HOLE STATES OBSERVED IN THE ^{28}Si(p,d) REACTION

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Analyses have been completed of the data obtained for 52 states or groups of states up to 11.42 MeV in ^{27}Si excited by the ^{28}Si(p,d)^{27}Si reaction at E_p=95.3 MeV, and for 55 states or groups of states up to 12.50 MeV excitation in ^{27}Si observed at E_p=136.2 MeV. Excitation energies have been extracted for all of these groups, over 30 of which are not included in the Endt and van der Leun compilation.[1] Cross sections were extracted at 2^o or 4^o intervals between 6^o and 60^o lab angle for states up to 7 MeV excitation, and at 4^o intervals between 8^o and 44^o lab angle for higher states. Preliminary results on early data taken in this experiment have been reported previously.[2] For reference, a description of the experimental method and final results for the ^{24}Mg(p,d)^{23}Mg reaction at E_p=94.8 MeV, for which part of the data were taken in parallel with the Si(p,d) work here being reported, has been published.[3]

Figures 1 and 2 display sample angular distributions obtained in this work for known low-lying states in ^{27}Si at the two bombarding energies employed. The ℓ=0, 1, and 2 pickup states all show a rapid drop with angle, with the expected steeper slope at E_p=136.2 MeV. When these low-lying states are plotted as a function of momentum transfer, the cross sections show similar slopes and magnitudes in the range from 350 to 600 MeV/c. A distinctive oscillation is observed only for the known ℓ=0 transition. The ℓ=1 and ℓ=2 transitions may be distinguished[3] by the turndown at small angles observed for the ℓ=2 cases, especially at E_p=95.3 MeV. Presumed two-step transitions show a broad maximum above 15^o lab, as characterized by the angular distributions shown for the $7/2^+$, 2.16 MeV state.

Some assignments for higher states can be inferred by comparison with the sample angular distributions shown in Figs. 1 and 2. The state in ^{27}Si at 4.474 MeV[1] exhibits an angular distribution essentially identical to that of the 2.16 MeV state, suggesting a $7/2^+$ assignment, which corresponds to the assignment[1] for the 4.580 MeV state in the mirror ^{27}Al nucleus. Also, ℓ=2 angular distributions are observed for the 5.066

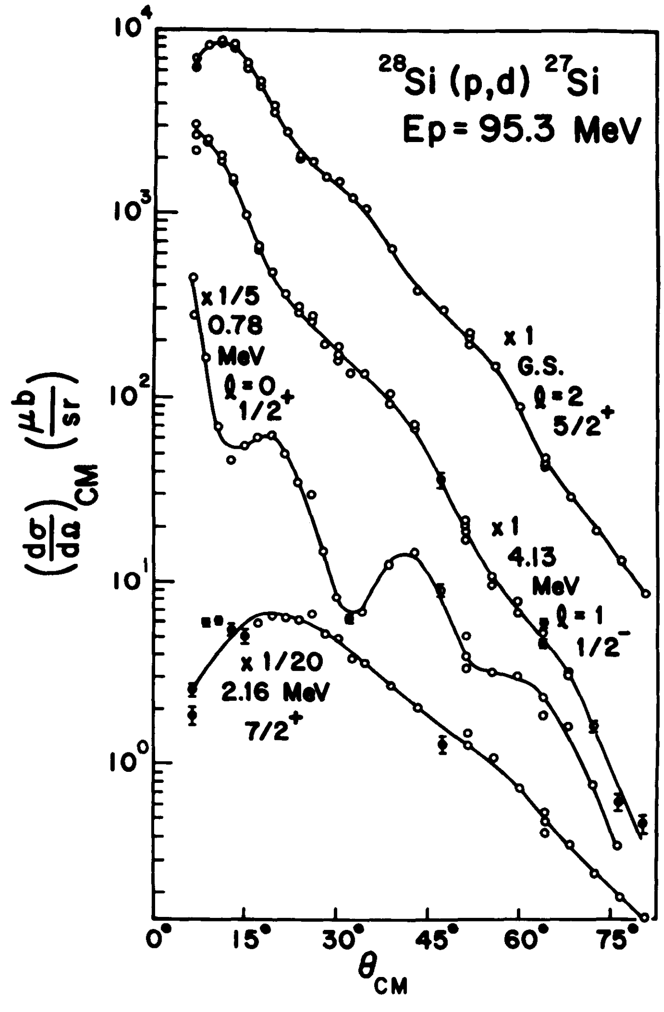

Figure 1. Angular distributions for the ^{28}Si(p,d)^{27}Si reaction at 95.3 MeV proton bombarding energy. The curves are a guide to the eye.

