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Phenomenological optical model analysis of elastic scattering of polarized ^{3}He

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The elastic scattering of polarized ^{3}He has been the subject of a number of studies using the 33.4 MeV polarized ^{3}He beam from the University of Birmingham Cyclotron, aimed to determine the optical model potential, and in particular the spin-orbit term.

Analyses of the data upto mass 58 had indicated an anomalously small spin-orbit diffuseness parameter, a_s = 0.2 - 0.4 fm. When measurements on heavier targets became available, preliminary calculations suggested that a_s of about 0.8 fm was needed for the Pb data, but the fits at small angles were not satisfactory. Initial analysis of the Zr data also indicated a_s = 0.8 fm with good fits to the polarization data.

To resolve the anomaly, a more detailed study of the new data for ^{89}Y, ^{90,91}Zr, ^{207,208}Pb and ^{209}Bi, along with the earlier data for ^{40}Ca and ^{54}Fe [1,2] has been undertaken. For this work the code RAROMP [3] was extensively modified to perform grid searches for any two parameters of the potential. All the remaining parameters were kept constant. A 60 by 60 grid was used so that parameters over a wide range could be investigated. The results of the grid

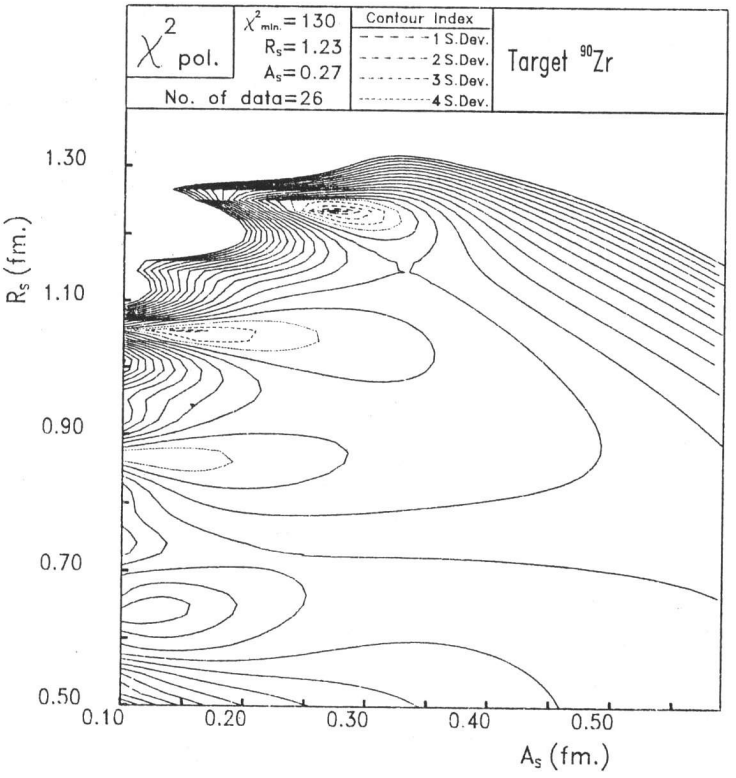

Fig. 1. Contour plot of a grid search for ^{90}Zr varying a_s and r_s.

searches are presented as contour plots, and an example for ^{90}Zr is shown in Fig. 1. These searches are useful in selection of potential families and in study of parameter correlations. Once a particular family is selected the normal search routines are used to obtain optimum parameter values. The results are given in Table 1 and the corresponding fits are shown in Figure 2. The results

Table 1. The best fit optical model parameters.

	V_R	r_R	a_R	W_D	r_D	a_D	V_s	r_s	a_s	J_R	χ^2_σ	χ^2_P
^{40}Ca	135	1.11	0.80	15.5	1.31	0.82	2.44	1.15	0.22	371	6.20	17.5
^{54}Fe	107	1.28	0.71	20.7	1.26	0.82	2.66	1.30	0.22	380	1.55	4.89
^{89}Y	136	1.12	0.85	18.6	1.32	0.86	2.22	1.30	0.25	342	0.81	3.44
^{90}Zr	136	1.16	0.76	24.1	1.14	0.85	3.98	1.24	0.27	356	1.24	4.99
^{91}Zr	139	1.15	0.61	18.0	1.04	1.20	3.36	1.23	0.24	337	1.05	1.89
^{207}Pb	162	1.23	0.57	20.9*	1.11	1.04	5.68	1.14	0.09	445	2.34	1.47
^{208}Pb	159	1.25	0.50	21.7	0.97	1.30	4.36	1.14	0.10	449	1.84	1.89
^{209}Bi	165	1.23	0.58	17.7*	1.22	0.95	5.54	1.14	0.08	448	2.50	1.61

*In addition ^{207}Pb and ^{209}Bi require volume absorption terms (W_v, r_v, a_v) of 6.36, 1.26, 0.08 and 8.62, 1.25, 0.08 respectively. (MeV and fm).

show that that a_s of about 0.3 fm gives a significantly improved fit to the ^{89}Y and $^{90,91}Zr$ data, and a value of about 0.1 fm makes a major improvement for $^{207,208}Pb$ and ^{209}Bi. These small values may at first seem totally unphysical, but in the Pb region the scattering is dominated by the Coulomb interaction and the probe can only "feel" the outermost surface of the spin-orbit potential.

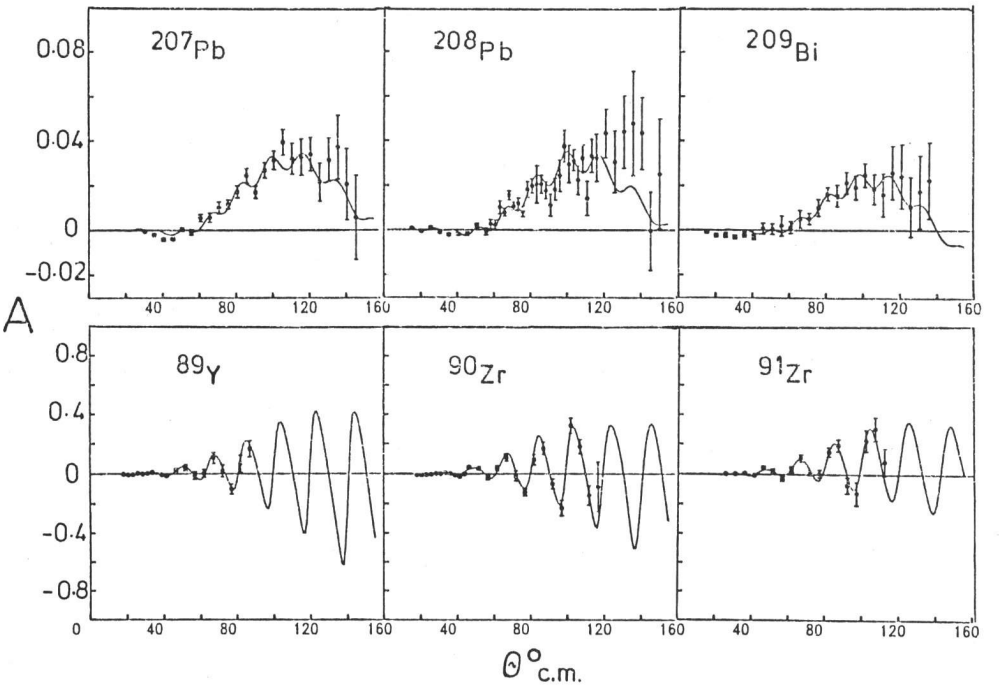

Fig. 2. Optical model fits to the polarization data with the above potentials.

References

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