Single-Proton Strengths in 19F Through the (d, n) Reaction at 25 MeV

I. 2. Single-Proton Strengths in ^{19}F through the (d,n) Reaction at 25 MeV

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The ^{19}F nucleus, located at the lightest mass region in the 2s1d shell nuclei, has been described as the system which consists of the ^{16}O core and three valence nucleons. The properties of the positive parity states in ^{19}F can be compared with the results by the recently developed 2s1d-shell model wave functions[1]. However, since the ^{19}F nucleus is in the mass region near the limit for the application of the ^{16}O core plus three nucleons model, an effect arising from the limited model space truncated should be considered. The comparison of the level properties between experimental data and the shell model predictions would be one of the crucial tests of the model wave function. As such, we have carried out a study of the $^{18}O(d,n)^{19}F$ reaction at 25 MeV in order to obtain the single-proton strength for the states in ^{19}F, and to compare these experimental results with the 2s1d shell model predictions.

The experiment was performed using a 25 MeV deuteron beam obtained from the AVF cyclotron, and TOF facility[2] with a 44 m flight path at Cyclotron and Radioisotope Center, Tohoku University. The target used was the isotopically enriched ^{18}O gas (98.7 %).

The obtained neutron spectrum at $\theta_L = 10^o$ is shown in fig. 1. The states in an excitation energy range up to 15 MeV is observed. The energy resolution for neutrons leading to the low-lying states is 190 keV. Figure 2 shows the angular distributions of the differential cross sections, and the results predicted with the zero-range distorted-wave theory which includes s-wave deuteron breakup effects by means of the adiabatic approximation (ADBA) 3), including as well the finite-range and non-local corrections. ADBA calculations have been carried out with the code DWUCK4[4]. The potential parameters used in the present calculations have been taken from the systematic compilation of Becchetti and Greenlees[5] for proton, and Carlson et al.[6] for neutron. The results for the levels up to 8 MeV are presented in this report.

The present results are compared in table 1 with those of the (^{3}He,d) reaction studied by Schmidt and Duhm[7], and the 2s1d-shell model prediction[1]. These theoretical spectroscopic strengths have been obtained using the shell model code OXBASH[8]. Figure 3 shows the comparisons of the experimental strength distributions for each orbit with those obtained by shell model calculation. The present results well agree with the previous (^{3}He,d) work[7] except for the cases of 7.112 MeV and 7.540 MeV states. The 0.110 MeV, 1/2- and 1.459 MeV, 3/2- states are known to be hole states which have the mixed configurations mainly consisting of $(1p)^{-1}(2s1d)^4$ component. Unfortunately, in the present experiment, neutrons leading to these states have been masked by those exciting nearby strong peaks, while Schmidt and Duhm[7] have observed these 0.110 MeV and 1.459 MeV states and given a tentative assignment of $l = 1$ transition, suggesting incomplete occupancy of protons for both the $1p_{1/2}$ and $1p_{3/2}$ orbits in the ground state of ^{18}O.

Comparison of our results with the predictions of the 2s1d shell model calculations[1] indicates that the experimental strengths seem to be slightly smaller than the theoretical results, while the $1d_{5/2}$ strength distribution are successfully reproduced by the shell model. For the other orbits, especially for the $1d_{3/2}$ orbit, the significant single-particle strengths predicted in the higher excitation have not so far been resolved. Thus, the data analysis for $E_x > 8$ MeV is now in progress.

References

1) Wildenthal B.H., Progress in particle and nuclear physics, vol. 11 (Pergamon, NY, 1983) p5.
2) Orihara H., Nishihara S., Furukawa K., Kabasawa M., Kawamura T.,Takahashi Y., Nakagawa T., and Maeda K., Nucl. Instr. and Meth. **A257** (1987)189.
3) Wales G.L. and Johnson R.C., Nucl. Phys. **A274** (1976) 168.
4) Comfort J.R., extended version of DWUCK by Kunz P.D., unpublished.
5) Becchetti F.D. and Greenlees G.W., Phys. Rev. **182** (1969) 1190.
6) Carlson J.D. Zafiratos C.D. and Lind D.A., Nucl. Phys. **A249** (1975) 29.
7) Schmidt C. and Duhm H.H., Nucl. Phys. **A155** (1970) 644.
8) Brown B.A., Ormand W.E. and Winfield J.S., MSU version of OXBASH 82 by Etchegoyen A., Rae W.D.M. and Godwin N.S., unpublished.
9) Ajzenberg-Selove F., Nucl. Phys. **A392** (1983) 1.

