4.5. Study of the $^{12}C(n, n)\,3\alpha$ reaction in a kinematically complete experiment

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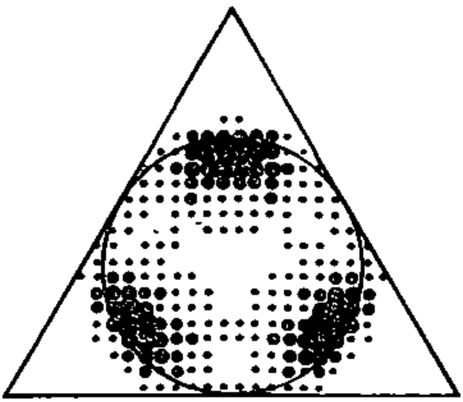
The reaction $n + {}^{12}C \rightarrow n + \alpha + \alpha + \alpha$ was investigates using nuclear emulsions simultaneously as a target and the detector. The reaction involves four particles in the final state; however the measurements of the three exit particles completely define the kinematics of the final channel. The three alpha prong events were measured and selected from other three prong processes in nuclear emulsion by the energy and momentum balance with the aid of an off-line CAE 90—40 computer code.



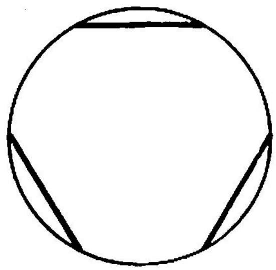


Fig. 1. Dalitz diagram of the three alpha breakup of the ^{12}C nucleus in the 9.6 MeV state. The loci of relative energies corresponding to the ground state of ^{8}Be are given in the lower scheme.

The neutron and alpha particle spectra in the ^{13}C centre-of-mass system as well as the spectrum of the n-alpha relative energies were analysed in order to define the contribution of different sequential processes:

1) $n + {}^{12}C \rightarrow n + {}^{12}C(\alpha)\,{}^{8}Be(2\alpha)$,

2) $n + {}^{12}C \rightarrow \alpha + {}^{9}Be(n)\,{}^{8}Be(2\alpha)$
$\rightarrow \alpha + {}^{9}Be(\alpha)\,{}^{5}He(\alpha n)$, and

3) $n + {}^{12}C \rightarrow {}^{8}Be(2\alpha) + {}^{5}He(\alpha n)$.

It was found that the $^{12}C(n, \alpha)^{9}Be(n)2\alpha$ reaction contributes only in the intermediate 2.43 MeV state of ^{9}Be. The presence of this reaction manifests as a distinct peak on the continuum of the three alpha energies generated in the process 1) The intensity of the sequential process via ^{9}Be is 9.8%, but due to the kinematical conditions it coincides only with the events of process 1) involving ^{12}C excitations higher than 11.5 MeV.

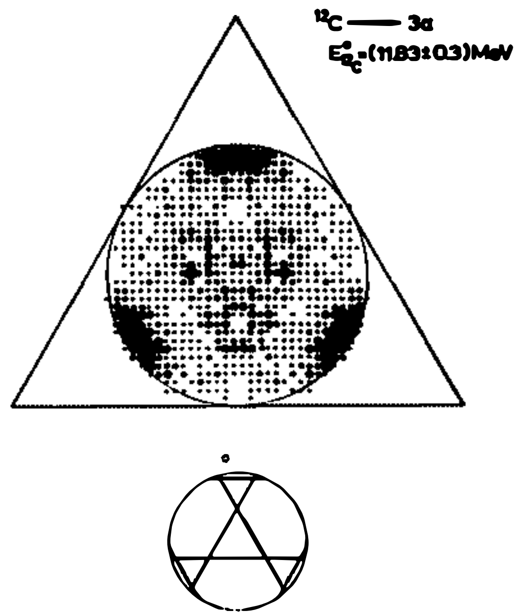


Fig. 2. Dalitz diagram of the three alpha breakup of the ^{12}C nucleus in the 11.8 MeV state. The loci of relative energies corresponding to the ground and first excited state of ^{8}Be are given in the lower sheme.

The overwhelming decay mode was found to be the $^{12}C \to 3\alpha$ chain of the process 1). The neutron energy spectrum exhibits a shape which is in accordance with the known level scheme of the ^{12}C nucleus. Hence the three correlation spectra were analysed for several ^{12}C resonances. Figs. 1 and 2 are representative Dalitz diagrams of the $^{12}C \to 3\alpha$ breakup involving the 9.6 and 11.8 MeV states of the ^{12}C nucleus.

The density distribution of the experimental data in Fig. 1 clearly demonstrates a sequential decay through the $^{8}Be_{g.s.}$ with the strong intensity peaks near the maximum energies of the three alphas. There is no trace of evidence for the simultaneous breakup to be present.

The data on the three alpha breakup of the 11.8 MeV state of ^{12}C nucleus presented in Fig. 2 show a high density of events along the lines corresponding to the transition via the ground state of ^{8}Be. A large part (~25%) of the ^{12}C(11.8 MeV) $\to 3\alpha$ decay process via the $^{8}Be_{g.s.}$ (0^{+}) contradicts the tentative 2^{-} spin-parity assignment[1], leaving 1^{-} as the only possible one. The spectrum also shows a very weak intensity of experimental points at the intersections of the two bands of the 2.9 MeV relative energies of ^{8}Be. These minima can be explained by the destructive interference effects.

References

1) F. Ajzenberg-Selove and T. Lauritsen, Nucl. Phys. A114 (1968) 1.

4.6. The three-nucleon bound state wave function from elastic electron scattering

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The theoretical investigation of the three-nucleon bound state wave function had a considerable success in the last few years. Nevertheless, the number of independent experimental data is less than the number of parameters we need to define the theoretical problem.

The cross section of the elastic electron scattering (defined as a product of Mott scattering cross section and the form factor of the nucleus) on ^4He and ^3He nuclei shows a diffraction minimum[1,2] in the region of squared momentum transfer $q^2 \sim 11(\mathrm{fm})^{-2}$.

These data are explained as the efect of the repulsive core in the two nucleon interaction to the three and four nucleon bound state wave function [3,4,5]. In the case of the three-nucleon bound state wave function situation somewhat complicates

TABLE

$q^2(\mathrm{fm})^{-2}$	$F_s(q^2)$	$F_{s-s}'(q^2)$
0	1.0000	0.0000
1	0.6497	—0.2029
2	0.4228	—0.2500
3	0.2768	—0.2351
4	0.1810	—0.1997
5	0.1175	—0.1611
6	0.0752	—0.1262
7	0.0469	—0.0971
8	0.0279	—0.0738
9	0.0152	—0.0555
10	0.0068	—0.0415
11	0.0013	—0.0308
12	—0.0023	—0.0227
13	—0.0045	—0.0166
14	—0.0057	—0.0121
15	—0.0064	—0.0087
16	—0.0066	—0.0061
17	—0.0065	—0.0043
18	—0.0063	—0.0030
19	—0.0059	—0.0020
20	—0.0054	—0.0013