Was ^{5}H observed in the reaction ^{6}Li(π^-, p)?

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The interpretation of the proton spectrum from the reaction ^{6}Li(π^-,p) as a ^{5}H resonance is not the only possible interpretation of this spectrum[1] (K. Seth Kamal, Proceedings of the Fourth International Conference on Nuclei Far from Stability, Helsingor, Denmark, 1981, CERN Publication 81-09, p. 655). The experimental data can be described well by taking into account the interaction of two neutrons in the output channel. Allowance for the contribution from the ^{4}H resonance suggests that there are resonance parameters of ^{5}H other than those reported in Ref. 1.

In a recent experimental study[1] of the nuclei far from stability the spectrum of energetic protons ($\theta_{\rm lab} = 20°$) from the reaction ^{6}Li(π^-,p) was measured at $E_\pi = 125$ MeV. The experimental data (the histogram in Fig. 1a) showed that the phase space of the four particles ($p + n + n + {}^3$H) is greater than the calculated dependence normalized in the energetic part of the spectrum. This result, shown in Fig. 1, has a characteristic shape. As a possible explanation of this result, we suggested the existence of a ^{5}H resonance with a 11-MeV decay energy and a 14-MeV width. In this letter we present the results of an analysis of these experimental data using methods similar to those used by Kamal.[1] We also show that in terms of this analysis the existence of ^{5}H with the indicated parameters is not the only possible explanation of the measured distribution.

The products of the reaction ^{6}Li(π^-,p) include two neutrons which are characterized by strong attraction in the singlet state. This attraction, as we know, accounts for the fact that the energy profile of the relative motion of this neutron pair has a sharp maximum at $E_{n-n} \approx 100$ keV. Since this value is much smaller than the missing-mass values (Fig. 1) and smaller than the channel value (1 MeV), the final-state interaction in this case can be simulated by calculating the phase space for three particles ($p + {}^2n + {}^3$H). Since the process we are considering, which involves large energies, does not necessarily produce s-state neutrons, we approximated the spectrum by the method of least squares by combining the invariant phase space for three particles and for four particles. In Fig. 1b, where the data of Ref. 1 are given on the logarithmic scale, these two components are described by the dashed line and the dot-dashed line. We see that the experimental data can be described by the sum of these processes (the solid line).

In our calculation we ignored the width (~ 1 MeV) and the particular features of the energy distribution of the interacting neutrons. To check what this simplification does, we carried out a calculation with a wave function of the relative motion of two neutrons. We used an expansion in the effective radius ($a = -16$ fm, $r_0 = 2.4$ fm, and $b = 1.4$ fm). The second component of the fitting expression was again the phase space

