LOW-LYING TRANSITIONS IN THE ^{207}Pb(p,p') REACTION AT 135 MeV

AND A TEST OF THE DWIA

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Data were obtained over the angular range from 18° to 56° with a self-supported 23.3 mg/cm^2 target[1)] with ^{207}Pb enriched to 99.8%. With the QDDM spectrograph and helical wire and scintillator detection system,[2)] an overall resolution of 90 keV was obtained. All peaks were carefully stripped with a reference peak shape fitted to the experimental elastic peak shape from each run, using the interactive program on the SEL computer in the ORIC Laboratory.[3)] The background feature was used to "draw-in" long tails on each side of the main reference peak through the data points, between low excited states on the low energy side.

1. Neutron-hole transitions

Microscopic model calculations have been made by Love for the measured cross sections[4)] for the neutron-hole transitions to the first 4 excited states. A new realistic three-Yukawa (M3Y)[5] N-N interaction was used for the "valence" contributions which includes odd and even states, non-central parts and knock-on exchange. The results of these M3Y calculations are shown (Figures 1 and 2) for the J=2 transitions with collective core polarization strength equal to the electromagnetic values.[6)] The overall fit to the data is good for the state at 0.570 MeV and good for the 0.898 MeV

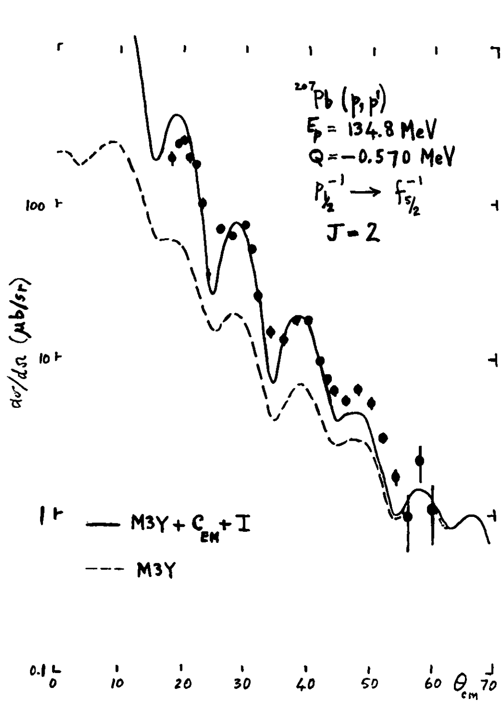

Figure 1

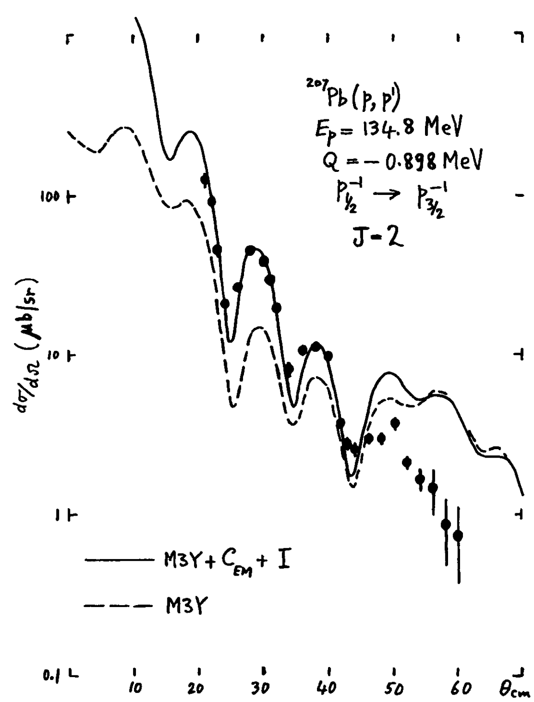

Figure 2

state out to 45 degrees, but at larger angles the M3Y interaction produces too much valence cross section for this state at 0.898 MeV.

