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DEUTERON PROJECTILE BREAKUP ON ^{28}Si AT E_d=17.85 MeV

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ABSTRACT

Deuteron breakup on ^{28}Si has been studied at 17.85 MeV using both singles and p-n coincidence techniques. Angular correlation data were obtained between 144 and -144 for protons and between 120 and -120 for neutrons. These results allow the separation of the breakup reaction into elastic, inelastic, and absorptive parts, and the determination of the contribution of each part to the reaction cross-section.

The first discovered and most frequently studied projectile breakup process is that of the deuteron. At energies of 190[1] and 56[2] MeV the features of the breakup process are similar to those observed in the breakup of ^3He[3-5]. The most common technique used to study deuteron breakup has been the measurement of the inclusive (d,p) reaction spectra. Kleinfeller _et al_[6] have recently measured this reaction at low energies. So far only a few angular correlation studies of the (d,pn) reaction have been made.

In this paper we present measurements of the 17.85 MeV $^{28}Si(d,pn)$ reaction carried out at the AVF cyclotron at the University of Colorado. At only 9 MeV per nucleon, this reaction is near the low-energy limit for the application of direct reaction, and therefore of direct breakup, models. The measurements should therefore provide a strong test of such models. The Si target was chosen because its ground and first-excited states are easily separated even with short pathlength time of flight measurements, and because the long-range Coulomb breakup mechanism is not expected to be dominant in such a light nucleus.

Fig. 1 shows the inclusive proton spectrum at 10°. This spectrum exhibits a continuum structure as well as discrete states up to an excitation of 15 MeV. The continuum structure may be divided into a bump visible at forward angles and a tail that is visible even at 144°. It is clear from this singles spectrum that high resolution in the proton detector is needed in order to distinguish between the discrete states and the continuum part of the spectrum.

Fig. 2 shows the total kinetic energy (TKE) spectra at θ_n=-12.5°and θ_p=+/-12.5° together with projected proton spectra in coincidence with both neutrons and certain gates in the relevant TKE spectrum. It follows from the TKE spectra that the dominant reactions at forward angles are elastic and inelastic breakup. The projected proton spectra clearly indicate the large contributions to the TKE spectra of either (d,n) transitions to proton unbound states or (d,p) transitions to neutron unbound states. Insufficient proton energy resolution may easily result in an overestimate of the cross-section of the projectile breakup process by a factor of two.

Fig. 3 shows the angular correlation for the elastic breakup process with θ_n fixed at -12.5° and θ_p variable. Similar angular correlations have been obtained for inelastic breakup to the 1.78 MeV 2^+ state of ^{28}Si. Correlations were also measured with the proton detector fixed at -12.5° and

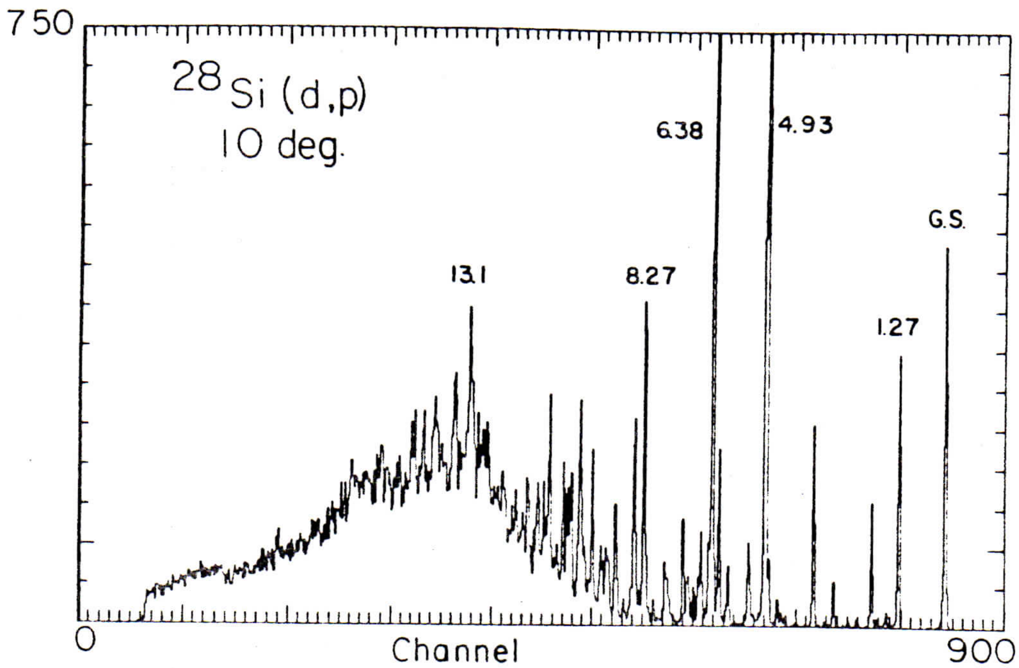

Fig. 1: Proton singles spectrum at 10 .

the neutron detector variable. All of the direct breakup correlations are similar in shape; they show a peak for detectors on opposite sides of the beam. The correlations with θ_n fixed show a second maximum at $\theta_p=50°$. This maximum is absent in the fixed-proton correlations. This situation is similar to that of the p-d correlations measured in the 52 MeV breakup of ^{3}He on ^{28}Si. In this case it was found that the correlation with θ_d fixed showed a secondary maximum at $\theta_p=45°$, while the correlation with θ_p fixed showed no secod maximum[4,5]. For ^{3}He breakup the angular correlations could be reproduced by calculations using the quasi-free breakup model (QFBM) with the proton a spectator[4]. Such calculations are presently being used to determine which particle is the dominant spectator in the breakup of the deuteron.

