Comments

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^{19}F(α, t)^{20}Ne reaction at 28.5 MeV*

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The measured ^{19}F(α, t)^{20}Ne angular distributions of Hansen *et al.* at 28.5 MeV to the first 0^+-2^+-4^+ states have been reanalyzed in terms of the collective-model coupled-channel Born-approximation theory. The "j-forbidden" 4^+ cross section at 4.247 MeV is well described by the theory, while the allowed transitions show little change from the distorted-wave Born-approximation results. Limited excitation-function measurements of the ^{19}F(α, t)^{20}Ne reaction from 25 to 26 MeV show little structure, indicating little compound contribution to the "allowed" and "j-forbidden" transitions.

[NUCLEAR REACTIONS ^{19}F(α, t) ^{20}Ne, $E = 28.5$ MeV; for first 0^+-2^+-4^+ calculated $\sigma(\theta)$, DWBA and CCBA; deduced S.]

To extend studies of the applicability of the collective-model coupled-channel Born approximation (CCBA) in the $2s$-$1d$ shell, a reanalysis of the ^{19}F(α, t)^{20}Ne data of Hansen *et al.*[1] at 28.5 MeV was performed in terms of the CCBA theory. Hansen *et al.*[1] applied only a distorted-wave Born-approximation (DWBA) analysis to the 0^+-2^+-4^+ members of the ground-state band. A study of the ^{19}F(^{3}He, d)^{20}Ne reaction[2] has shown that the "j-forbidden" 4^+ level at 4.247 MeV in ^{20}Ne is well described by CCBA, while the fits to the "allowed" 0^+ and 2^+ levels were somewhat improved over DWBA. As in the (^{3}He, d) case,[2] the 4^+ state in the (α, t) reaction has a large cross section, and is therefore most probably populated by multistep processes, since the g component in such a light nucleus can be estimated to be less than 3%. Furthermore, in the DWBA analysis of Hansen *et al.*[1] the absolute normalization of the theory D_0^2 was not known, so that only relative spectroscopic factors for the two allowed transitions were extracted. In the present work, absolute spectroscopic factors are compared to extracted ^{19}F(^{3}He, d)^{20}Ne and ^{19}F(d, n)^{20}Ne spectroscopic factors.

In addition, limited excitation-function measurements with two counter telescopes at 25 and 45° and in the energy range from 25 to 26 MeV show no structure, indicating little probable compound-nuclear contribution. This conclusion is further supported by the smooth behavior of more extensive excitation-function measurements for the ^{9}Be(α, t)^{10}B and ^{13}C(α, t)^{14}N reaction in this energy region.[3]

The angular distributions of Hansen *et al.*[1] leading to the 0^+, 2^+, and 4^+ states were reanalyzed in the present work in terms of the zero-range CCBA theory using the code MARS,[4] with deformed form factors calculated using the code NEPTUNE.[5] Nilsson-model transition amplitudes were taken from an analysis of the ^{19}F(^{3}He, d)^{20}Ne reaction[2] and divided by $\sqrt{2}$ since, in the present work, the projectile is spinless. For the optical-potential parameters with entrance and exit channels, the

TABLE I. Optical-model parameters in entrance, exit, and bound-state channels.

Parameter set	Channel	V^a (MeV)	r_0 (fm)	a_0 (fm)	W (MeV)	W_D (MeV)	r_i (fm)	a_i (fm)	r_c (fm)	V_{so} (MeV)	β_2	β_4
A	$\alpha + {}^{19}$F DWBA	191.	1.52	0.54	33.	0.	1.52	0.54	1.25	0.	0.	0.
B	$\alpha + {}^{19}$F CCBA	191.	1.52	0.54	30.	0.	1.52	0.54	1.25	0.	0.45	0.
C	$t + {}^{20}$Ne DWBA	147.	1.22	0.74	0.	22.	1.22	0.74	1.25	0.	0.	0.
D	$t + {}^{20}$Ne CCBA	147.	1.22	0.74	0.	18.	1.22	0.74	1.25	0.	0.45	0.
E	$p + {}^{19}$F DWBA	⋯	1.25	0.65	⋯	⋯	⋯	⋯	1.25	7.5	0.	0.
F	$p + {}^{19}$F CCBA	⋯	1.25	0.65	⋯	⋯	⋯	⋯	1.25	7.5	0.45	0.

[a] Adjusted to fit the appropriate separation energies for the bound-state channel.

"deeper" set of potentials used by Hansen *et al.*[1] were chosen, as these best fitted their DWBA analysis. Only the absorptive potentials were slightly reduced to account for explicit coupling to higher states. In the entrance channel, the $\frac{1}{2}^+$-$\frac{3}{2}^+$-$\frac{5}{2}^+$ ground-state band members were coupled, and the absorption was reduced from 33 to 30 MeV. In the exit channel, the 0^+-2^+-4^+ states were coupled and the absorption was reduced from 22 to 18 MeV, as this best fitted the 0^+-2^+-4^+ scattering[6] of ^{20}Ne by 17.83-MeV ^{3}He. A fractionally smaller reduction was taken in the entrance channel, since there the $\frac{3}{2}^+$-$\frac{5}{2}^+$ states in ^{19}F are assumed to be a proton hole coupled to the 2^+ state in ^{20}Ne, so that effectively only the 0^+-2^+ excitation is being considered. While high-energy (~100-MeV) α scattering[7] from ^{20}Ne has shown the presence of a hexadecapole moment, this mode of excitation is apparently not excited in 18-MeV ^{3}He scattering[6] and for this reason, β_4 was set equal to zero in the present work. A difference between the modes of excitation produced in high-energy α scattering and lower-energy α scattering (~28 MeV) has also been observed[8] for ^{28}Si and is not understood at the present time.

