PHYSICAL REVIEW C, VOLUME 60, 067601

The ^{20}Ne(n,p) reaction at high momentum transfer

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(Received 6 May 1999; published 26 October 1999)

Proton spectra from the ^{20}Ne$(n,p)^{20}$F reaction induced by 298 MeV neutrons have been measured for angles between 14° and 32°, angles at which the excitation of the stretched 6^- states is expected to be observed. The results are presented and are compared with those from the ^{20}Ne(p,n) reaction study of Tamimi *et al.* [Phys. Rev. C **45**, 1005 (1990)] and the calculations of Carr *et al.* [Phys. Rev. C **45**, 1145 (1990)].
[S0556-2813(99)01011-0]

PACS number(s): 25.40.Kv, 27.30.+t

INTRODUCTION

Stretched states of the *sd*-shell nuclei, of spin-parity 6^-, have been studied in a number of reactions, including inelastic scattering of protons [1] and electrons [2] as well as the (*p,n*) charge exchange reaction [3]. The scattering reactions are characterized by high resolution and, in general, good statistical accuracy, while this charge exchange reaction has relatively poor energy resolution and, in general, lesser statistical accuracy.

Calculations of the fragmentation of 6^- strength in the $4n$ *sd*-shell nuclei have been made by Carr *et al.* [4]. They show quantitative agreement with experiment in the case of ^{28}Si, semiquantitative agreement in the case of ^{32}S, where the fragmentation of the 6^- strength is well predicted but the distribution of strength is not so well given.

The case of ^{20}Ne is of particular interest for two reasons. First, the calculations of Carr *et al.* [4] indicate little fragmentation of the strength, the major component being at 20.2 MeV of excitation and containing well over 90% of the total strength. Second, the (*p,n*) experiment of Tamimi *et al.* [3] on this target shows considerable fragmentation of 6^- strength, finding five components within the excitation energy range 6 to 11 MeV in the residual nucleus ^{20}Na. This paper reports a search for 6^- strength in ^{20}F via the ^{20}Ne(n,p) reaction which was carried out using the TRIUMF charge exchange facility [5].

EXPERIMENT

The neutron beam, of energy 298 MeV, was produced by the ^{7}Li(p,n) reaction, using 300 MeV protons from the TRIUMF cyclotron. The ^{20}Ne target was contained in a pressurized gas cell [6] which can be operated in one of two possible modes. One of these modes has two compartments, these being separated by a multiwire proportional counter. The other mode has just one compartment, of volume 180 cm^3; this latter mode was used in the present experiment. The pressure of the neon gas, isotopically enriched to 99.95% in ^{20}Ne, was at a pressure of 20 atmospheres. There was also a CH$_2$ target in the assembly in the target box; the isolated peak from the ^{1}H(n,p) reaction in the CH$_2$ provided the means of normalization of the cross section, the data from this target being collected simultaneously with the data from the ^{20}Ne target. Protons emitted from these targets then entered the MRS, and were momentum analyzed using the counter arrangement commonly in use with the CHARGEX facility. The overall resolution of this experiment, as determined from the ^{1}H(n,p) peak, was about 1.2 MeV.

The proton spectra from the ^{20}Ne(n,p) reaction were measured at six angles, namely, 14.9°, 18.5°, 21.9°, 25.3°, 28.7°, and 32.1° (laboratory system), covering the region where the angular distribution of protons populating the 6^- states of ^{20}F is expected to peak. There is also a 5^+ state in ^{20}F, at 1.82 MeV excitation, whose configuration is known to be predominantly a $[(1d5/2)^{-1}$proton$][(1d-5/2)$neutron$]$ ''stretched'' excitation. As will be seen below, this state was clearly seen in the data. The largest angle at which measurements were made (32.1° laboratory angle) was determined by a physical constraint in the laboratory.

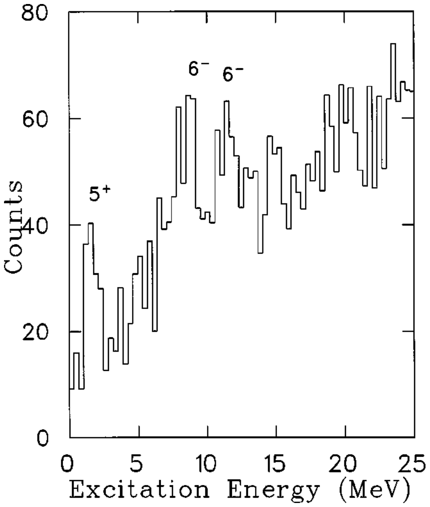

FIG. 1. The energy distribution of protons at 21° (laboratory angle) plotted against excitation energy in the residual nucleus, ^{20}F. The continuous quasifree spectrum is expected to go to zero at approximately 15 MeV excitation.

