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Note

Continuous Energy Spectra of Deuterons in the $^3He+^2H$ Reaction Induced by 81.4 MeV ^3He

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A great number of experiments have been made for the search of excited states of ^3He. Recently Chang *et al.*[1] presented evidence on the existence of $T=1/2$ resonance in the ^3He system from measurements of radiative capture of protons by deuterons. This was interpreted as a broad resonance in ^3He at an excitation energy of 14.5 ± 0.5 MeV with a width of about 2 MeV. Additional evidence for the resonance near 15 MeV excitation in ^3He was presented by Arvieux *et al.*[2] following a study of a phase-shift analysis of nucleon-deuteron scattering cross sections in the energy range $0\sim 46$ MeV. It is interesting to ascertain the existence of this resonance by using other reactions. We report on results of preliminary experiments about the $^2H(^3He, d)^3He^*$ reaction at 81.4 MeV. This reaction has not yet been reported about searching for evidence of excited states in ^3He. By using this reaction, resonances in ^3He were searched for excitation energies up to 20 MeV.

The experiment was performed with an 81.4 MeV ^3He beam from the INS-FM cyclotron. The beam was transported on a target chamber through a beam analyzer magnet system. The beam intensity on the target was about 1 nA without debunching. Reaction particles were analyzed with a broad-range magnetic spectrometer using 200 proportional counters followed by scintillation counters.[3] Deuterons were separated from other particles by different $B\rho$-values due to reaction kinematics. However, the separation of tritons was not possible because $B\rho$-values of tritons are larger than those of deuterons in the present reaction. Firstly, a deuterated polyethylene (CD_2) foil of 4.87 mg/cm^2 in thickness was used as a target. Spectra of deuterons were measured at 6 and 10 degrees. Then, with a 5.64 mg/cm^2 thick carbon target, spectra were obtained at corresponding angles. The over-all energy resolution was about 400 keV (FWHM) for a peak of elastic scattering by deuteron, which was limited mainly by the energy loss in the target and the kinematical spread due to finite solid angle of the spectrometer.

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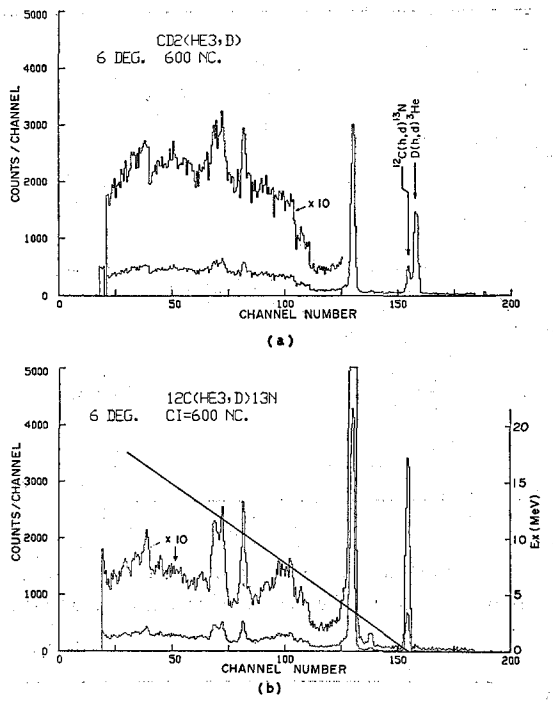

Fig. 1. Typical examples of deuteron spectra at 6°. Figure 1-a shows the spectrum of deuterons for the (^3He, d) reaction on a deuterated polyethylene (CD_2) target. Figure 1-b shows the spectrum of deuterons for the $^{12}C(^3He, d)^{13}N$ reaction. Line shows the relation between the channel number of the spectrometer and the excitation energy of ^{13}N.

Typical deuteron spectra from the CD_2 and C targets are shown in Fig. 1. The background of deuterons from carbon in the CD_2 target was subtracted using the spectra of the carbon target after normalizing deuteron peaks at the $^{12}C(^3He, d_{2,3})^{13}N$(3.51 and 3.56 MeV) reaction of both data. In order to smooth these data, yields of five channels were added.

