THE (d,p) REACTION ON ^{208}Pb AND ^{28}Si AT E_d = 75 MeV

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Angular distributions in the range $4° \leq \theta_{lab} \leq 65°$ have been measured for the reactions ^{208}Pb(d,p) and ^{28}Si(d,p) at E_d = 75 MeV, with a proton energy resolution of 60-90 keV. The aim is to determine whether a DWBA analysis of these results can yield meaningful information on the shape and strength of the bound-neutron wave functions in a region of high momentum transfer (up to ≈500 MeV/c) which is also sampled in near-threshold (p,π^+) reactions.

The measurements were made using the QDDM spectrograph and self-supporting targets 5-10 mg/cm^2 thick. Representative energy spectra are shown in Fig. 1. We observe selective population of sharp states in ^{29}Si up to $E_x \simeq 12$ MeV, well above the excitation at which the states become neutron-unbound; on the other hand, little structure is seen in the continuum region of the Pb spectrum. In addition to the seven well-known single-particle states at $E_x \leq 2.5$ MeV in ^{209}Pb, we observe several states between 3 and 4 MeV excitation which are believed to correspond$^{1)}$ to fragments of $1j_{15/2}$ or $2h_{11/2}$ strength.

One potential obstacle to the extraction of spectroscopic information is the possible role of multi-step reaction mechanisms at high momentum transfer. Several features of the present data suggest that this role is no more important than at low bombarding energies. For example, the known$^{1)}$ two-particle one-hole states at E_x = 2.15 and 2.32 MeV in ^{209}Pb are populated very weakly over the whole angular range. In addition, as illustrated in Fig. 2, the angular distributions for states of the same spin and parity, but of quite different structure, are very similar. According to Kovar et al.$^{1)}$, the $15/2^-$ states of ^{209}Pb at E_x = 1.42 MeV and E_x = 3.05 MeV account, respectively, for ≈60-75% and ≈7-9% of the $1j_{15/2}$ single-particle strength; the dominant configuration in the 3.05-MeV state is expected to consist of a $g_{9/2}$ neutron added to the 3^- first-excited state of ^{208}Pb. As can be seen from Fig. 2a, not only are the measured angular distributions for these two states nearly identical over the whole angular range studied, but their relative strengths are in excellent agreement with those measured by Kovar et al.$^{1)}$ at E_d = 20 MeV. This close correspondence suggests that the two-step mechanism proceeding via inelastic excitation of the 3^- state cannot be too important.

Perhaps an even more striking indication that the (d,p) reaction at 75 MeV is sensitive primarily to the single-particle components of even weakly excited states is afforded by comparison of results for the $3/2^+$ states at E_x = 1.27 and 2.43 MeV in ^{29}Si. The present measurements (Fig. 2c) reveal a similar stripping angular distribution for both states, despite a factor of 30 difference in the magnitude of the cross section. This is in marked contrast to the low-energy results of Mermaz