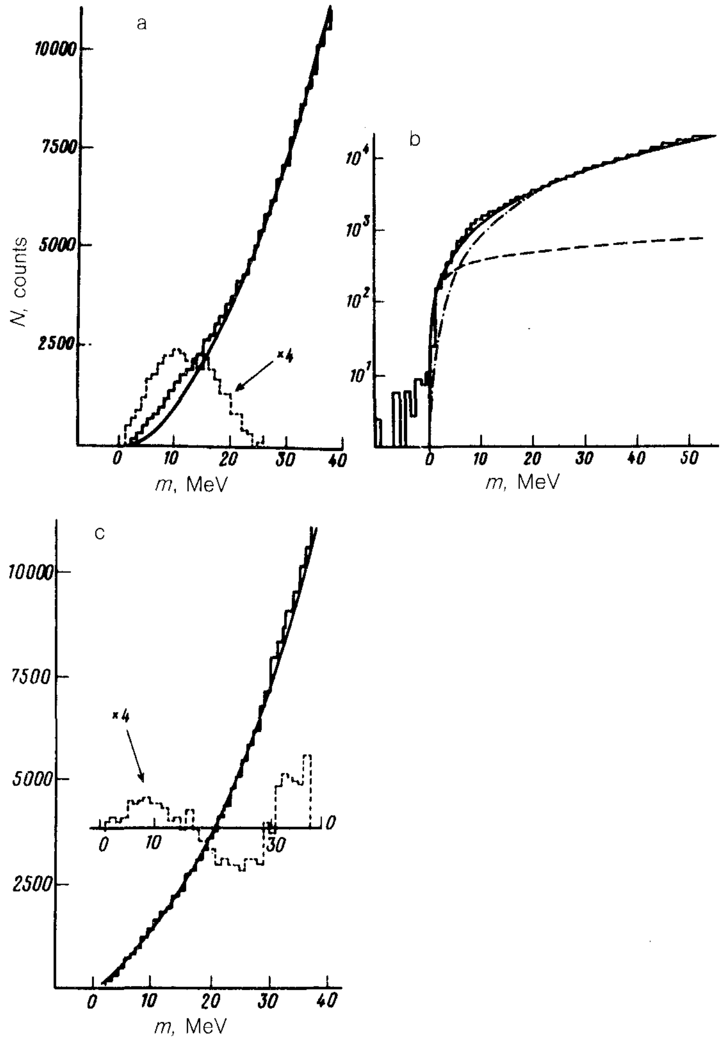

FIG. 1. (a) Energy spectrum of protons from the reaction $^6Li(\pi^-, p)$ at $E_\pi = 125$ MeV and $\theta_{lab} = 20°$ (in the missing-mass coordinates).[1] Solid curve—calculation of the phase space of the four particles ($p + n + n + {}^3H$). Dashed curve—deviation from the calculated curve. (b) Dashed and dot-dashed curves—approximation of the experimental data from Ref. 1 obtained by combining the phase space of the three particles ($p + 2n + {}^3H$) and of the four particles. Solid curve—the result of the approximation. (c) Calculation similar to that in 1b, but with allowance for the finite width of the $E_{n\ \ n}$ distribution (see the text proper). Solid curve—the result of the approximation; dashed curve—deviation of the experimental data from the calculated curve.

for the four particles which accumulate at high energies at which there is a degradation of the conditions under which the effective-radius approximation is used. The phase space appeared as a model for the processes which are not accompanied by the interaction of the *s*-state neutrons and which cancelled the wave-function error for the

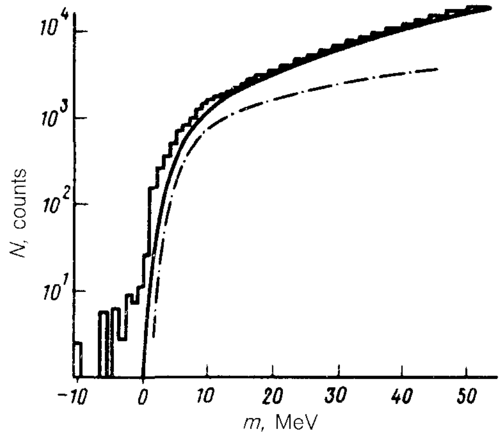

FIG. 2. Plot of the experimental data from Ref. 1, with allowance for the contribution from the ^{4}H resonance in the exit channel. Solid and dot-dashed curves—the result of an approximation and the ^{4}H contribution, respectively (see the text proper).

$n + n$ system. The result of an approximation is represented by a solid line in Fig. 1c. We see that the spectrum can be reproduced, as before, if the finite width of the E_{n-n} distribution is taken into account. Also shown in this figure is the difference between the experimental and calculated curves. In contrast with Fig. 1a, we can now see deviations both in the positive and negative directions. These deviations are, however, much smaller in magnitude (on the order of the change in the experimental spectrum in a single channel).

In addition to the $n + n$ system with a virtual level considered by us, there is another dynamically identifiable subsystem in the reaction products $(p + n + n + {}^3\text{H})$: the ^{4}H resonance. The resonance properties of the ^{4}H system were simulated by using the R-matrix expression for the isolated p resonance with the following values of the reduced width, channel radius, and resonance energy: $\gamma^2 = 5.5$ MeV, $R = 4$ fm, and $E_r = 3.4$ MeV. The distribution obtained in this manner has a maximum at an energy of 3.7 MeV of the relative motion of n and ^{3}H and a width $\Gamma = 2.6$ MeV. The result of an approximation using this calculation and the phase space of the experimental spectrum is represented by a solid line in Fig. 2. We see that the process with the final-state ^{4}H (the dot-dashed line) also contributes in the region in Fig. 1a, where the experimental curve for the phase space exceeds the calculation. A discrepancy between the calculation and experiment occurs at lower energies in Fig. 2 than in Fig. 1a. This discrepancy is characterized by a structure with the center at ≈ 6 MeV and width at half-maximum at ~ 9 MeV. In other words, if this structure is hypothetically linked with the ^{5}H resonance, the characteristics of this resonance would differ from those in Fig. 1a. Finally, we note that as a result of increasing the number of adjustable parameters, the agreement with the experiment can be further improved in comparison with that in Figs. 1 and 2 through a combined use of the models for the final-state interaction in the $n + n$ and $n + {}^3\text{H}$ systems.

Accordingly, the explanation of the spectrum from the reaction $^6\text{Li}(\pi^-,p)$ as a resonance is not the only possible interpretation. Allowance for the final-state of two neutrons and/or a neutron and a tritium nucleus may alter the hypothesis on the formation of the ^{5}H resonance or change the conclusion concerning the resonance parameters of this system. The last point should be kept in mind in view of the distinct bunching above the phase space observed in the reaction $\pi^- + {}^9\text{Be} \rightarrow p + t + {}^5\text{H}$.

[1] K. Seth Kamal, Proceedings of the Fourth International Conference on Nuclei Far from Stability, Helsingor, Denmark, 1981, CERN Publication 81-09, p. 655.
[2] M. G. Gornov, Yu. B. Gurov, V. P. Koptev *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **45**, 205 (1987) [JETP Lett. **45**, 252 (1987)].

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