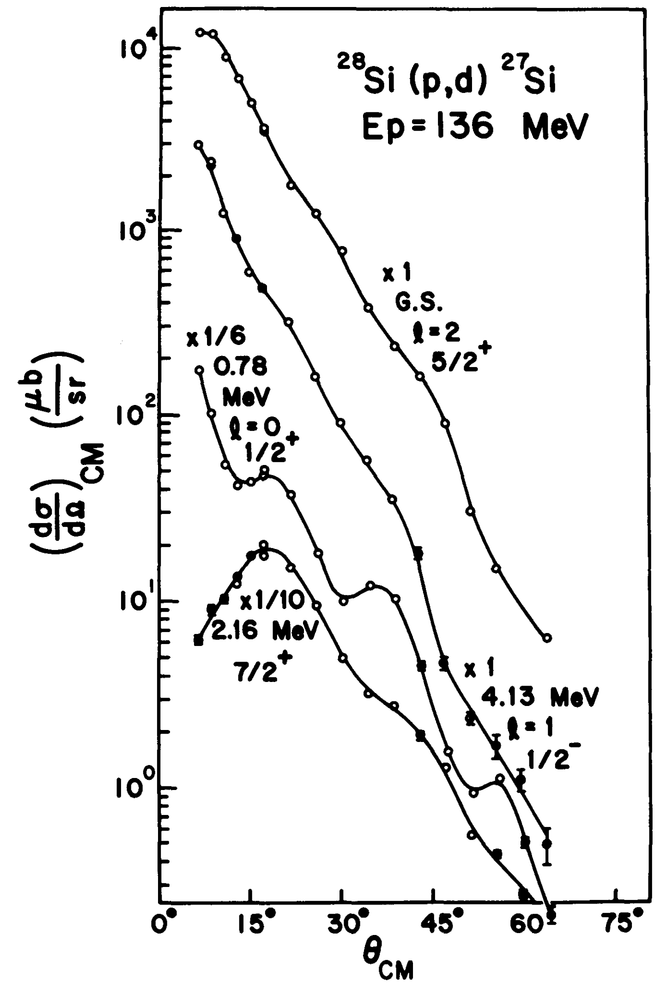

Figure 2. Angular distributions for the $^{28}Si(p,d)^{27}Si$ reaction at 136 proton bombarding energy. The curves are a guide to the eye.

and 5.400 MeV states of ^{27}Si, which may correspond to the ^{27}Al states at 5.248 and 5.438 or 5.551 MeV. Possible assignments of ℓ=0 to a group at 6.04 MeV and $5/2^-$ to a group at 6.51 MeV excitation are also suggested.

Figure 3 shows spectra obtained at the lowest and highest momentum transfers over the full excitation range studied in this work, at E_p=95.3 MeV and $\theta_{lab}=8^o$ (q$\approx$100 MeV/c), and E_p=136.2 MeV and $\theta_{lab}=48^o$ (q$\approx$500 MeV/c). Assignments to groups corresponding to deep-hole states are difficult because of what appear to be large two-step contributions, probably from unresolved states. Among the strong groups observed in Fig. 3 at forward angles, the major contributions to the 8.67 and 10.03 MeV groups appear to be ℓ=2, while an ℓ=1 contribution seems to dominate the 12.50 MeV group. A number of the groups appearing in the large angle spectrum in Fig. 3 appear to include two-step processes and drop off very slowly with momentum transfer. For example, the 6.34 MeV group peaks at forward angles with an ℓ=2 shape, in agreement with the assignment[1] to the 6.343 MeV state. However, it drops off so slowly at larger angles that an unresolved two-step or high-spin state must contribute strongly. A similar behavior is noted for the 9.62 MeV group, which behaves as ℓ=1 or ℓ=2 at forward angles, but drops off slowly at large angles with the suggestion of a secondary peak at a momentum transfer of about 250 MeV/c. Groups at 8.37 and 9.00 MeV apparently have at least two strong states contributing, since both show apparent ℓ=1 behavior at small momentum transfers, with a secondary peak at about 270-300 MeV/c. Of special interest are the pronounced 7.12 and 11.65 MeV groups in the top spectrum of Fig. 3, which are probably dominated by high-spin states excited in two-step processes, since they both peak at large momentum transfers between 330 and 360 MeV/c. Simiarly, groups at 7.03, 7.24, 7.67 and 8.18 MeV excitation all show maxima at momentum transfers of about 275 MeV/c.

1) P.M. Endt and C. van der Leun, Nucl. Phys. A310, 1 (1978).

2) Indiana University Cyclotron Facility Technical and Scientific Report, Nov. 1, 1975 to Jan. 31, 1977 (unpublished) p. 37. Also D.W. Miller, D.W. Devins, R.E. Pollock, and R. Kouzes, Bull. Am. Phys. Soc. 21, 978 (1976).

