Comments

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Study of the reaction $^{12}C(^{12}C,d)^{22}Na$†

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Excitation functions for the reaction $^{12}C(^{12}C, d)^{22}Na$ in the energy range 37–44 MeV (lab) are compared to those for the $^{12}C(^{12}C, p)^{23}Na$ reaction. Evidence is presented that the different channels "resonate" at different energies.

[NUCLEAR REACTIONS $^{12}C(^{12}C, d)$, $^{12}C(^{12}C, p)$. Measured $\sigma(E_d)$, $\sigma(E_p)$, for $\theta=0°$, $E(^{12}C)=37–44$ MeV.]

Excitation functions for reactions following the bombardment of ^{12}C by ^{12}C show considerable structure near 20 MeV (c.m.) which has been interpreted as statistical fluctuations[1] or as resonant structure.[2] Van Bibber, Cosman, Sperduto, Cormier, and Chin[2] have pointed out that the structure which exists at $E_{c.m.}=19.3$ MeV in the $^{12}C(^{12}C,p)^{23}Na^*$ reaction favors very strongly the emission of protons to selected high-lying states at excitation energies of 9.84 and 9.04 MeV. Recently, Cormier, Cosman, Grodzins, Hansen, Steadman, Van Bibber, and Young[3] have shown that the 9.84 and 9.04 MeV states are very likely members of the ground state rotational band with probable spins $\frac{17}{2}^+$ and $\frac{15}{2}^+$, respectively. Similar results have been demonstrated for the mirror reaction $^{12}C(^{12}C,n)^{23}Mg$.[4]

The purpose of this comment is to report that considerable resonance-like structure exists in the $^{12}C(^{12}C,d)^{22}Na$ excitation function which favors the emission of deuterons to the 7^+ member of the ground state rotational band of ^{22}Na. We also demonstrate that while there are many similarities to the structure reported by Van Bibber *et al.*,[2] there are also important differences.

A C^- beam was obtained from running CO gas in a direct extraction Penning-type ion source. The C^- beam was accelerated by the Florida State University FN tandem Van de Graaff accelerator. The 4^+ beam was selected and entered a target chamber which is provided with a facility for placing a Ge(Li) detector very close to the target.[5] The ^{12}C beam passed through a 60 ± 10 $\mu g/cm^2$ carbon foil and was stopped in a 160 ± 10 mg/cm^2 gold foil. Electron suppression was used for both the target and the stopping foil which were located 1.3 ± 0.1 cm apart. The beam current from the stopping foil was integrated. Immediately behind the gold stopping foil, protons and deuterons were detected in a ΔE-E solid state detector telescope which was placed so that it subtended a solid angle of approximately 70 msr; the center axis of the detector telescope was at an angle of 10° to the beam axis. Coincident γ rays were detected at 90° to the beam axis by a 35 cm^3 Ge(Li) detector at an incident

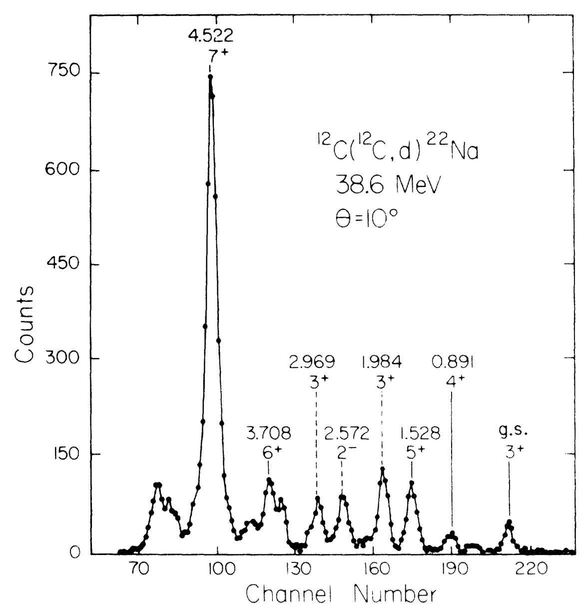

FIG. 1. Deuteron spectrum from the $^{12}C(^{12}C, d)^{22}Na$ reaction. Excitation energies for the prominent deuteron groups in the ground state rotational band are indicated with solid lines; others are indicated with dashed lines.

