Comments

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Dip in the $^{12}C(^{12}C, \alpha)^{20}Ne$ cross section at $E_{c.m.} = 19.2$ MeV†

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(Received 15 April 1974)

In most of the excitation functions for the $^{12}C(^{12}C, \alpha)^{20}Ne$ reaction to levels of ^{20}Ne below $E_x = 17$ MeV, a pronounced minimum occurs at a center-of-mass (c.m.) bombarding energy of 19.2 MeV. The c.m. width is 400–500 keV. This structure is very likely due to the resonance reported by Van Bibber *et al.* in the $^{12}C(^{12}C, p)^{23}Na$ reaction at an energy of 19.3 MeV, with a width of ~500 keV.

[NUCLEAR REACTIONS $^{12}C(^{12}C, \alpha)$, $E = 36–51$ MeV. Measured $\sigma(E)$ at $\theta = 5°$ (lab) for 22 levels.]

Excitation functions[1] of the $^{12}C(^{12}C, p)^{23}Na$ reaction show a pronounced resonance-like structure at a center-of-mass (c.m.) bombarding energy of $E_{c.m.} = 19.3$ MeV, with a width of about 500 keV in c.m. This resonance is most prominent for population of states at 9.07 and 9.84 MeV in ^{23}Na, but is also present for a number of other higher-lying states. The resonance has also been seen[2] in the $^{12}C(^{12}C, n)^{23}Mg$ reaction, as is expected from isospin conservation. We have measured excitation functions for the reaction $^{12}C(^{12}C, \alpha)^{20}Ne$, leading to a number of levels in ^{20}Ne, from $E_x = 0$ to $E_x = 17$ MeV. A number of prominent features appear, only one of which is discussed here, because of its bearing on the results of Ref. 1. A fuller discussion will appear elsewhere.[3] Most (about $\frac{2}{3}$) of the present excitation functions exhibit a minimum near 19.3 MeV. None show an increase in yield at that energy. The data and the results of two statistical analyses are displayed in Fig. 1. The top part of the figure contains the sum of 22 excitation functions measured at $\theta_{lab} = 5°$. These include excitation functions for states at excitation energies of 0.0, 1.63, 4.25, 4.97, 5.62, 5.78, 6.72, 7.01, 7.17–7.20, 7.42, 7.83, 8.45, 8.77, 9.04, 9.49, 9.99, 11.95, 12.16, 13.07, 13.34, 13.95, and 15.20 MeV. These include all the known states below 8 MeV excitation and all states above that energy that were excited strongly enough to allow data extraction. Within the experimental energy resolution (about 40 keV) many of the "levels" above ~10 MeV could include other nearby states. For example, the yield for the 11.95-MeV state could (and probably does) include contributions from two states—at 11.948 (8^+) and 11.953 (1^-).

The presence of a pronounced minimum at $E_{c.m.} = 19.2$ MeV is evident. Since this energy is within 100 keV of the $^{12}C(^{12}C, p)^{23}Na$ resonance (an energy difference of 100 keV is well within the combined uncertainties in the absolute energy calibration of the Brookhaven and Argonne tandem accelerators for heavy ions), and since the present structure also has a width of about 400 keV, they are probably due to the same phenomenon. A correlation analysis emphasizes the fact that this minimum is present in most of the excitation functions. In the

