seems improbable that even this technique will give as strong an energy dependence as is found in the data.

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NEW TWO-NEUTRON PICKUP REACTION: $Mg^{26}(He^4, He^6)Mg^{24}$ †

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Forty-MeV alpha particles from the Brookhaven 60-in. cyclotron were used to study levels of Mg^{24} excited by the $Mg^{26}(He^4, He^6)Mg^{24}$ reaction. The (He^4, He^6) reaction, a hitherto unobserved two-neutron pickup reaction, will be a useful tool in nuclear spectroscopy in that its use will complement the results obtained from the (p, t) reaction, and other two-neutron pickup reactions. A similar situation exists for the one-neutron pickup reactions (p, d), (d, t), and (He^3, He^4).[1] Here, we describe the observation of the $Mg^{26}(He^4, He^6)Mg^{24}$ reaction and make a qualitative comparison with the $Mg^{26}(p, t)Mg^{24}$ reaction.[2]

The detectors used for this work were transmission-mounted surface-barrier counters. Three detectors were used: a thin ΔE detector, a stopping detector, and a veto detector to reject events associated with long-range particles. Coincident pulses were required on the first two detectors, with anticoincidence in the veto detector. ΔE pulses were multiplied by E pulses that were produced from the addition of pulses from the ΔE and stopping detectors.[3] The product pulse, which is proportional to the particle mass, was analyzed in a single-channel analyzer to select the particles of interest. A mass discrimination between mass 4 and mass 6 of over 10^5:1 was attained.

Figure 1 shows a typical He^6 spectrum corresponding to the levels[4] of Mg^{24} at a scattering angle of 52.2 degrees. Figure 2 shows the angular distributions corresponding to the different levels shown in Fig. 1. The angular distributions are characterized by a strong oscillatory structure that persists over the angular range that was studied. The strong oscillatory structure indicates that the reaction probably is predominantly a direct-type process with relatively little contribution from compound-nucleus type processes.[5]

A number of interesting features are apparent when the angular distributions for the $Mg^{26}(He^4, He^6)Mg^{24}$ reactions measured at 40-MeV bombarding energy are compared with the angular distributions for the $Mg^{26}(p, t)Mg^{24}$ reactions measured at 28-MeV bombarding energy. There appears to be a substantial difference in the differential cross sections for the two reactions. The cross section for the $Mg^{26}(p, t)Mg^{24}$ reaction to the ground state is one hundred times as

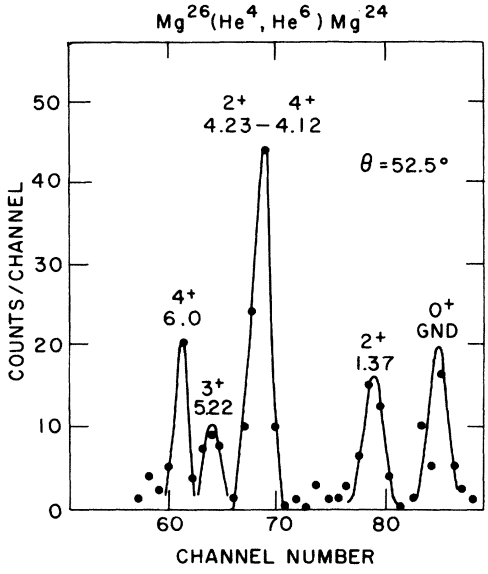

FIG. 1. Pulse-height distributions of He^6 particles produced in the $Mg^{26}(He^4, He^6)Mg^{24}$ reaction with 40-MeV alpha particles. The pulse-height analyzer was gated with pulses from a mass-identification circuit. The peaks have been labeled with the spin, parity, and excitation of the state produced in the residual Mg^{24} nucleus. The spectrum, taken at a laboratory angle of 52.5°, shows the strong excitation of the 3^+ unnatural-parity state at 5.22 MeV.

