CORE POLARIZATION AMPLITUDES FOR SINGLE-NEUTRON-HOLE TRANSITIONS EXCITED IN THE $^{207}Pb(p,p')$ REACTION AT 135 MeV and 61 MeV

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DWBA semi-microscopic fits have been made by Love to our data[1,2] at projectile energies E_p = 61 MeV and 135 MeV for low-lying single-neutron-hole states in ^{207}Pb. Love used the M3Y force[3] for *real* valence amplitudes, *fixed* collective deformed-spin-orbit (DSO) and imaginary amplitudes (with $\beta_L^{SO} = \beta_L^{IMAG} = \beta_L^{EXP}$ from entirely collective model fits to the data), and the strength of each collective *real* core amplitude (deformation of the real optical model potential with $\beta_L^{REAL}(core) = fA_L$) was adjusted to obtain the best fit to the overall shape and magnitude of each measured cross section at each projectile energy. The core-coupling parameter A_L has been defined earlier[4]. The S=1 amplitudes for these transitions are known to be quenched[5]. For a given L-transfer transition, the shapes of the partial cross sections are quite different for the M3Y real valence, imaginary, spin-orbit (DSO) and real core contributions, so the combination of amplitudes, with interferences, produces an overall *shape* of each theoretical cross section which is sensitive to the magnitudes of each of these partial cross sections. For this reason, great care has been taken with the peak-stripping of our data[6] to ensure the extraction of accurate *shapes* of the measured cross sections, which then provide more stringent tests of assumptions of all microscopic calculations including those of the present semi-microscopic model.

The values of core-coupling parameters A_L, which Love found gave the best fits of his semi-microscopic calculations to our IUCF data at 135 MeV and our earlier data[1], are shown in column 5 of the table below. A recent article[7] reported experimental scaling factors (we call $s_L^{EXP}(e,e')$) for the ratio sections for corresponding core and total contributions in transitions in $^{207}Pb(e,e')$ and $^{208}Pb(e,e')$ experiments, respectively. To correct for multiplicity factors we write $s'_L(e,e') = \{(2J_i+1)(2L+1)/(2J_f+1)\}\, s_L^{EXP}(e,e')$ where J_i and J_f describe the initial and final spins of states in ^{207}Pb. In a collective model description, $\beta_L^{207\,core}(e,e') = \{s'_L(e,e')\}^{1/2}\,\{\beta_L^{208}(3,3')\}$, where we use the definition of collective deformation parameters βL which yields a sum of weighted values of $\beta_L^{J_f\,2}$ for a weak-coupling

E_{ex} (MeV) (in ^{207}Pb)	Hole configuratn.	L	E_p (MeV)	Extracted directly from (p,p') caln. with real M3Y $A_L(p,p')$	With assumed $\{s'_L(e,e')\}^{1/2}$ and $\beta_L^{208}(p,p')$ for E_p = 61 MeV A_L
0.570	$f_{5/2}^{-1}$	2	61.2	0.018[a]	
			134.8	0.030[b]	0.032
0.898	$p_{3/2}^{-1}$	2	61.2	0.029[a]	0.030
			134.8	0.029[b]	
2.34	$f_{7/2}^{-1}$	4	61.2	0.009 (0.014)[c]	0.026
			134.8	0.019[b]	
1.63	$i_{13/2}^{-1}$	7	61.2	0.004[b]	
			134.8	0.004[d]	$s'_L(e,e')$ not available

[a] DSO amplitude has small effect at 61 MeV(L=2), similar A_2 for β_2^{DSO} = 0.00
[b] With smaller β^{SO} and same A_L the fit is as good to data
[c] With β_L^{SO} = 0.00, larger A_4 yields as good a fit to data
[d] Fit to shape with β_7^{SO} used is better than with smaller β_7^{SO}

multiplet equal to the $\beta_L{}^2$ for the corresponding core transition amplitude.

The A_L-values of column 6 are obtained with the expression $A_L = \{\beta_L^{207\ \mathrm{core}}(p,p')\}/\{(2L+1)^{1/2}(i^{-L})M_L(h_i \to h_f)\}$, where as a guess we assumed that the (p,p') core amplitude in each of our ^{207}Pb transitions is also related to the collective amplitude in the corresponding ^{208}Pb(p,p') transition at the same E_p by the same corrected scaling factor $\{s_L'(e,e')\}^{1/2}$ as in the (e,e') experiment for the same ^{207}Pb transition. With this assumption our values of $\{\beta_L^{207\ \mathrm{core}}(p,p')\} = \{s_L'(e,e')\}^{1/2}\{\beta_L^{208}(p,p')\}$, with the values of $\beta_L^{208}(p,p')$ extracted from collective model fits to our earlier ^{208}Pb(p,p') data$^{8)}$ at E_p = 61 MeV. The M_L are the matrix elements for the single-hole transitions in ^{207}Pb.