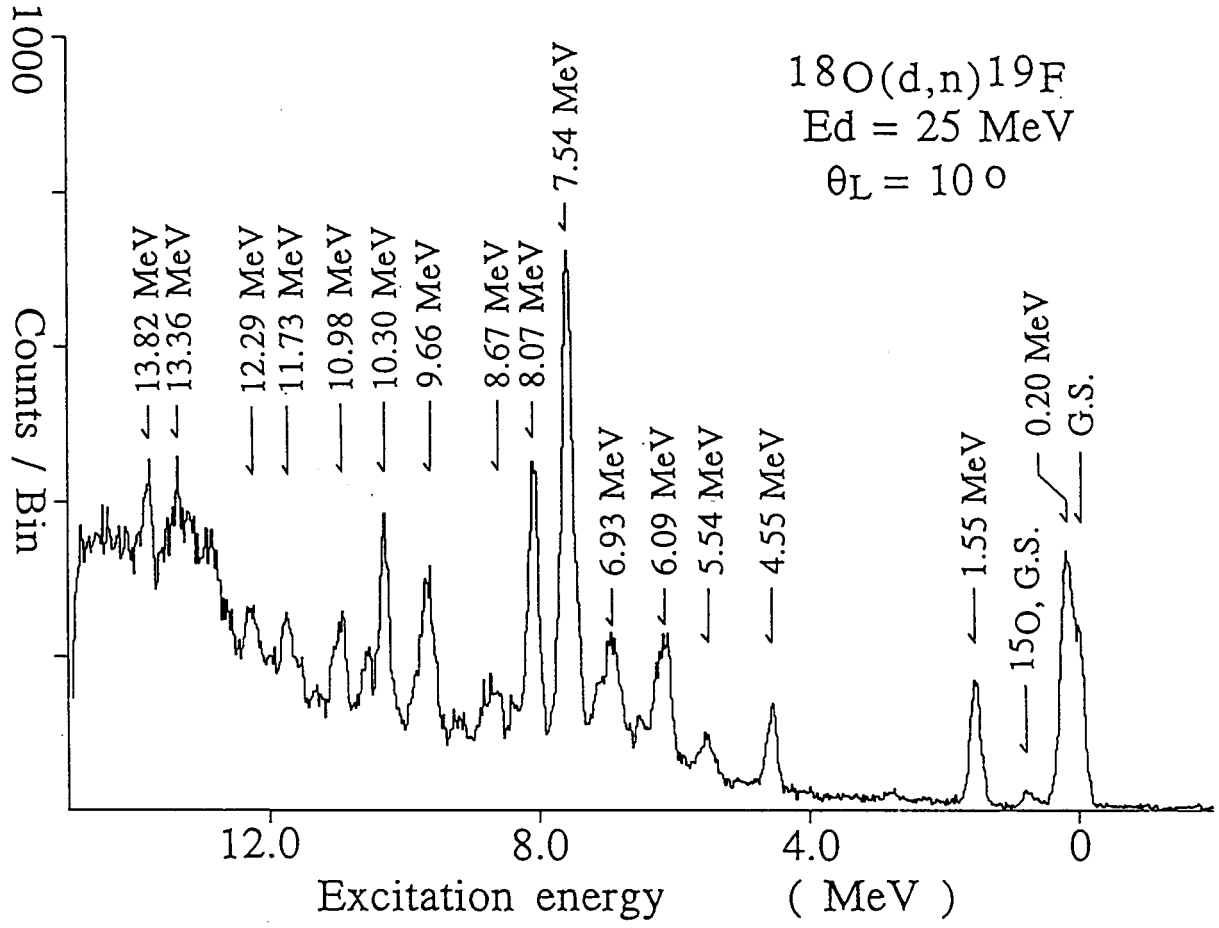

Fig. 1. Excitation energy neutron spectrum for the $^{18}O(d,n)^{19}F$ reaction at E_d = 25 MeV obtained at a laboratory angle of 10°. Energy per bin is 25 keV.

