident energy.

1. Introduction

The reaction $^{11}\text{B}(\alpha, n)^{14}\text{N}$ has been studied, in the energy range 2-6 MeV, by Bonner [1] (1956), Haddad [2], (1957, 1961), Calvert [3] (1961), Mani and Dutt [4] (1963, 1966), who have accomplished excitation function and angular distribution measurements. The resonant structure of the excitation function and the energy variation of the distribution curves point out that the formation of the compound-nucleus with a very complex level con-

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figuration, is possible . Particularly, in the 13.6 - 13.9 MeV excitation energy range of ^{15}N , there are three resonances ($r \gg D$) at least, with different spin and/or parity, and a level with unknown J, π .

The measured values of the total cross section clearly exhibit a monotone increasing background which may be generated by the contribution of some broad resonances, with small spins, or by a knock-out or particle transfer reaction .

In order to establish the probable interaction modes of the alpha-particle with ^{11}B -nucleus and the states in the ^{15}N also, we decided to carry out polarization measurements of the neutrons in the energy range 2-6 MeV, though there are many difficulties due to small sections and low energy neutrons .

2. Experimental Method

The alpha-particle beam, having a natural modulation of about 3 ns. and an energy spread of 100 KeV, was obtained from the Y-120 cyclotron of IAP-Bucharest, by He^{4++} - acceleration on multiplied frequency states [5]. The integrated current beam on the enriched ^{11}B -target ($\rho=1$ cm) of approximately $1\text{mg}/\text{cm}^2$ thickness, was about $5\ \mu\text{A}$. The experimental arrangement and the electronics block-diagram [6], are shown in figs. 1 and 2.

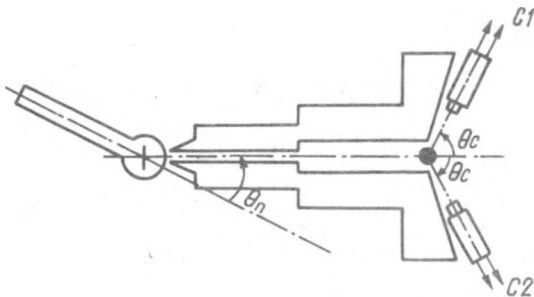


Figure 1
The experimental set-up for neutron polarization measurements.

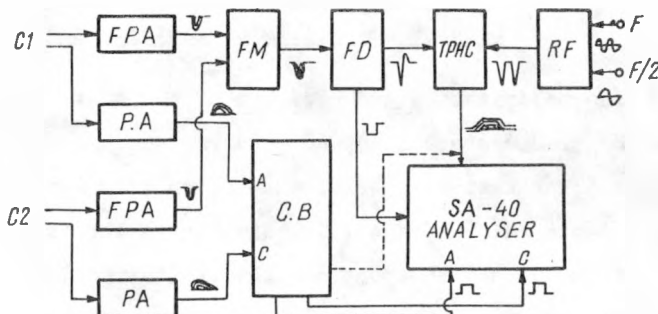


Figure 2

The electronic block-diagramme for time-of-flight technio (c1, c2-stilben counters, FPA-fast preamplifier, PA-preamplifier, FM-fast mixer, FD- fast discriminator, TPHC-time to pulse height converter, CB-command block, RF-radio frequence) .

By means of this arrangement we have obtained neutron time-of-flight spectra (fig.3) for 117 cm target-to-detector distance, with a time resolution on γ -peak of 2-3 ns, at a beam current of $0.1 \mu\text{A}$. In the polarization measurements the time-resolution was 4 ns, and the current beam 5-8 μA . As a polarization analyser, the elastic scattering of neutrons by ^{12}C has been used, at 60° SL-angle and 16 cm. scatterer-to-detector distance .

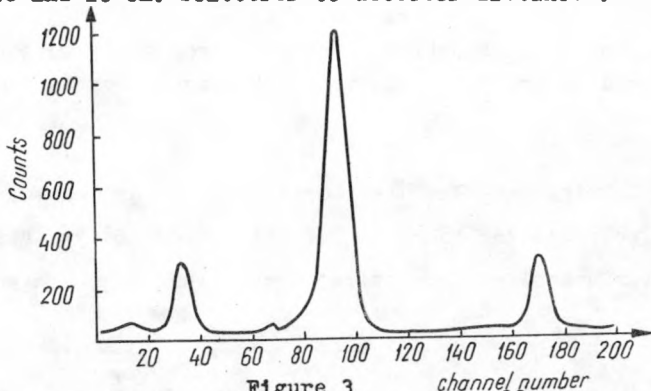


Figure 3
Time-of-flight neutron spectrum from $^{11}\text{C}(\alpha, n)$ reaction at $E_\alpha = 3.6 \text{ MeV}$ and $\theta_n = 30^\circ \text{ SL}$.