The microscopic calculations for J=4 and J=7 transfers (Figures 3 and 4) assumed collective core polarizations to be the same as for our previous experiment[6] at 61 MeV. For these higher angular momentum transfers J, this M3Y interaction produces too little valence cross section at smaller angles and too much valence cross section at larger angles.

The collective core polarization contributions included in all these microscopic calculations did not have deformed spin-orbit(DSO) contributions, but both real and imaginary potentials were deformed. The principal effect of inclusion of this DSO contribution in the collective model at 135 MeV is to increase the cross section at larger angles and "fill in" the minima, as demonstrated for the 3^- doublet at 2.64 MeV (Fig. 5). We have found similar magnitude effects for the angular momentum transfers corresponding to those for the neutron-hole states. With DSO in the collective core contributions of the microscopic calculations, the overall cross section at larger angles would then be even higher than the measured values and the need for a different interaction would be even more marked in order to produce smaller valence contributions at larger angles and larger valence contributions at smaller angles. It appears that

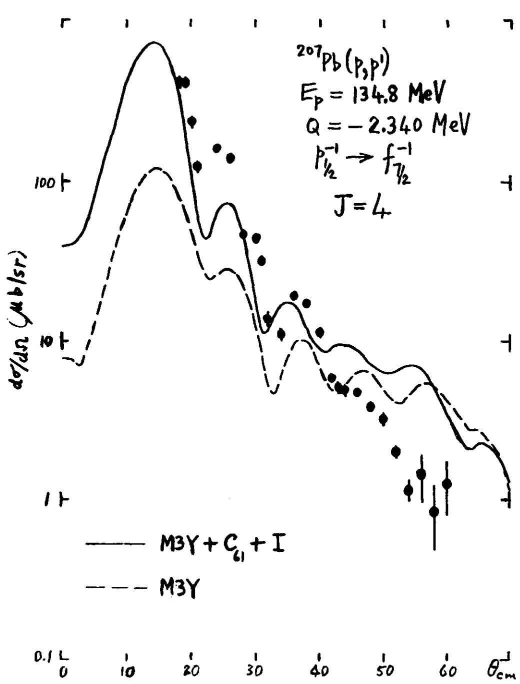

Figure 3

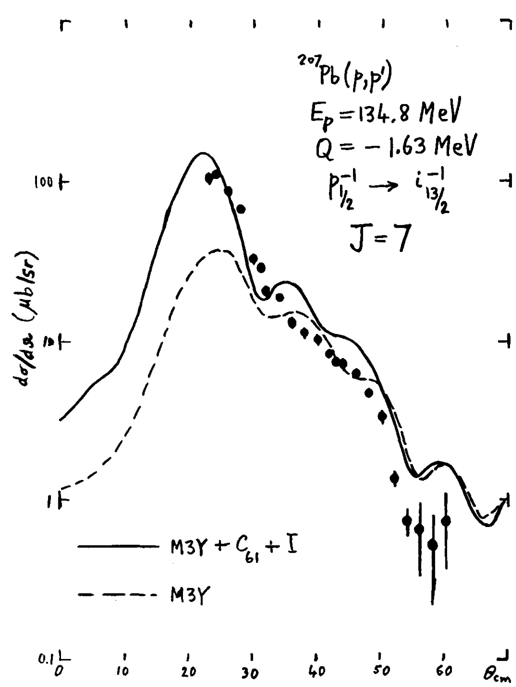

Figure 4

a longer range force may be required or a density dependent interaction may be more appropriate.

Microscopic calculations with this M3Y interaction are in progress for our earlier data at 61 MeV, from which we can then determine if the core coupling parameters A_L continue to change as rapidly with projectile energy from 61 MeV to 135 MeV as they did[6] from 20 MeV to 61 MeV.