We note that both neutrons and protons contribute to the amplitudes described by $\beta_L^{207\ \mathrm{core}}(p,p')$ and $\beta_L^{208}(p,p')$, but only protons contribute to the amplitudes described by $\beta_L^{207\ \mathrm{core}}(e,e')$ and $\beta_L^{208}(e,e')$. We also note that deformed-spin-orbit (DSO) contributions make negligible contributions to the shapes and magnitudes of collective model cross sections at E_p = 61 MeV for the ^{208}Pb(p,p') reaction (even for an angular momentum transfer as large as L=7), but the collective DSO amplitude has a very significant effect on the shape and magnitude of each collective cross section at E_p = 135 MeV in the ^{208}Pb(p,p') reaction$^{9)}$, for all L-transfers from L=2 to L=7.

At E_p = 135 MeV the values of A_L for (p,p') in column 6(deduced assuming the $s_L'(e,e')$ ratios may be used for (p,p')) are strikingly close, for both L=2 transitions and for the L=4 transition, to the values A_L(p,p') directly extracted from Love's DWBA semi-microscopic calculations with M3Y real valence amplitudes. At E_p = 61 MeV, however, only the A_2-value extracted directly for the L=2 transition to the $p_{3/2}$ hole-state at 0.898 MeV agrees with the A_2-value of column 6 (using the factor $s_L'(e,e')$), whereas the direct value A_2(p,p') (column 5) for the $f_{5/2}$ hole state at 0.570 MeV is much smaller than the A_2-value of column 6(using the factor $s_L'(e,e')$). At E_p = 61 MeV, for the L=4 transition to the $f_{7/2}$ hole-state at 2.34 MeV the values of A_4 extracted directly from the semi-microscopic (p,p') calculations (column 5) are much smaller than the A_4-value assuming the factor $s_L'(e,e')$, but the agreement is somewhat better when the deformed-spin-orbit parameter is taken as zero. We also note that the DSO contributions have a negligible effect on the shape of Love's semi-microscopic calculations, and little effect on the magnitudes of overall cross sections, for both L=2 transitions and the lower projectile energy, E_p = 61 MeV. These disagreements, at E_p = 61 MeV but not for E_p = 135 MeV, may possibly be indicating greater sensitivity to the correct description of the nucleon-nucleon force when it is overlapped in the form factor with the wave functions of the $f_{5/2}$ and $f_{7/2}$ neutron-hole states at 0.570 MeV and 2.34 MeV, and less sensitivity for the $p_{3/2}$ hole state at 0.898 MeV.

It is most unfortunate that there is no factor $s_L'(e,e')$ available for the L=7 transition, for which the DSO amplitude in Love's DWBA microscopic calculation exerts it's maximum influence on the shape of the overall theoretical cross section at both E_p = 61 MeV and 135 MeV; so that the assumptions of this model would be tested most severely.

Fully microscopic DWBA(^{9}p,p') calculations, with the M3Y force and supposedly complete wave functions$^{10)}$, have been made by Love$^{2)}$ for our data$^{1,2)}$ at E_p = 61 MeV and 135 MeV for the unresolved doublet at 2.64 MeV. At E_p = 61 MeV, this calculation is an excellent fit to the shape and magnitude of the data without any adjustment, but at E_p = 135 MeV it was necessary to arbitrarily increase the M3Y real valence amplitude by a factor of 1.4 to match the data, even though the fit to the shape is quite reasonable.

In contrast, a fully microscopic DWIA calculation at E_p = 135 MeV by Love[11], using a nucleon-nucleon potential G3Y calibrated by the free N-N t-matrix which fits the phase shifts at 140 MeV and the supposedly complete wave functions[10], fits the magnitude of our data for this ^{207}Pb doublet at 2.64 MeV without adjustment, but it gives a poor description of the shape of this data in the angular region near 20 degrees. Spin-orbit amplitudes were included in these DWIA calculations.

These differences for the doublet at 2.64 MeV, between the fully microscopic DWBA calculation at 135 MeV and the microscopic DWIA calculation at 135 MeV, are found to be primarily due to differences in the isovector part ($(V_{pp} - V_{pn})/2$) of the M3Y G-matrix used in this DWBA calculation and the isovector part of the t-matrix used in the DWIA calculation.

Overall, these analyses appear to be consistent with the view[12] that over the range from E_p = 61 MeV to 135 MeV the (p,p') effective interaction is changing from one that is more like a lower energy G-matrix interaction to one that is more like a free nucleon-nucleon t-matrix, but the G-matrix behaviour is still quite significant at E_p = 135 MeV. A further complication, which has not been included specifically, is the possibility of multistep processes which may well be energy dependent.

A manuscript reporting these results is almost complete, and will shortly be submitted to Nuclear Physics.

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