Figures 2 and 3 show deuteron spectra obtained at 6 and 10 degrees respectively. Besides the continuous parts, the spectra show a number of discrete peaks. A large peak at the high energy side is deuteron scattered elastically by the incident ^3He. Two peaks at the low energy side can be assigned kinematically as proton and α particle from the $^2H(^3He, p)^4He$ reaction. The contamination of proton and α particle in deuteron spectra at the higher energies than these peaks can be neglected. The disturbance from tritons seems unimportant from small amount of the background at the higher energies than the deuteron peak of the elastic scattering.

The thresholds of two-body ($p+d$) and three-body ($p+p+n$) breakup of ^3He are shown in these figures. It is apparent that deuteron continua are almost structureless. So, there is no significant evidence for production of relatively strong resonance of ^3He. The present result implies some limit on its cross section, but does not necessarily exclude the existence of resonances.

The continua exhibit a broad maximum towards the high-energy end at 6° which

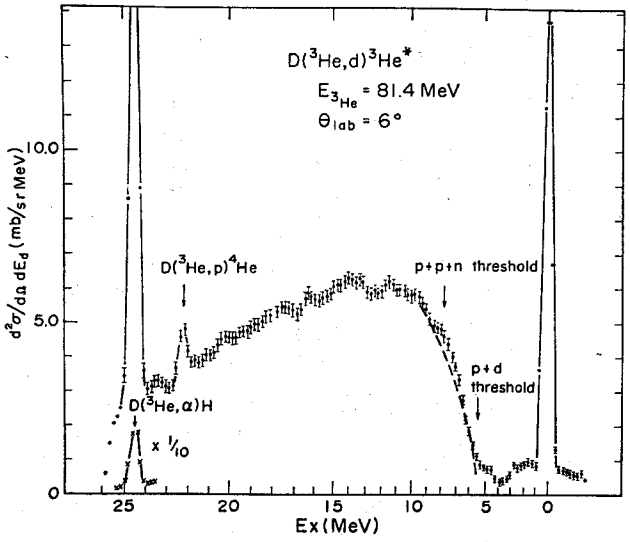

Fig. 2. Spectrum of deuterons from the ^{2}H(^{3}*He*, *d*)^{3}He* reaction at 6°. Dashed curve shows the density of phase space which was arbitrarily normalized.

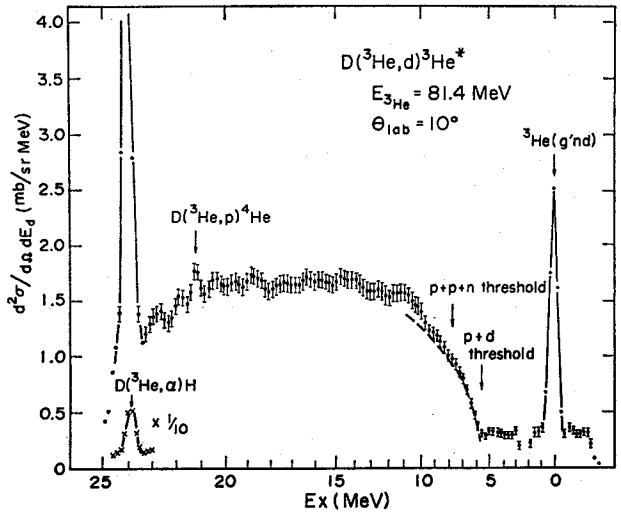

Fig. 3. The same as in Fig. 2 except for the different angle.

diminishes at 10°. Phase space factors which were arbitrarily normalized to data can explain the shape of spectra near thresholds, but can not reproduce the continua over the whole energy range. It would be valuable to pursue studies to investigate properties of the strongly populated continua. It is necessary to make a kinematically complete experiment to detect two or three particles.

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