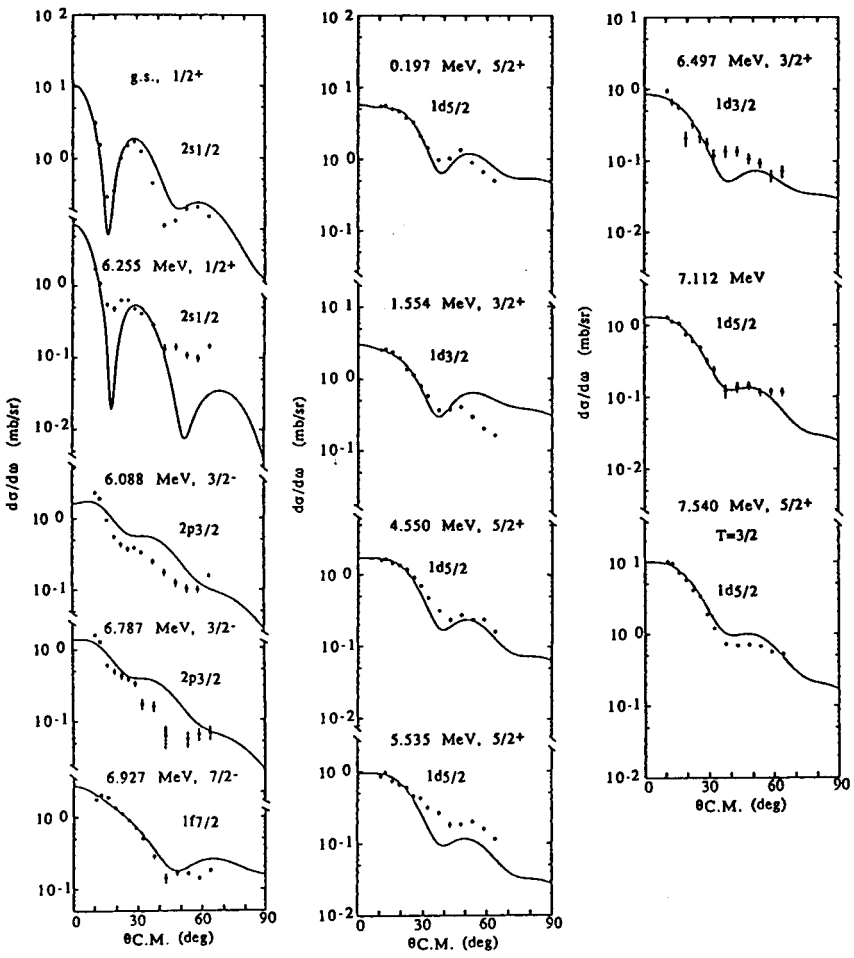

Fig. 2. Angular distributions of the differential cross sections for the $^{18}O(d,n)^{19}F$ reaction at Ed = 25 MeV.

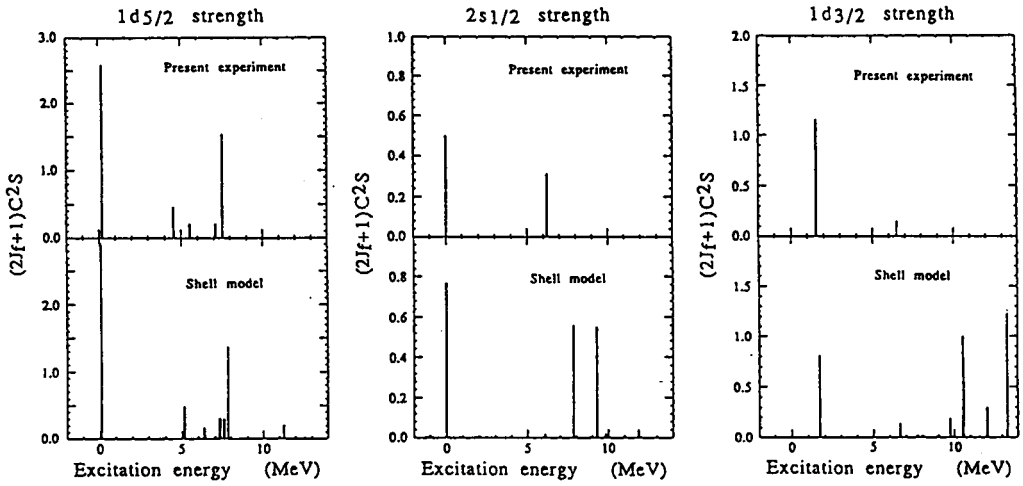

Fig. 3. Strength distributions of the 2s1d shells in ^{19}F. Experimental data summed up to $E_x = 8$ MeV are shown.