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ANGULAR CORRELATION STUDY OF SOME HIGHLY EXCITED LEVELS OF ^{16}O

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Résumé. — Des expériences de corrélation angulaire $^{12}\text{C}(^6\text{Li}, d)^{16}\text{O} \rightarrow \alpha_0 + ^{12}\text{C}_{\text{g.s.}}$, faites à 0° , ont permis d'étudier plusieurs états de ^{16}O , entre 20 et 24 MeV. Un contrôle de la méthode a été fait sur le niveau 6^+ à 16,3 MeV, bien identifié. D'une analyse détaillée autour du pic large à 20,9 il ressort qu'aucun niveau 8^+ ne peut être mis en évidence dans cette région. Le résultat est en accord avec l'attribution de 7^- faite précédemment. Un spin 6 est attribué au niveau à 21,8 MeV, observé dans les réactions ($^6\text{Li}, d$) ($^7\text{Li}, t$).

Abstract. — Angular correlation measurements at 0° involving the reaction

have been used to study several highly excited states in ^{16}O , between 20 and 24 MeV. The method has been tested using the known 6^+ at 16.3 MeV. No indication of a 8^+ level was found from detailed analysis around the 20.9 broad peak; our result is in agreement with earlier assignment of 7^- for this level. A spin 6 is assigned to the 21.8 level, observed in ($^6\text{Li}, d$) and ($^7\text{Li}, t$) data.

The investigation of quartet and α -like states in sd shell nuclei has been in the last few years the object of increasing attention due to the development of experimental techniques and of new ideas on nuclear models [1]; one of the most interesting features of the experimental data [2] is the evidence that selectively populated states also occur at high excitation energy (20-30 MeV and more) indicating the persistence at these energies of simple nuclear structure and simple symmetry properties. There is at this time little direct experimental information on the properties of these highly excited states (spin, parity, decay modes) and more data would be desirable.

In our laboratory Li-induced α particle transfer reactions have been extensively used to investigate in detail this excitation region [3, 4]. The present work is a preliminary report on the experimental study of some highly excited levels of ^{16}O populated by the

$^{12}\text{C}(^6\text{Li}, d)^{16}\text{O}$ reaction. In the energy region around 20 MeV of excitation broad and more or less marked structures are apparent in the deuteron energy spectrum (see Fig. 1); they are superimposed to a continuous background probably due to the break-up of ^6Li ions. The strong peak at 20.9 MeV has been

FIG. 1. — Deuteron spectrum from the $^{12}\text{C}(^6\text{Li}, d)^{16}\text{O}$ reaction at 32 MeV. The lines — correspond to the energy interval covered by the PSD placed in the focal plane of the spectrometer.

(*) According to the contract BT-II/12.766 between the CEN Saclay and the CSFN/SM, Catania.

identified as the 7^- state of a negative parity rotational band [5, 6]; there is at present no indication of the expected [7] $(^1) 8^+$ member of the first positive rotational band. One of the purposes of this work is to obtain new information on this energy region through a direct measurement of level properties by particle-particle correlation method.

It has been shown [6, 8] that, if the deuterons are detected at 0° with respect to the beam (method II of Litherland and Ferguson), the angular correlation of α particles in the $^{12}\text{C}(^6\text{Li}, d)^{16}\text{O} \rightarrow ^{12}\text{C}_{\text{g.s.}} + \alpha$ is given by :

$$W(\theta) = \sum_m B_m(m) [Y_I^m(\theta, 0)]^2 \quad (1)$$

where I is the spin of the ^{16}O decaying level.

The geometry of the system implies that only magnetic substates with $m = 0, \pm 1, \pm 2$ can be populated [6, 8, 9]. The $B(m)$ in eq. (1) cannot be calculated explicitly without knowledge of the mechanism of the reaction leading to ^{16}O -states.

In a simple approximation, if the $(^6\text{Li}, d)$ reaction proceeds by direct transfer of an α -particle and no spin-flip is assumed, the $B(m)$ for $m \neq 0$ should be suppressed [6, 9] and eq. (1) reduces to the simple expression :

$$W(\theta) \propto P_I(\cos \theta)^2. \quad (2)$$

Where $P_I(\cos \theta)$ is the Legendre polynomial of degree I . In eq. (2) it is also assumed that the solid angle subtended by the 0° detector is sufficiently small [10, 11]. It is to be noted that, due to the selected geometry of our experimental arrangement, no angular shift is to be applied to fit the experimental data with the $P_I(\cos \theta)^2$ function [6].

In our experiment the deuterons were detected at 0° by means of a magnetic spectrometer equipped with a 50×14 mm position sensitive detector (PSD) 600 μm thick placed in the focal plane; the surface was protected by a gold foil 50 μm thick to prevent damage due to the direct lithium beam; the decay α -particles were detected by a second 50×14 mm, 300 μm thick PSD placed at 80 mm from the center of the scattering chamber with its sensitive surface defined by a grid with 13 slits 2 mm wide. The half-angle subtended by the magnetic spectrometer was $\pm 3.5 \times 10^{-2}$ rad. The $^6\text{Li}^{++}$ beam was produced by the FN Tandem VdG of Saclay laboratory; the deuteron energy resolution was about 100 keV. An overall time resolution of 40 ns was obtained using a time compensation method [12].

Energy and position signals from the two detectors and the time signal were pretreated on-line and simultaneously recorded on magnetic tape for off-line analysis [13].

Figure 2 shows the results for the two known ^{16}O levels at 16.3 and 20.9 MeV respectively; our data

confirm the previous assignment of 6^+ and 7^- respectively [6]; both levels are found to strongly decay to the $^{12}\text{C}_{\text{g.s.}}$. No significant change in the correlation function was noted when the data of the 20.9 MeV broad peaks were analyzed off-line with a deuteron energy window corresponding to 150 keV and spanning the deuteron peak from 20.7 to 21.1 MeV.

FIG. 2. — Results of the correlation measurement for the 16.3 and 20.9 MeV levels respectively, the 6^+ and 7^- previous values of the spin are confirmed.

Figure 3 shows the results concerning the ^{16}O level at 21.8 MeV; this peak is evident in the experimental $(^7\text{Li}, t)$ data of M. E. Cobern [14]; but it is not reported in (α, α) and (α, α') experiments [5, 15]. In spite of the large errors and the presence of the background, a 6^+ spin and parity assignment for this level can be made; it decays predominantly to the first 2^+ excited level of ^{12}C at 4.43 MeV.

The amount of available information is at this time not sufficient to have a complete understanding on the structure of this level. However we point out that its excitation energy (~ 20 MeV) and its decay

FIG. 3. — Results of the correlation measurements for the 21.8 level. The solid line is the $[P_6(\cos \theta)]^2$ function.

(¹) Zuker, A. P., Mc Grory, J. B., private communication.

mode suggest an interpretation in terms of the weak-coupling model [16], this level could arise from the coupling of the 2^+ state of ^{12}C and the 6^+ state of ^{20}Ne . Further work on this line is in progress.

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