2. The transition to the doublet at 2.64 MeV and a test of the DWIA

This doublet centered at 2.64 MeV results from the coupling of a $3p_{1/2}$ neutron-hole to the 3^- core excitation of ^{208}Pb. We were unable to resolve this doublet with our overall resolution of 90 keV. The measured cross section for this doublet is compared with a collective calculation using equal values of the central and DSO deformation parameters of 0.10 (Fig. 5), which are the same as those required at 61 MeV for this doublet. A fully microscopic DWIA calculation (Fig. 6) used a complex effective local interaction (G3Y) derived from the nucleon-nucleon phase shifts together with the wave functions of Ring and Speth[7] for the octupole state in ^{208}Pb at 2.614 MeV. Central and spin-orbit terms were used in this effective interaction and knock-on exchange was included. Coulomb excitation was included "macroscopically." The use of these wave functions is justified because the cross section for this unresolved doublet at 2.64 MeV in ^{207}Pb is essentially identical in magnitude to that for the 3^-

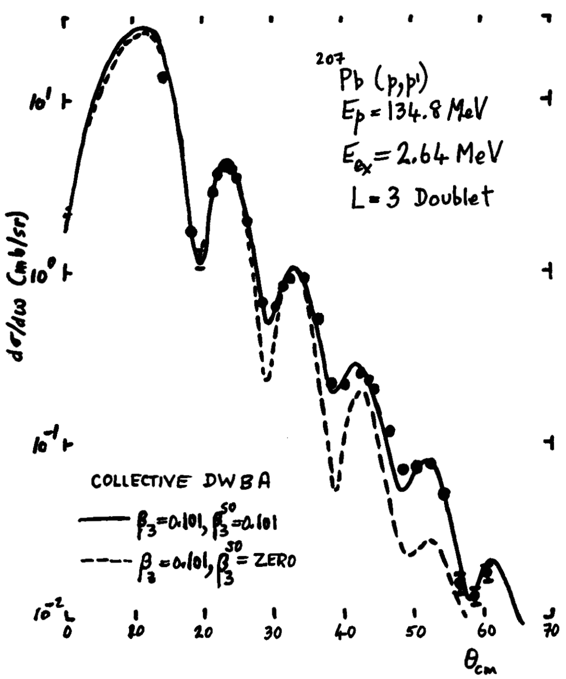

Figure 5

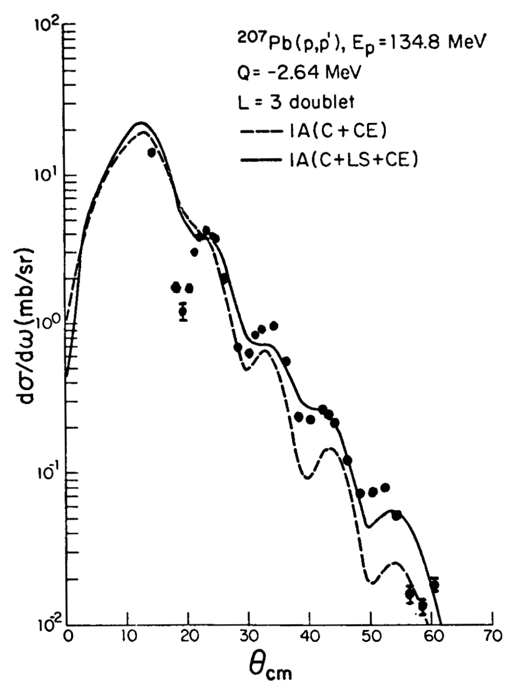

Figure 6

level in ^{208}Pb at 2.61 MeV at a number of projectile energies.[6] These completely microscopic (and unadjusted) DWIA calculations (Fig. 6), with "macroscopic" Coulomb excitation, yield an overall magnitude in quite reasonable agreement with the measured cross section, and the shape is fairly well described except for the minimum near 20 degrees. The inclusion of the spin orbit contribution improves the agreement for angles beyond 30 degrees, but the deep minimum near 20 degrees is still not explained by this DWIA calculation.

The fully collective calculations, including DSO, describe this measured cross section very well (Fig. 5), including the shape and the deep minimum near 20°. These calculations with DSO deformation parameter equal to the central parameter of 0.10 clearly fit the measured shape at all angles much better than with a zero value of this DSO parameter.

