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den Herder et al. reply

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published in
Physical Review Letters
1988

DOI (link to publisher)
10.1103/PhysRevLett.60.1343

document version
Publisher's PDF, also known as Version of record

den Herder *et al.* Reply: The Comment by Perez on the results of our $(e,e'p)$ experiment[1] on ^{51}V basically criticizes the unexpected smallness of the summed spectroscopic strength $\sum S_{1f} = 1.11 \pm 0.14$ found for the transitions to the $(1f_{7/2})^2$ quadruplet in ^{50}Ti. This value is considered incompatible with both the independent-particle shell-model value $\sum S_{1f} = 3$ and with the result $\sum S_{1f} = 3 \pm 0.15$ of a spin-dependent sum-rule (SDSR) analysis[2] of pickup and stripping data. We first discuss the $(e,e'p)$ result.

The value $\sum S_{1f} = 1.1$ was obtained from distorted-wave impulse-approximation analysis with an approximate correction for Coulomb distortion of the electron wave functions[3] and with a proton current operator that is not gauge invariant. From a reanalysis of the momentum distributions with a recent code[4] that takes both effects into account, we obtain $\sum S_{1f} = 1.33 \pm 0.12$. However, this is not all $1f$ proton knockout strength in ^{51}V. For example, in discrete transitions between 5 and 8 MeV we find $\sum S_{1f} = 0.13$, i.e., 10% of the quadruplet strength, the same fraction as observed in a recent high-resolution $(d,{}^3\text{He})$ experiment.[5] The total $1f$ strength determined from an l decomposition[3] of our data in the excitation-energy region from 4 to 10 MeV is $\sum S_{1f} = 0.37 \pm 0.15$. Since we observe no additional strength (upper limit 0.05) between 10 and 20 MeV, we arrive at a summed spectroscopic strength ^{51}V of 1.7 ± 0.2, i.e., $(57 \pm 7)\%$ of the independent-particle shell-model sum-rule value.

The issue is how to interpret this number. The possible depletion of shell-model orbitals is an important one that has been the subject of a long-standing controversy.[6,7] Recent calculations in a correlated basis[8–10] yield a depletion of the occupation for states near the Fermi edge in the doubly magic nucleus ^{208}Pb of about (20–35)%. It would seem reasonable to assume that in the open-shell nucleus ^{51}V the depletion is not smaller than in ^{208}Pb. Hence, a fair estimate of the number of $1f$ protons in ^{51}V would be 2.0–2.4, which is not too far from the experimental value, especially if one realizes that these calculations also predict that because of short-range correlations some strength is scattered to (very) high excitation energies.

Now is this observation incompatible with a SDSR analysis? We think not. The sum-rule analysis, as mentioned by Perez himself, may be blind to orbit depletions or unobserved strength provided that a particular spin dependence is assumed. In fact Perez gets good agreement with both $\langle J_r \rangle$ and $\langle Q \rangle$ by taking into account the strength in the quadruplet only, leaving out the experimentally found[1,5] strength in higher-lying states. Moreover, as pointed out by Clement,[11] the calculated quadrupole moment $\langle Q \rangle$ is very sensitive to small $2p$ admixtures. As a result the calculated $\langle Q \rangle$ varies between -0.024 and -0.041. At present, experiment has not determined the amount of $2p$ pickup strength with sufficient accuracy.

In conclusion, we believe that the strength of 1.7 found in our experiment is not unreasonable compared with theoretical estimates, and, given the uncertainties[7,12] in the SDSR analysis due to unobserved stripping strength, not incompatible with Perez's analysis. Nevertheless one should be open to the possibility that the distorted-wave impulse-approximation description of the $(e,e'p)$ reaction process can be improved. Preliminary studies of the final-state interaction[3,13] show no larger effects than 10% on the deduced spectroscopic factors. Results obtained for the virtual-photon–proton coupling[14] indicate that the observed deviation from the impulse approximation is not larger than (10–20)%. An extensive investigation of the $(e,e'p)$ reaction mechanism is presently undertaken at Sektie Kernfysica, Nationaal Instituut voor Kernfysica en Hage-Energiefysica, in order to study these effects in greater detail.

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Received 25 August 1987
PACS numbers: 25.30.Fj, 21.10.Jx, 27.40.+z

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