Formation of the 17.637 MeV state in ^{9}B in the reaction $^{6}Li(^{3}He,\alpha)^{5}Li(g.s.)$†

O. P. Gupta,* A. Bond, and P. M. S. Lesser
Brooklyn College of C.U.N.Y., Brooklyn, New York 11210
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Formation of the 17.637 MeV state in ^{9}B in the reaction $^{6}Li(^{3}He,\alpha)^{5}Li$ (g.s.) has been observed by an α-α coincidence method.

[NUCLEAR REACTIONS $^{6}Li(^{3}He,\alpha)^{5}Li(g.s.) \rightarrow p+\alpha$; measured $\alpha\alpha$ coincidence as a function of ^{3}He bombarding energy, observed the formation of the ^{9}B state.]

The nuclear reaction of ^{3}He with ^{6}Li, studied in the past by several authors,[1-6] has been shown to proceed mainly via the following two sequential processes:

$$^{6}Li + {}^{3}He \rightarrow \alpha_1 + {}^{5}Li \rightarrow p + \alpha_2 , \quad (1)$$

$$^{6}Li + {}^{3}He \rightarrow p + {}^{8}Be \rightarrow \alpha_1 + \alpha_2 . \quad (2)$$

The reaction has also been shown to be predominantly a direct reaction in the first step at certain bombarding energies for both (1) and (2). However, in reaction (2), Vignon *et al*[6] have shown that the 17.637 MeV level in ^{9}B (see Fig. 1) can be formed at a ^{3}He bombarding energy of 1.6 MeV. An observation of such a compound nucleus formation in the first step of the ^{5}Li channel would be of interest, as it was argued by Livesey and Piluso[4] that it may have a measurable effect on the angular correlation between the protons and the α particles from this reaction. A simple excitation function measurement in the ^{5}Li channel, performed by measuring the yield of an α peak corresponding to a ^{5}Li state as a function of ^{3}He bombarding energy, is made difficult by the fact that at low bombarding energies, the α singles spectrum has a large continuum component which obscures the α peaks from a ^{5}Li state.

The present study aims at observing the ^{9}B state using an α-α coincidence method, in which the α-α coincidence yield corresponding to the formation of ^{5}Li(g.s.) is measured as a function of ^{3}He bombarding energy.

Singly charged ^{3}He beams, ranging in energy from 1.4 to 1.8 MeV, were obtained from the Brooklyn College 3.75 MeV Dynamitron accelerator. A 17-inch diameter scattering chamber was used for the experimental study. Two surface barrier (SB) detectors of thicknesses 150 and 75 μm were mounted inside the scattering chamber at angles of 80° and −68.5° with respect to the incident beam to detect the α particles. Their thicknesses provided a discrimination between protons and α particles above 4.6 MeV, which was sufficient for the purpose of this measurement. Targets of ^{6}LiF (^{6}Li enrichment $\simeq$96%), of a thickness 33 $\mu g/cm^2$ deposited on a 20 $\mu g/cm^2$ carbon foil were used for the experiment. Elastically scattered ^{3}He particles from ^{6}Li, ^{12}C, and ^{19}F were monitored separately in a 300 μm SB detector fixed at an angle of 130°.

Coincidences between the two α particles were measured using slow-fast coincidence electronics with a resolving time of 6 nsec. The measurements were taken at ^{3}He bombard energies ranging from 1.47 to 1.75 MeV in the steps of about 25 keV.