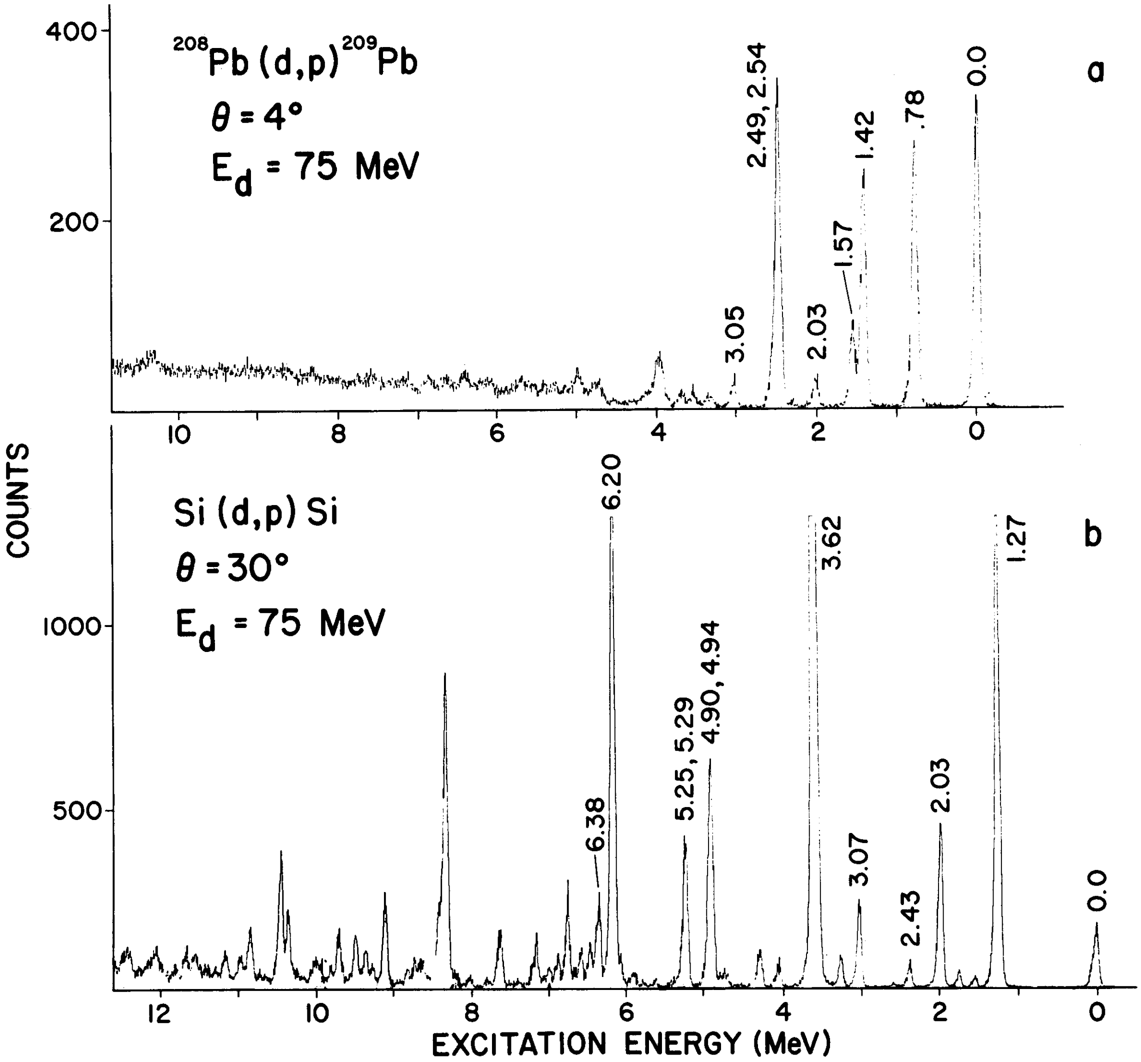

Figure 1. Representative energy spectra acquired for a) ^{208}Pb(d,p)^{209}Pb and b) ^{28}Si(d,p)^{29}Si. In the latter spectrum, peaks attributable to ^{29}Si, ^{30}Si or contaminants present in the target are shaded. Excitation energies are indicated for peaks whose identification is clear from previous work.

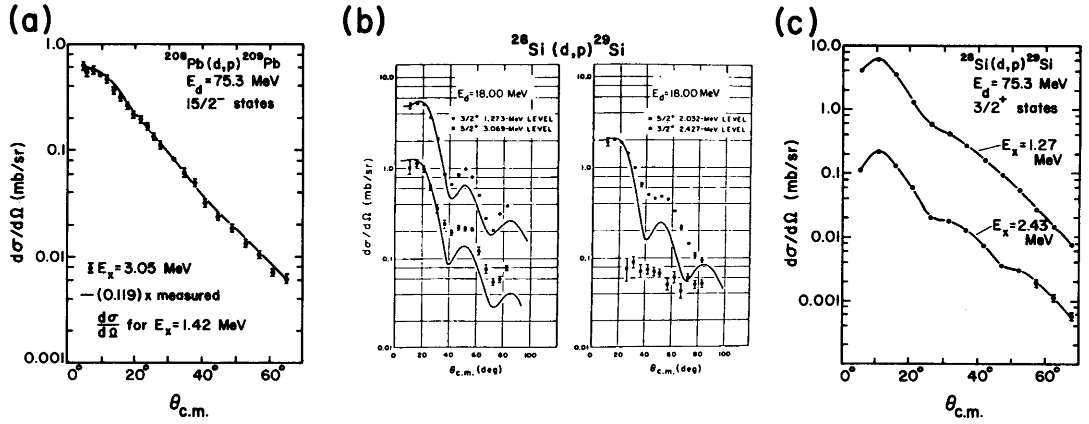

Figure 2. Comparison of measured angular distributions for states of the same spin and parity, but widely different spectroscopic factors. In (a) the solid curve represents the data for the 1.42-MeV 15/2$^-$ state in ^{209}Pb, renormalized by the ratio of the spectroscopic factors determined in Ref.1 for this state and the 15/2$^-$ state at E_x = 3.05 MeV. Attention should be directed in (b) to the measurements at E_d = 18.0 MeV (Ref. 2) for the 3/2$^+$ levels of ^{29}Si at E_x = 1.27 and 2.43 MeV, which are in contrast to the present results shown in (c). The solid curves in (c) are intended to guide the eye, while those in (b) represent DWBA calculations reported in ref. 2.

et al.$^{2)}$ (Fig. 2b), where the weakly excited 2.43-MeV level exhibits a nearly flat non-stripping distribution.