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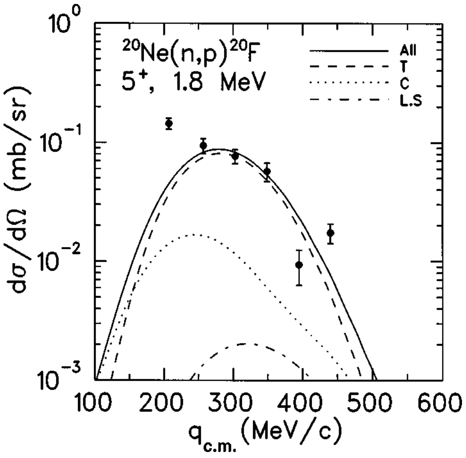

FIG. 2. The differential cross section of protons populating the 1.8 MeV (5^+) state in ^{20}F. The result of DWIA calculations is shown, using the Franey-Love effective interaction [7], and scaled to fit the data. The three dashed lines represent the contributions of the tensor force, the central force and the spin-orbit force, respectively, and the solid line is the sum of all contributions.

RESULTS

The proton spectrum measured at a laboratory angle of 21.9° and plotted against excitation energy in ^{20}F with bin widths of 0.35 MeV, is shown in Fig. 1. Three prominent peaks are evident in this spectrum. The peak corresponding to lowest excitation clearly corresponds to transitions to the 1.82 MeV (5^+) state in ^{20}F, while the other two, at excitation energies of 8.6 and 11.6 MeV, respectively, are candidates for the 6^- states. The differential cross sections for these three peaks are shown in Figs. 2 and 3, respectively. The differential cross sections are calculated in the DWIA, using the Franey-Love interaction [7], and scaled to fit the data. There is also an indication of a low excitation ‘‘shoulder’’ associated with the 8.6 MeV peak. It is proposed that the latter two features of the spectra be identified as corresponding to the peaks reported by Tamimi *et al.* [3] at 7.2 and 7.5 MeV, 8.9 MeV, and 10.8 MeV excitation. There is also a contribution to the proton yield in this experiment corresponding to excitation energies in ^{20}F above about 5 MeV (a smaller ‘‘shoulder’’), which could correspond to the weak peak observed by Tamimi *et al.* [3] at an excitation energy of about 6.1 MeV in ^{20}Na.

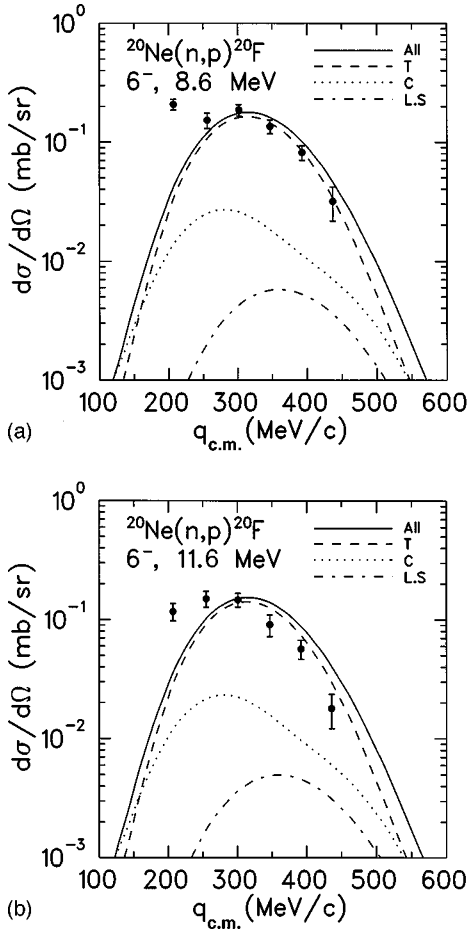

FIG. 3. The angular distributions of protons populating (a) the 8.6 MeV peak and (b) the 11.6 MeV peak in ^{20}F (both suggested as 6^- states). Again, the results of DWIA calculations are shown, using the Franey-Love effective interaction, and scaled to fit the data. The dashed lines again represent the contributions of the individual forces involved in the interaction.

Therefore, the results of this experiment do tend to support the findings of Tamimi *et al.* [3] that the 6^- strength in ^{20}Ne is more fragmented than would be indicated by the calculations of Carr *et al.* [4]. The strength distribution found in this experiment is in general agreement with that found by Tamimi *et al.* [3] insofar as one can make this comparison, given the vastly different resolutions of the two experiments. Certainly, the structure occurs in the same excitation region in ^{20}F, though the distribution of strength may well be somewhat different, as found by the two experiments. It is suggested that the basis restriction applied in the calculations of Carr *et al.* [4], namely, of one particle in the $1f_{7/2}$ orbit and unrestricted occupancy of the *sd*-shell orbits, may be too severe. In ^{20}Ne, it may be necessary to consider the $1p$-shell orbits not necessarily filled, at least to some approximation. This would, one might expect, lead to fragmentation of strength beyond that calculated by Carr *et al.* [4].

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