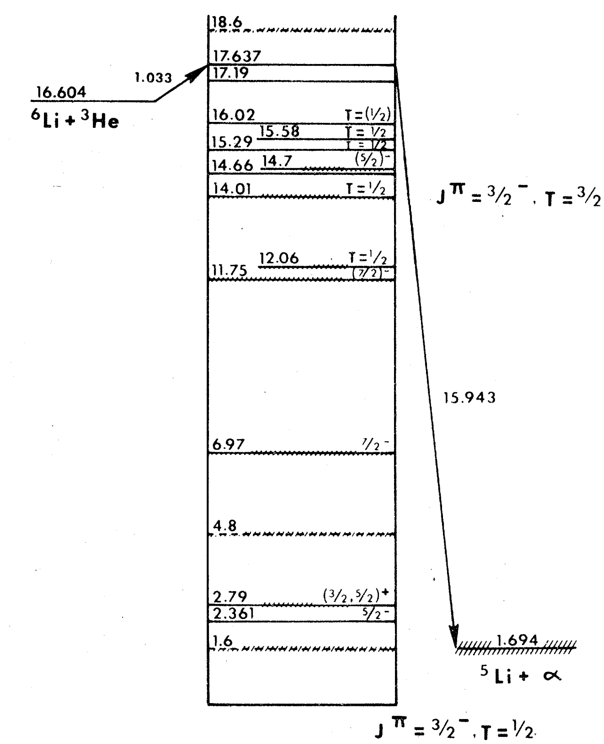

FIG. 1. Energy level diagram of ^{9}B.

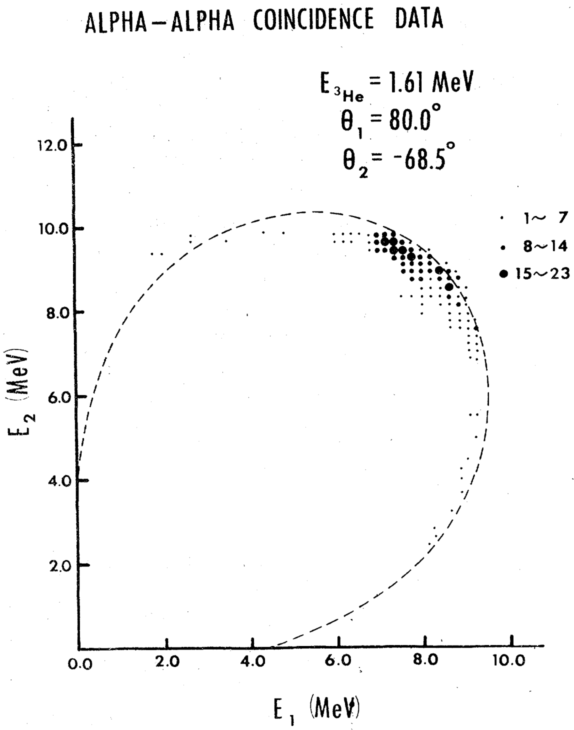

FIG. 2. α-α coincidence data at a ^{3}He bombarding energy of 1.61 MeV for detector angles of 80° and −68.5° with respect to the incident beam.

Coincidences measured at fixed detector angles, between any two particles of energies E_1 and E_2, in a three-body final state reaction, e. g. the ^{6}Li(^{3}He, α_1)^{5}Li(g.s.) $\to p + \alpha_2$ reaction, lead to a kinematic curve in the E_1-E_2 plane. The coincidences between α_1 and α_2 at detector angles fixed at 80° and −68.5° form such a curve.

The experimentally observed α_1-α_2 kinematic curves, one of which is shown in Fig. 2, have as their principal feature an enhancement due to the formation of ^{5}Li(g.s.). This enhancement is seen in the form of two peaks located along the kinematic curve, whose widths are determined by the 1.5 MeV width for the ^{5}Li(g.s.). One peak corresponds to an α_1 detected by the 80° detector and α_2 detected by the −68.5° detector; the other peak corresponds to reversing α_1 and α_2.