Conventional DWBA calculations have been performed for the ^{208}Pb(d,p) and ^{28}Si(d,p) transitions using the code DWUCK4, including relativistic kinematics, non-locality corrections, finite-range corrections in the local-energy approximation, and only the S-state of the deuteron. The measured angular distributions for the low-lying single-particle states of ^{209}Pb are compared in fig. 3 with the results of calculations using bound-state parameters and spectroscopic factors from ref. 1, and optical model parameters determined from the relevant elastic scattering data.$^{3),4)}$ The agreement with the data is poorest, despite the best angular momentum matching, for the transitions of highest ℓ_n. Preliminary DWBA calculations for ^{28}Si(d,p) yield only qualitative agreement with the measured angular distributions.

In attempting to understand the source of the large-ℓ_n discrepancies in fig. 3, we are in the process of investigating the sensitivity of the calculations to bound-state versus scattering parameters. Of particular interest are the effects of (1) replacing the deuteron potential with one based on the adiabatic model of Johnson and Soper,$^{5)}$ (2) changing the bound-state spin-orbit potential, and (3) using alternate (e.g., Hartree-Fock) prescriptions for the bound-state wavefunction.

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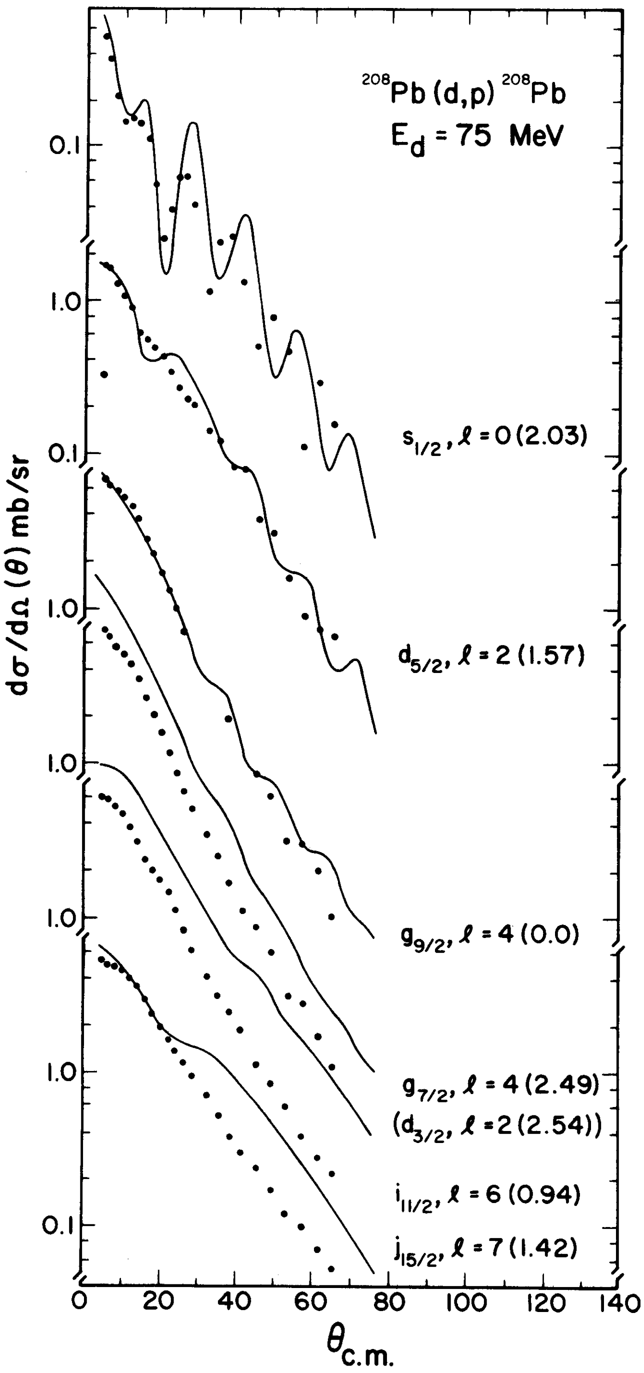

Figure 3. Measured angular distributions and DWBA calculations for states in ^{209}Pb. Spectroscopic factors from Ref. 1 were used to scale the DWBA predictions.

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