The ratio of the integrated cross section for the real potential to that for the imaginary potential is 1.14 for this DWIA fully microscopic calculation, but 5.0 for this collective calculation with deformation parameters equal to 0.10. Real and imaginary parts of the interaction yield cross sections of nearly the same shape in the DWIA, but the real part of the collective form factor is quite different from that of the collective imaginary term.

The overall shape and magnitude of the spin-orbit _partial_ cross section from these fully microscopic calculations are surprisingly close to both the shape and magnitude of the collective DSO _partial_ cross section (Fig. 7) which is included in the totally collective calculation of Fig. 5 with $\beta_3^{SO} = 0.10$. This microscopic DWIA spin-orbit calculation appears to account for this empirically determined collective DSO cross section.

An article on this test of the DWIA has been published.[8]

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1) Metal purchased from the Isotope Research Materials Laboratory, ORNL; target rolled by W.R. Lozowski, IUCF.

2) Technical and Scientific Report Nov. 1977 Jan. 1977, pp. 22-24.

3) SESAME, by T.P. Cleary (unpublished), ORIC Laboratory, ORNL. We thank Dr. Cleary for his advice and assistance, and Dr. D.C. Hensley for permitting us to use this SEL computer.

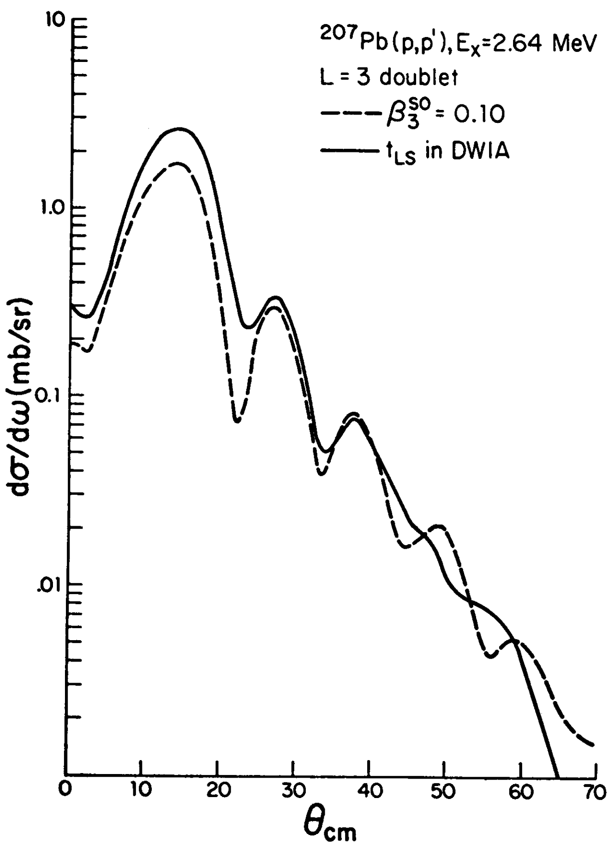
4) A. Scott, F.T. Baker, W.G. Love, W.P. Jones and J.D. Wiggins, Jr., Bull. Am. Phys. Soc. _22_, 543 (1977); and manuscript in preparation.

5) G. Bertsch, J. Borosowicz, H. McManus and W.G. Love, Nucl. Phys. _A284_, 399 (1977).

6) Alan Scott, M. Owais and W.G. Love, Nucl. Phys. _A289_, 123 (1977).

7) P. Ring and J. Speth, Phys. Lett. _44B_, 477 (1973); Nucl. Phys. _A235_, 315 (1974).

8) W.G. Love, Alan Scott, F. Todd Baker, W.P. Jones and J.D. Wiggins, Jr., Phys. Letters _73B_, 277 (1978).



$^{207}Pb(p,p'), E_x$=2.64 MeV
L = 3 doublet
β_3^{so} = 0.10
t_{LS} in DWIA
10
1.0
0.1
.01
$d\sigma/d\omega$(mb/sr)
0
10
20
30
40
50
60
70
θ_{cm}

Figure 7