3. Results and Preliminary Discussion

The polarization measurements of the neutrons leaving ^{14}N in the ground state (1^+), were carried out at the angles where the polarization power of the carbon is known [7], and has an appreciable value (fig.4). In this figure the energy distribution of the ground neutrons and the excitation function, are also displayed .

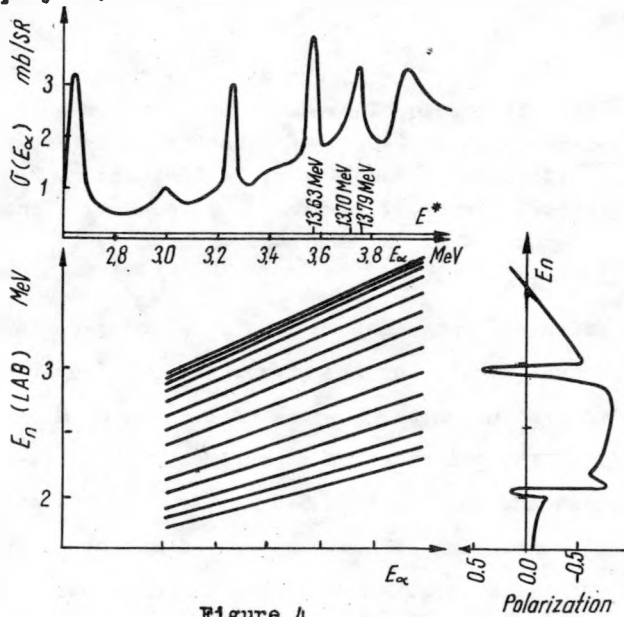


Figure 4

Excitation function, energy neutron distribution and neutron polarization from elastic scattering on C.

In fig.5 angular distribution curves are shown, for the neutron polarization taken at 3.8 and 3.6 MeV alpha-particle energies. Statistical uncertainties associated with each point, are given .

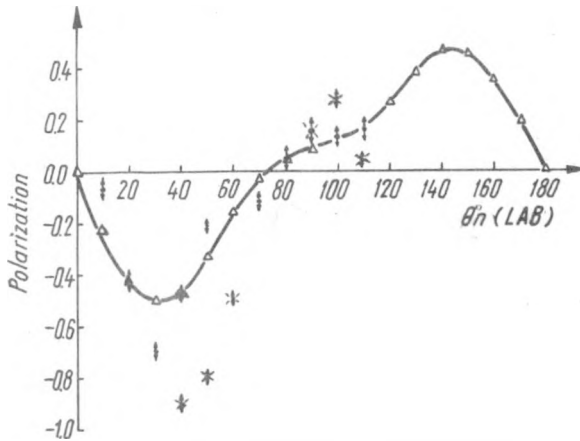


Figure 5
 Angular distribution of the neutron polarization
 from $^{11}\text{B}(\alpha, n)^{14}\text{N}$ at 3.6 MeV (\circ), 3.8 MeV (\times) and
 fitted curve at 3.6 MeV (Δ) incident energy .

The solid line on the same figure represents the curve fitted by
 the least-squares method to the expression

$$P(\theta) = \frac{\sum_k A_k P_k^1(\theta)}{\sum_k a_k P_k(\theta)}$$

using the coefficients a_k ($k= 0, 1, 2, 3, 4$) for 3.6 MeV incident
 energy, from fig.5 of [4].

The existence of the high values of the polarization, an
 interference phenomenon-by excellency, shows the formation of the
 compound nucleus - ^{15}N , in different spin and parity states,
 allowing different momenta in the entrance and exit channels. Thus,
 in the case of the 13.63 and 13.79 MeV resonances, in the en -
 trance channel ($S = 3/2^-$) the even values appear for the first
 resonance and the odd values for the second; in the exit chan-
 nels ($S = 1/2^+$ and $3/2^+$), the situation is reversed. On the other

hand, it is not likely that at such low energy of the alpha particle, higher orbital momenta are present in the reaction .

If one supposes the preponderance of some states with $l=1$, then the polarization should have a maximum value for θ angles situated in the region of 45° and 135° . Our measurements really show maximum values of the neutron polarization at the forward angles 30° and 40° as well as at 100° .

It is seen from fig.5, that the fit of the experimental data is unsatisfactory using the coefficients a_k from angular distributions. This implies new calculations for the polarization, using the interference of 3 levels in this range of the excitation energy, and also the contribution of the broad $3/2^+$ level, centred around 14 MeV excitation energy, with a width of 2-3 MeV.

The calculation of the polarization magnitude, in this energy range, will confirm if this assumption is satisfactory, or if also a direct mechanism is probable responsible for the slow change and the relatively large polarization observed .

References

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