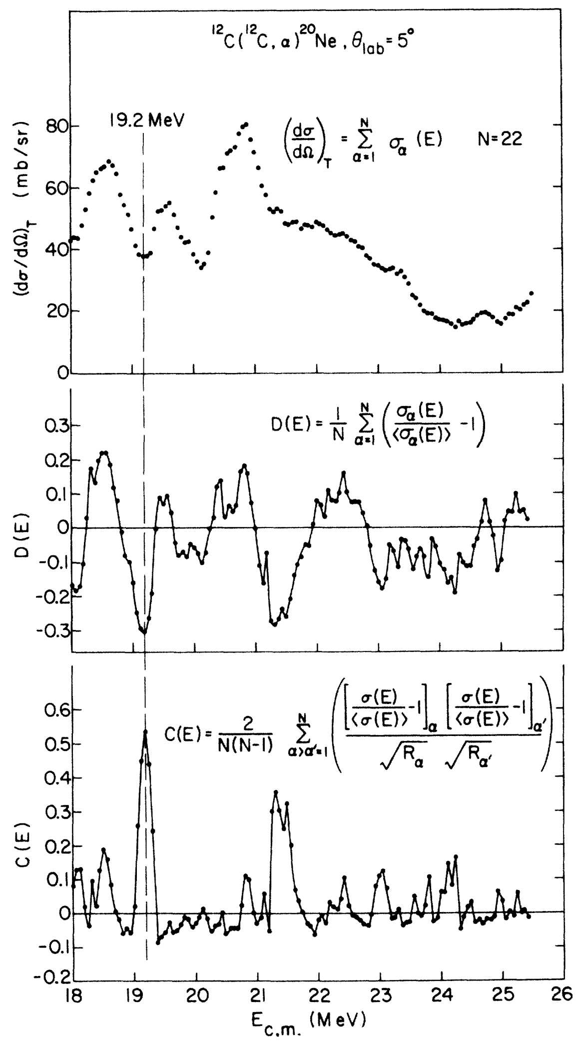

FIG. 1. Results of 22 excitation functions measured at $\theta_{lab}=5°$ for the $^{12}C(^{12}C,\alpha)^{20}Ne$ reactions plotted vs center-of-mass bombarding energy. The final states are listed in the text. Top: Summed cross section. Middle: Energy-dependent deviation function summed over the 22 excitation functions. Bottom: Energy-dependent cross correlation function summed over all 231 correlations.

middle of Fig. 1 is plotted the deviation function summed over the 22 yield curves:

$$D(E)=\frac{1}{22}\sum_{i=1}^{22}\left(\frac{\sigma_i(E)}{\langle\sigma_i(E)\rangle}-1\right),$$

where $\langle\sigma_i(E)\rangle$ is a running average over 25 data points ($\Delta E_{c.m.}=1.56$ MeV). Again the minimum is evident at 19.2 MeV, with a width consistent with the width of the $^{12}C(^{12}C,p)^{23}Na$ resonance.

Finally, we show in the bottom of Fig. 1 the energy-dependent cross-correlation function summed over all pairs of excitation functions:

$$C(E)=\frac{2}{22\times 21}\sum_{i>j=1}^{22}\frac{[\sigma(E)/\langle\sigma(E)\rangle-1]_i[\sigma(E)/\langle\sigma(E)\rangle-1]_j}{\sqrt{R_i}\sqrt{R_j}},$$

where R_i is the autocorrelation value for state i, evaluated over the entire bombarding-energy range. The presence of the correlated minimum at 19.2 MeV is especially striking here. (Even though the structure is a minimum in the excitation functions, the cross-correlation function for populating two states is positive if both possess the minimum.) The width of the spike at 19.2 MeV is 220 keV, consistent with a width of the underlying structure of ~400 keV.

A more complete analysis of this reaction, including the other prominent features that appear, is continuing and will be published elsewhere.[3] The agreement in energy and width of the 19.2-MeV structure with that seen in $^{12}C(^{12}C,p)^{23}Na$ make it very likely that they are both manifestations of the same resonance. The presence of minima in the yield for $^{12}C(^{12}C,\alpha)^{20}Ne$ implies that the proton channel is robbing the α channel of flux at this energy. This is consistent with the hypothesis of Ref. 1 that the resonance has a microscopic configuration that strongly favors proton decay to states of ^{23}Na. Further work is necessary to explain the puzzling properties of this resonance.

†Work supported by the U. S. Atomic Energy Commission and the National Science Foundation.

[1]K. Van Bibber *et al.*, Phys. Rev. Lett. 32, 687 (1974).
[2]P. Sperr *et al.*, to be published.
[3]L. R. Greenwood, R. E. Segel, H. T. Fortune, and J. R. Erskine, unpublished.