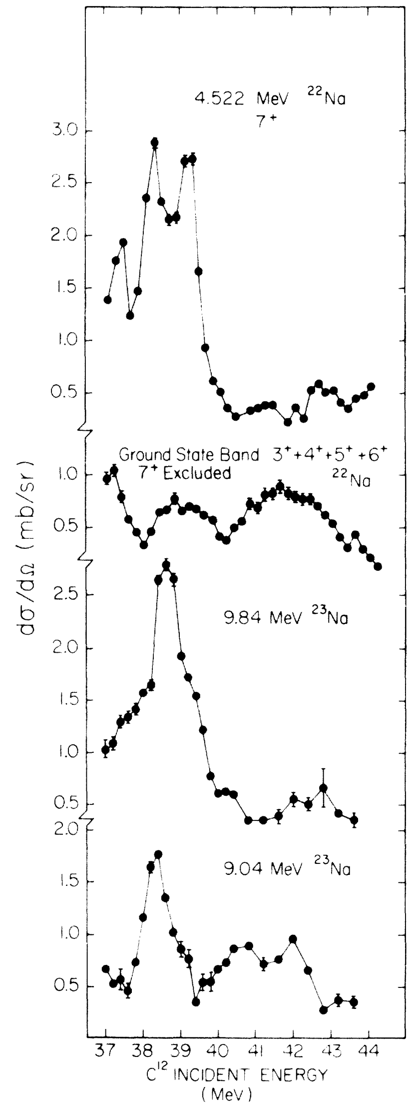

FIG. 2. Excitation functions for the $^{12}C(^{12}C, d)^{22}Na$ and $^{12}C(^{12}C, p)^{23}Na$ reactions for deuteron groups leading to the 4.52 MeV 7^+ state and other numbers of the ground state rotational band of ^{22}Na, and for proton groups leading to the 9.84 and 9.04 MeV states in ^{23}Na at $\theta = 0°$.

carbon beam energy of 38.6 MeV. Excitation functions could also be taken with this arrangement, in which case only the charged particle detector telescope was used at an angle of $\theta = 0°$ and solid angle of 1.16 ± 0.09 msr. A deuteron spectrum taken at 38.6 MeV is shown in Fig. 1.

The excitation functions for the proton groups previously observed,[2] the deuteron group leading to the 7^+ level in ^{22}Na at 4.52 MeV, and the sum of the excitation functions for the deuteron groups leading to other members of the ground state rotational band of ^{22}Na are shown in Fig. 2. The assignments of the deuteron groups to the respective members of the ground state rotational band was confirmed by the γ ray measurements. The absolute error in the cross sections indicated in Fig. 2 is about 28% due to inaccuracies in the target thickness and effective solid angle. The error bars represent fitting and statistical errors only. The relative magnitudes of the cross sections are in qualitative agreement with statistical model expectations.[6]

By far the most prominent structure observed in the excitation functions is that for the deuteron group leading to the 7^+ state in ^{22}Na. It appears to resonate close to, *but not exactly at,* the energy of the 38.6 MeV proton emitting structure. Since the proton and deuteron data were taken at the same time, there is no chance that the difference in apparent resonance energies arises from error in calibration or from energy drifting. There is much more structure in the deuteron excitation function than is seen in the proton channel, but it is not correlated with the proton channel. At this state of the analysis, we can only conclude that while the excitation functions and cross sections support the conjecture that the structure represents statistical fluctuations, it is interesting that prominent structures, favoring decay to high-spin members of rotational bands, appear so very close in energy for the two different channels. This suggests that perhaps there exists high-spin entrance channel structure in the energy region near 19.3 MeV in the center of mass.

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