Other possible contributions to the spectrum in this region could result from the formation of the ^{8}Be(11.4 MeV) state, which kinematically could produce an enhancement in the counting rate near the ^{5}Li(g.s.) location because of its width of 3.5 MeV. However, an examination of the data near the calculated location of the ^{8}Be(11.4 MeV) state shows that this contribution is negligible. Contributions to the coincidence data may also be expected from the simultaneous process. Previous studies[2,3] have shown that at low bombarding energies such con-

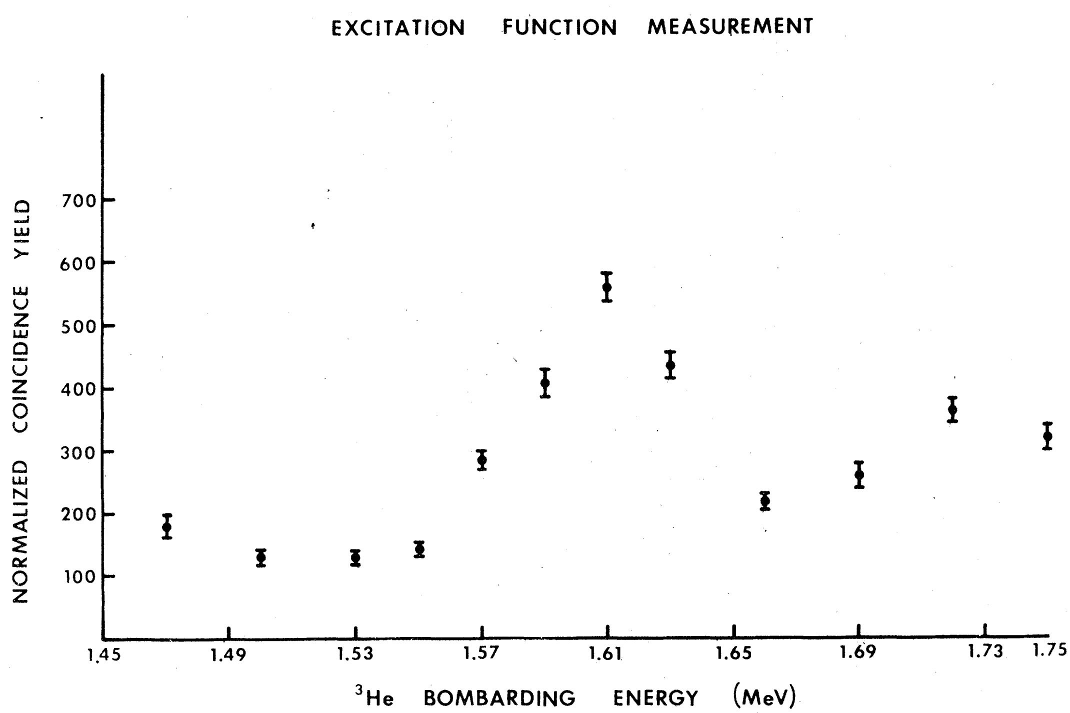

FIG. 3. Excitation function for the reaction ^{6}Li(^{3}He, α) ^{5}Li(g.s.).

tributions are less than 10%. The present data are found to be in agreement with such an estimate.

The coincidence yield due to ^{5}Li(g.s.) was obtained for each bombarding energy by adding up counts on the coincidence curve from $E_1 = 5.9$ to $E_1 = 9.6$ MeV and $E_2 = 6.5$ to $E_2 = 10.2$ MeV, which included counts under both the peaks. The data were normalized to the yield of elastically scattered ^{3}He particles from the ^{19}F nuclei, detected in the 300 μm SB detector. This elastic scattering is largely Rutherford, and does not vary significantly over the range of ^{3}He incident energies for which the excitation function was measured. The normalized coincidence yields have been plotted as a function of ^{3}He bombarding energy in Fig. 3. The error in each data point is mainly due to the coincidence counting statistics.

A peak is seen in the excitation function curve at a ^{3}He bombarding energy of 1.61 MeV. After taking into account the target thickness which was 70 ± 20 keV of ^{3}He energy loss at 1.61 MeV ^{3}He incident energy, the ^{9}B resonance is found to occur at 1.57 ± 0.02 MeV corresponding to an excitation energy of 17.63 MeV. The width of the resonance as found from this measurement is 70 ± 20 keV. Both the excitation energy and width are in good agreement with previously measured values of 17.64 MeV and 71 ± 8 keV, respectively, which were obtained from a study[7] of the ^{7}Be$(d,p)^8$Be reaction.

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*Present address: Department of Physics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

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