Comment on "Fragmentation of Stretched Spin Strength in ^{28}Si"

In a recent Letter, Carr, Bloom, Petrovich, and Philpott[1] presented new calculations of the fragmentation of the 6^- states in ^{28}Si. The authors conclude that the "fragmentation of the stretched states provides... a clear explanation of the observed properties of the 6^- states seen in elastic scattering from ^{28}Si." In this Comment we point out that there is still a significant problem with the ratio of the inelastic scattering strength to the single-particle transfer strength.

In Table I, we show the four measured quantities: the inelastic scattering strengths (Z_T^2) for the two isospin T states ($T=0,1$) and the ^{27}Al(^{3}He,d)^{28}Si $f_{7/2}$ proton spectroscopic factors (S_p^T). We also show the ratios Z_0^2/Z_1^2, S_p^0/S_p^1, and the double ratio: $Z_0^2 S_p^1/Z_1^2 S_p^0$. We have taken the individual inelastic strengths and spectroscopic factors from Ref. 1 which used averages of the data from several sources. However, the ratios can be determined more accurately from the experiments.

Our point is simply that the experimental double ratio is $0.31^{+0.04}_{-0.08}$. The earlier calculation of Amusa and Lawson[2] in the $(d_{5/2},s_{1/2})^{12}$ and $(d_{5/2},s_{1/2})^{11}\times(f_{7/2})$ model space, and the Carr *et al.* calculation in the $(d_{5/2},s_{1/2})^{12-n}(d_{3/2})^n$ and $(d_{5/2},s_{1/2})^{11-n}(d_{3/2})^n\times(f_{7/2})$ model space (where $n\leq 4$) give double ratios of 0.88 and 0.81, respectively. At the 20% level, the calculated inelastic strengths follow the $f_{7/2}$ single-particle strength.

There is no question that the inelastic and spectroscopic strengths are related. As long as isospin is a good quantum number then the inelastic matrix elements are just the following:

$$Z_T^2 = |\langle 6^-,T\,||\,(a^\dagger_{f_{7/2}}a_{d_{5/2}})6,T\,||\,0^+,0\rangle|^2\,,$$

$$Z_T^2 = \left|\sum_i \langle 6^-,T\,||\,a^\dagger_{f_{7/2}}\,||\,i\rangle\langle i\,||\,a_{d_{5/2}}\,||\,0^+,0\rangle\right|^2,$$

where $|i\rangle$ labels the intermediate $d_{5/2}$ hole strength in the $A=27$ nuclei. If the $d_{5/2}$ destruction operator is only connected to one state $|i\rangle$, then the series truncates at one term and the ratio of the inelastic strengths would simply be proportional to the corresponding $f_{7/2}$ spectroscopic factors. Pickup reactions certainly populate several states in ^{27}Al, but the fact that the ratio is close to unity seems to indicate that the calculations *do not* exhibit much interference between the various terms $|i\rangle$ in the sum. The calculated quenching appears to arise primarily from a reduction of the $d_{5/2}$ (common to both states) and $f_{7/2}$ single-particle matrix elements. We hope this can be investigated in detail in the calculations.

We have taken the ratio of inelastic strengths from pion scattering[3] where the process is dominated by the formation of the $\Delta_{3,3}$ resonance and the isospin strengths of the interaction are determined primarily by simple isospin Clebsch-Gordan coefficients. We take the ratio of spectroscopic strengths from the higher resolution work of Nann.[4] Perhaps the most serious uncertainty lies in the treatment of the unbound 6^- $T=1$ state in the reaction mechanism studied by Clausen[5] and Nann.[4] We have assigned a 10% relative error to this. Even if one uses the ratio of cross sections, the double ratio is 0.44, much less than those given by the calculations.

TABLE I. Measured properties of 6^- states in ^{28}Si compared to the results of Refs. 1 and 2.

Quantity	Experiment[a]	Amusa	Carr
Z_0^2	0.14 ± 0.04	0.258	0.203
S_p^0	0.42 ± 0.06	0.412	0.312
Z_1^2	0.33 ± 0.04	0.522	0.374
S_p^1	0.40 ± 0.04	0.736	0.466
Z_0^2/Z_1^2	$0.39^{+0.04}_{-0.08}$ [b]	0.494	0.542
S_p^0/S_p^1	1.25 ± 0.10 [c]	0.560	0.670
$Z_0^2S_p^1/S_p^0Z_1^2$	$0.31^{+0.04}_{-0.08}$ [d]	0.881	0.809

[a]Taken from Ref. 1 except where noted.
[b]Reference 3.
[c]Reference 4. This reference does not explicitly give a relative error. We have inferred 0.1 as an upper limit based on Figs. 4, 6, and 7 of this reference.
[d]Taken from two entries above.

In summary, we believe that the calculation of Carr *et al.* is an important step in attempting to understand the reduction of inelastic strength to the stretched spin states in ^{28}Si. We have highlighted a particular difficulty which it shares with the earlier calculation. Perhaps this signals a problem with the effective interaction used in both calculations. Or perhaps the degree of collectivity contained in the calculation does not correctly reflect the physical situation in the middle of the (sd) shell.

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