3) D.W. Miller, W.P. Jones, D.W. Devins, R.E. Marrs, and J. Kehayias, Phys. Rev. C 20, 2008 (1979).

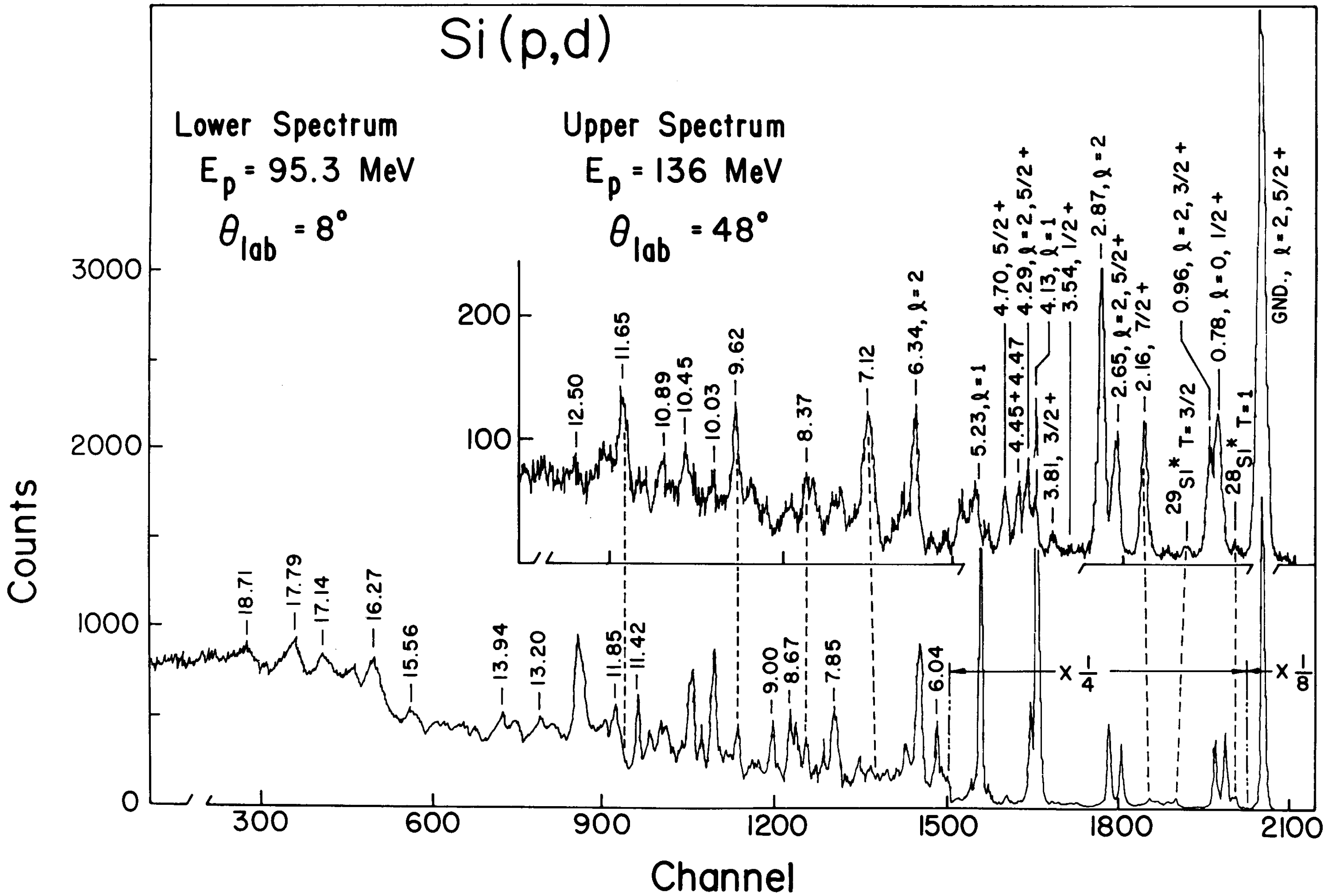

Figure 3. *Comparison of spectra from the* $^{28}Si(p,d)^{27}Si$ *reaction for the largest (upper plot) and smallest (lower plot) momentum transfer. Corresponding states in both spectra are labelled by excitation energy (MeV) and spin/parity assignment where known.*

DEEP HOLE STATES IN MEDIUM MASS NUCLEI

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Studies of deep hole states by single nucleon transfer reactions are limited by the fact that the angular distributions in general determine only the ℓ of the transferred neutron but not the J. However, Distorted Wave calculations of the analyzing power in (p,d) reactions using polarized protons imply that these analyzing powers should be a very good signature of the J of the final state. Earlier measurements of the (p,d) reaction at 90 MeV on a series of Sn isotopes showed that the deep hole states at 5 and 8 MeV