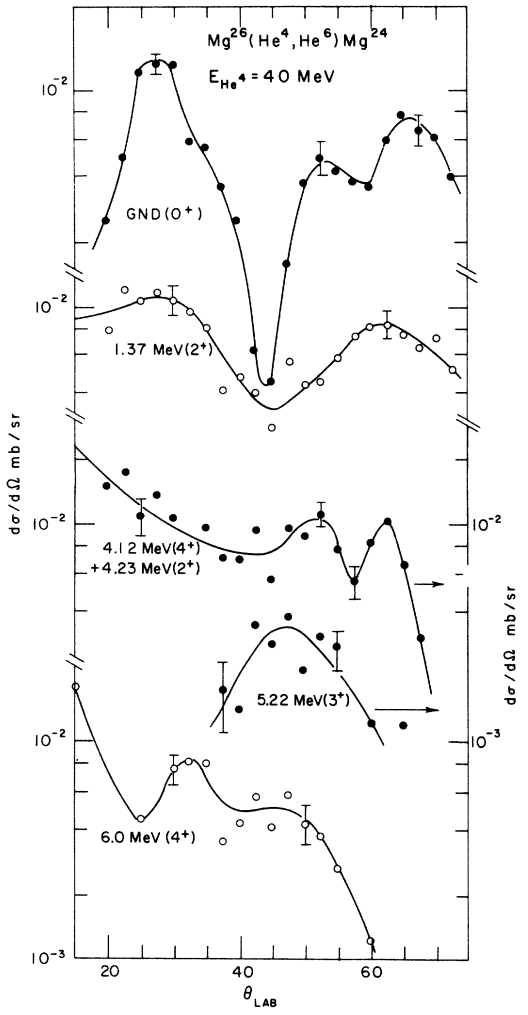

FIG. 2. Angular distributions for the $Mg^{26}(He^4, He^6)Mg^{24}$ reaction. The state in the residual Mg^{24} nucleus to which the reaction proceeds is shown on each curve. The error bars are for statistical errors only. The overall error in the absolute cross section is about ±25%.

large as the cross section for the $Mg^{26}(He^4, He^6)Mg^{24}$ reaction when compared at the first maximum in the angular distribution. The difference persists for most of the excited states examined, but the ratio does decrease as the excitation energy in the Mg^{24} residual nucleus increases. It may be that the (He^4, He^6) reaction accentuates higher angular-momentum transfers in a manner similar to that observed in the (He^3, He^4) reaction.[1]

The reason for the differences in the cross sections for the two reactions is not clear. The momentum transfer is approximately the same for both reactions. However, other quantities which are involved in a distorted-wave analysis, such as the optical-model parameters for He^6, are unknown and make an accurate theoretical comparison of the absolute cross sections for the two reactions difficult.

The 3^+ unnatural-parity state at 5.22-MeV excitation energy in Mg^{24} is very strong in the (He^4, He^6) reaction. The cross section is approximately equal to the ground-state cross section. In the case of the (p, t) reaction the cross section for the 3^+ state is 10^{-1} to 10^{-2} times less than that for the ground state.

The 0^+ state at 6.44 MeV is seen at several forward angles in the (He^4, He^6) reaction. It was not observed at all in the (p, t) reaction.

A group at 7.7-MeV excitation in Mg^{24} was produced in the (He^4, He^6) reaction with an intensity equal to that of the ground state at some angles. There are several closely spaced states in Mg^{24} at this excitation energy. The energy resolution of the present experiment was not good enough to resolve the individual states. Similar results were also found for the (p, t) reaction.

An overall comparison shows that there are rather striking differences between the $Mg^{26}(He^4, He^6)Mg^{24}$ and $Mg^{26}(p, t)Mg^{24}$ reactions. Further experimental work and a detailed theoretical interpretation of the results are necessary, but the work described here shows that the (He^4, He^6) reaction will be a valuable tool in the study of nuclear structure.

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