Parameters used in the present work are listed in Table I. Alternate triton potentials from ^{20}Ne(^{3}He, ^{3}He')^{20}Ne* and ^{19}F(^{3}He, d)^{20}Ne analyses[6,2] were tried, but these gave slightly inferior fits compared with the present choice.

The CCBA calculations are shown in Fig. 1 along with the DWBA results for comparison. The DWBA and CCBA fits to the $l=0$ ground-state transition are of about the same quality. The magnitude with both theories is seen to be overestimated at the forward angles by a factor of about 8, assuming a normalization constant[9] $D_0^2 = 46\times10^4$ MeV^2 fm^3. Severe angular momentum mismatch in the ^{19}F(α, t)^{20}Ne reaction does in fact inhibit $l=0$ transfer, suggesting the presence of nondirect or higher-order processes as seen by the large measured

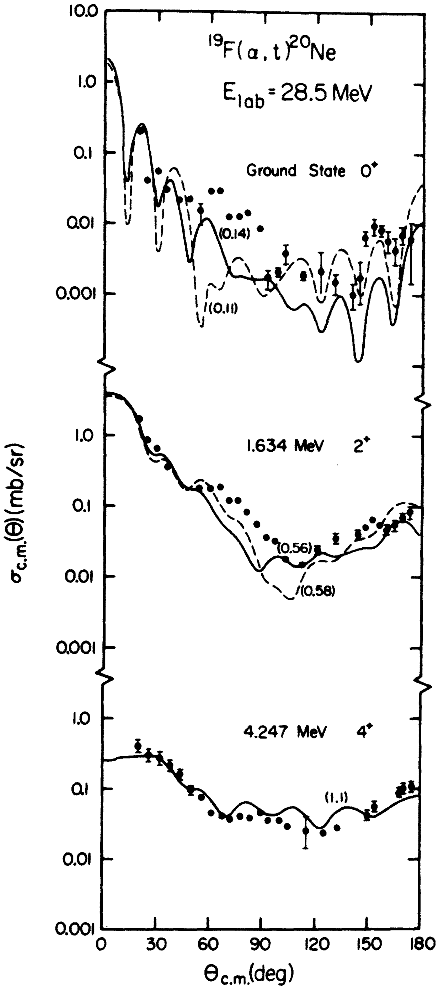

FIG. 1. Measured angular distributions for the ^{19}F(α,t)^{20}Ne reaction to the lowest 0^+-2^+-4^+ states at 28.5 MeV from Ref. 1. The dashed and solid curves correspond to DWBA and CCBA collective-model predictions with the parameters of Table I. The numbers in brackets indicate the renormalization of theory to data forward of 60°.

TABLE II. Spectroscopic results of the ^{19}F(α,t)^{20}Ne reaction and predictions of the models.

		CCBA C^2S		DWBA C^2S				Collective model[b]		Shell model[e]
E_x (MeV)	J^π	(α,t)[a] (28.5 MeV)	(^{3}He,d)[b] (21–23 MeV)	(α,t)[a] (28.5 MeV)	(^{3}He,d)[b] (21–23 MeV)	(^{3}He,d)[c] (10 MeV)	(d,n)[d] (3 MeV)	K^π	C^2S	C^2S
0.	0^+	0.08	0.43	0.06	0.30	0.31	0.62	0^+	0.59	0.72
1.634	2^+	0.16	0.38	0.16	0.42	0.62	0.70	0^+	0.28	0.43
4.247	4^+	0.0	0.0	0.0	0.0	≤0.21		0^+	0.0	0.0

[a] Here $C^2S = N(\Sigma A_j^2)/2$ where N is the renormalization of the theoretical predictions indicated in Fig. 1. The A_j are the direct transition spectroscopic amplitudes in Ref. 4.

[b] Reference 2.

[c] Reference 10.

[d] Reference 11.

[e] Reference 12.

backward-angle cross section. The 2^+ $l=2$ transition is better described in shape and magnitude by both DWBA and CCBA calculations. The theory is overestimated here in both cases by only a factor of 2. DWBA predictions for the 4^+ state are not shown since these would require an $l=4$ transition, as discussed above. The CCBA calculation predicts both the shape and magnitude of this state very well.

The derived spectroscopic factors are shown in Table II along with (^{3}He, d) and (d, n) results for comparison. The agreement with other work and with collective-model and shell-model theories is rather poor, perhaps because of severe angular momentum mismatch. The usefulness of the (α, t) reaction for spectroscopic purposes is therefore questionable in this case. Both DWBA and CCBA calculations give about the same results for the 0^+ and 2^+ states unlike the 20–23 MeV-(^{3}He, d) work[2] where the ground state 0^+ fit was noticeably improved with CCBA. Only the 4^+ level is improved with CCBA calculations in the present case.

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