Revista Brasileira de Física, Vol. 2, N.° 2, 1972

Some $^{14}N(d, p)\,^{15}N$ Reactions in the Deuteron Energy Range from 1 to 3 MeV

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Recebido em 25 de Fevereiro de 1972

In general, the (d,p) and (d, n) reactions in the energy range from 1 to 3 MeV in light nuclei show a large contribution from the stripping mechanism and also pronounced structures in the excitation curves[1-5]. The structures observed seem to be associated with the excitation of only a few particles in the compound nucleus. The purpose of this paper is to discuss some ideas concerning the $^{14}N(d, p_4)^{15}N$ (Ex = 7.16 MeV), $^{14}N(d, p_5)^{15}N$ (Ex = 7.31 MeV) and $^{14}N(d, p_6)^{15}N$ (Ex = 7.57 MeV) reaction mechanism and a model is proposed to explain the broad structure ($\Gamma \sim 650$ keV) observed in the p_5 excitation curves.

As reações (d, p) e (d, n) para núcleos leves e na região de 1 a 3 MeV apresentam, de modo geral, além de uma apreciável contribuição para o mecanismo de reação direta, estruturas bastante pronunciadas nas curvas de excitação[1-5]. As estruturas observadas parecem estar associadas a excitação de somente algumas partículas no sistema composto. Este trabalho discute algumas ideas concerning the $^{14}N(d, p_4)^{15}N$ (Ex = 7.16 MeV), $^{14}N(d, p_5)^{15}N$ (Ex = 7.3 MeV) and (Ex = 7.31 MeV) e $^{14}N(d, p_6)^{15}N$ (Ex = 7.57 MeV), na região de energias de 1 a 3 MeV e um modelo para explicar a estrutura larga (Γ - 650 keV) observada nas curvas de excitação para o grupo de próton p, é proposta.

The absolute cross section for the ^{14}N + d reactions were measured using a gas target and a surface barrier detector to detect the emergent protons. The incident deuteron energy was known with an accuracy of $\pm$ 9 keV. Further details of the experimental arrangement can be found in reference[4].

If we look at the excitation curves of all the other deuteron induced reactions studied in the energy range from 1 to 3 MeV, (Refs. 1-3), we can see pronounced structures in all proton and neutron groups observed. The important feature of the $^{14}N(d, p)^{15}$N excitation curves is the absence of structures except for the p_5 proton group[6]. For this proton group (p,), a broad structure around E, = 2 MeV is observed.

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To determine the energy E, and the width Γ of the structure an experimental fit was made to the p_5 excitation curves, with an expression of the type:

$$\frac{d\sigma}{d\Omega}(\theta) = \frac{1}{E}\left[A(\theta) + D(\theta)E + \frac{B(\theta) + C(\theta)(E - E_R)}{(E - E_R)^2 + \frac{\Gamma^2}{4}}\right],$$

where the first two terms represent the direct contribution to the reaction and, the other one, the contribution from an isolated resonance plus the interference term between the two processes. We found $E_R = 2.10$ MeV (corresponding to an excitation energy of 22.6 MeV in ^{16}O) and $\Gamma =$ $= 0.65$ MeV.

A possible explanation for the fact that we could not see similar structures in the excitations curves for p_4 and p_6 could be the inhibition of the process by the centrifugal barrier.

Let us suppose that the observed structure corresponds to a J" state in the compound system formed. The conservation of spin and parity requires:

$$\mathbf{L} + \mathbf{S} = \mathbf{J} = \mathbf{L}' + \mathbf{S}', \qquad (-1)^L = (-1)^{L'},$$

where $S = \mathbf{J}_A + \mathbf{s}$ is the entrance channel spin; $S' = \mathbf{J}_B + \mathbf{s}'$ is the exit channel spin and L and L' are the orbital angular momentum of the incident deuteron and emergent proton, respectively. Then, if there is any inhibition by the centrifugal barrier, only the states $J'' = 0^-$ (L: = 1 for p_5 and L' = 3 for both p_4 and p_6) and $J'' = 1^+$ (L' = 0 or 2 for p_5 and L' = 2 or 4 for both p_4 and p,) could be formed.

Based on this argument., we conclude that these states could have the following configurations: two particles coupled to $J = 0^-$ (T = 1) outside the "core" $^{14}N(J^\pi = 1^+, T = 0)$ to form the state $J^n = 1^+$ or three particles coupled to $J^\pi = 1/2^+$; T = 1/2) outside the "core" $^{13}N(J^\pi = 1/2^-$, T = 112) to form the state $J = 0^-$.

A. R. Barnett[7] observed a level of 22.5 MeV excitation energy and $\Gamma =$ $= 0.60$ MeV studying the analogue states $^{16}O - {}^{16}N$ using the reaction $^{15}N(p, n)^{15}O$.

M. Langevin et *al.*[8] observed a level in ^{16}O around 22.8 MeV excitation energy, using the reaction $^{16}O(\gamma, p)^{15}N$ (Ex = 9.06 or 9.17 MeV) and determined $J = 1^+$ fcr this level. M. Suffert et *al.*[9] observed the same level using the reaction $^{14}N(d, \gamma)^{16}O$ (Ex = 22.7 MeV, $\Gamma = 0.60$ MeV).

Certainly much more work needs to be done on that and the first step could be a fit to the experimental data using a expression with a DWBA term and a resonance tem and try to extract the J^π of this state.

I would like to thank Dr. L. C. Gomes, Dr. A. F. T. Piza and Dr. O. Sala for valuable discussions.

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