A correlation was also obtained with the neutron counter fixed and gates set on the region of the TKE spectrum above the 1.78 MeV state in ^{28}Si excitation. This correlation has a single maximum at about 12°, and a FWHM of about 50°.

Integrating the angular correlations over the angular range allows a comparison with the inclusive breakup cross-section at 12.5°. The

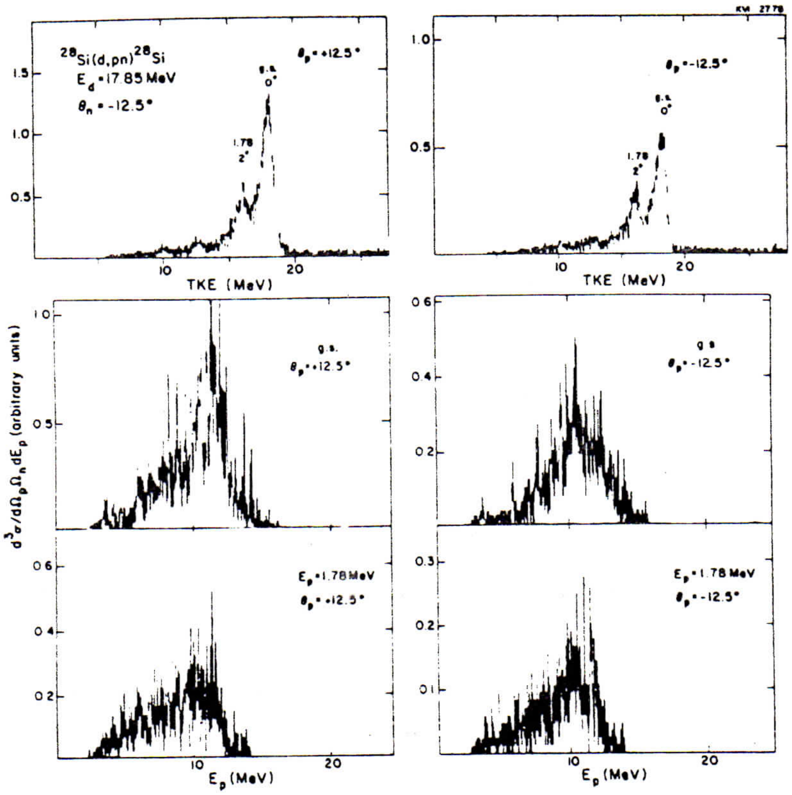

Fig. 2: TKE and projected proton spectra.

preliminary results are listed in table 1. From table 1 it may be concluded that the elastic and inelastic breakup together contribute about 20% of the cross-section, with the rest being absorptive breakup.

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REFERENCES

1. R. Serber, Phys. Rev. 72 (1947) 1008
2. N. Matsuoka et al, Nucl. Phys. A391 (1983) 357
3. E. H. L. Aarts et al, Phys. Lett. 105B (1981) 130
4. E. H. L. Aarts et al, Nucl. Phys. A380 (1982) 465
5. E. H. L. Aarts et al, to be published
6. J. Kleinfeller et al, Nucl. Phys. A370 (1981) 205

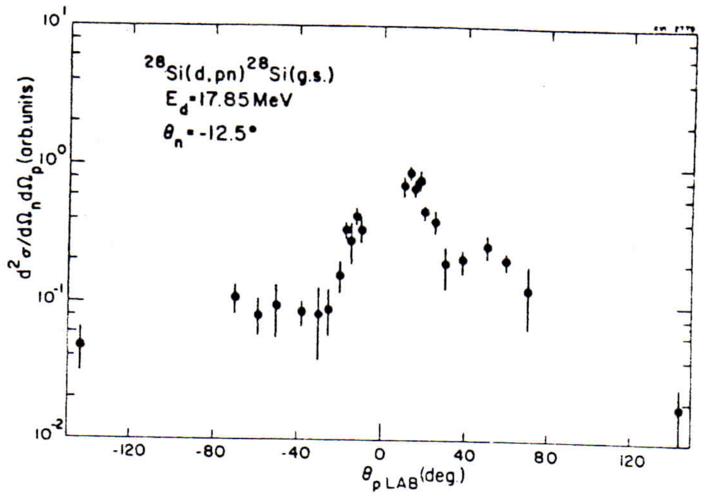

Fig. 3: Proton angular correlation.

Table 1

Comparison of proton and neutron breakup bump cross-sections at 12.5° together with cross sections obtained from the angular correlation measurements.

$\theta_n = -12.5°$:

Elastic:	14+/-3
Inelastic:	11+/-3
Absorptive:	85+/-10
Total:	110+/-16

Singles neutron continuum bump: 100+/-50

$\theta_p = -12.5°$:

Elastic:	17+/-4
Inelastic:	9+/-4
Absorptive:	(unmeasured)
Total:	26+/-6

Singles proton continuum bump: 148+/-20