Double folding optical parameters for studying giant resonances using a 240 MeV ^{6}Li beam

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Alpha inelastic scattering has been a valuable tool for studying isoscalar giant monopole resonances (ISGMR) for many years [1-3]. A comparison of the results of systematic studies of the isoscalar giant monopole resonance (ISGMR) in stable nuclei with calculations using the Gogny interaction resulted in a value $K_{nm} = 231 \pm 5$ MeV [1]. Calculations with other interactions and relativistic models have shown that the location of the GMR is also sensitive to the symmetry energy and studies of stable Sn isotopes have led to some constraints on K_{sym} [4]. To better determine the contribution from symmetry energy ISGMR measurements can be extended to unstable nuclei using inverse reactions. Chen et al. [5,6] have explored the possibility of using ^{6}Li as a target in studies of giant resonances in unstable nuclei.

We have studied elastic scattering of 240 MeV ^{6}Li ions on ^{24}Mg, ^{28}Si, ^{40}Ca, ^{48}Ca, ^{58}Ni, ^{90}Zr, and ^{116}Sn and inelastic scattering to low-lying states of these targets to develop a systematic optical potential that can be used in Giant Resonances studies of unstable nuclei.

A beam of 240 MeV ^{6}Li ions from Texas A&M K500 superconducting cyclotron, after passing through the beam analysis system, bombarded self-supporting target foils in the target chamber of the multipole-dipole-multipole (MDM) spectrometer. Data for elastic and inelastic scattering were taken at spectrometer angle from 5^{o} to 38^{o}.

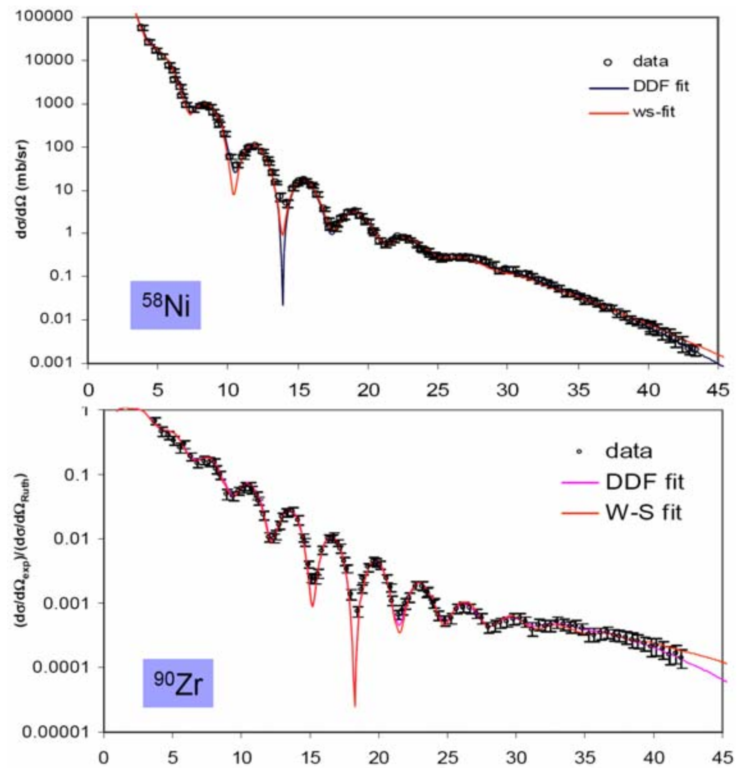

FIG. 1. Angular distribution of the cross sections of the elastic data and fits using WS and double folding potentials.

Elastic scattering data were fit with optical model calculations using the program, ECIS with WS phenomenological potentials and density dependent folding (DDF) calculations were carried out with the folding code DFPD4. These potentials were then used to calculate differential cross sections using ECIS.

The optical potential parameters obtained from the folding model fit for ^{24}Mg, ^{28}Si, ^{58}Ni, ^{90}Zr, and ^{116}Sn are listed in Table I and the calculated angulated angular distribution of the cross-section for ^{58}Ni and ^{90}Zr are shown in

TABLE I. Optical parameters sets obtained from the analysis of 240 MeV ^{6}Li scattering with DDF (density dependent double folded potential) fit.

Target	N_r	scaling	**W (MeV)**	r_{i0} (fm)	a_i (fm)	J_v (MeV fm^3)	J_w (MeV fm^3)	χ^2	σ_r (mb)
^{24}Mg	0.823	1.062	**58.67**	0.731	1.204	242	154	1.04	1799
^{28}Si	0.887	1.0624	**41.33**	0.905	1.048	256	136	1.46	1757
^{58}Ni	0.8746	1.0594	**35.331**	1.027	1.048	244.6	112	0.93	2397
^{90}Zr	0.8778	1.0661	**33.343**	1.09	1.0063	239.5	101.43	1.1	2792
^{116}Sn	0.659	1.0	**28.77**	1.151	0.905	202.1	89.9	0.98	2956

Fig. 1. Folding model DWBA calculations for low-lying 2^+ and 3^- states of target nuclei were carried out with ECIS. B(EL) values for 2^+ and 3^- state were extracted by fitting the inelastic scattering cross sections and are in agreement with the adopted values.

^{48}Ca: test nucleus

In order to establish unique optical potentials for ^{6}Li scattering for nuclei where elastic scattering has not been measured using the available experimental data, we have fit the volume integrals of the imaginary part of the nuclear potentials (see Table I) for target nuclei with respect to the mass number and a value for J_w corresponding to ^{48}Ca was extracted from the fit. Keeping this J_w = 117 MeV fm^3 constant, several sets of W_i, r_{i0}, and a_i were calculated using the expression for J_w given as:

$$J_W = \frac{1}{A_T A_p}\int W(r)\,d\tau$$

$$= \frac{4\pi}{A_T A_p}\sum_{r=1}^{r=20}\frac{W}{e^{(r-R_{i0})/a_i}}\,r^2 dr$$

where W(r) is the imaginary part of the optical potential and A_T and A_P are the mass numbers of the target and projectile. These different sets of parameters were used to calculate the cross sections for elastic scattering and inelastic scattering to low-lying states of ^{48}Ca. Meanwhile, optical parameters were also extracted by fitting the experimental data. Both sets of parameters were used for DWBA calculations (using double folding model) of the cross sections for low-lying states (2^+ and 3^- states) for ^{48}Ca. The angular distributions of the cross sections for these states are shown in Fig.2.

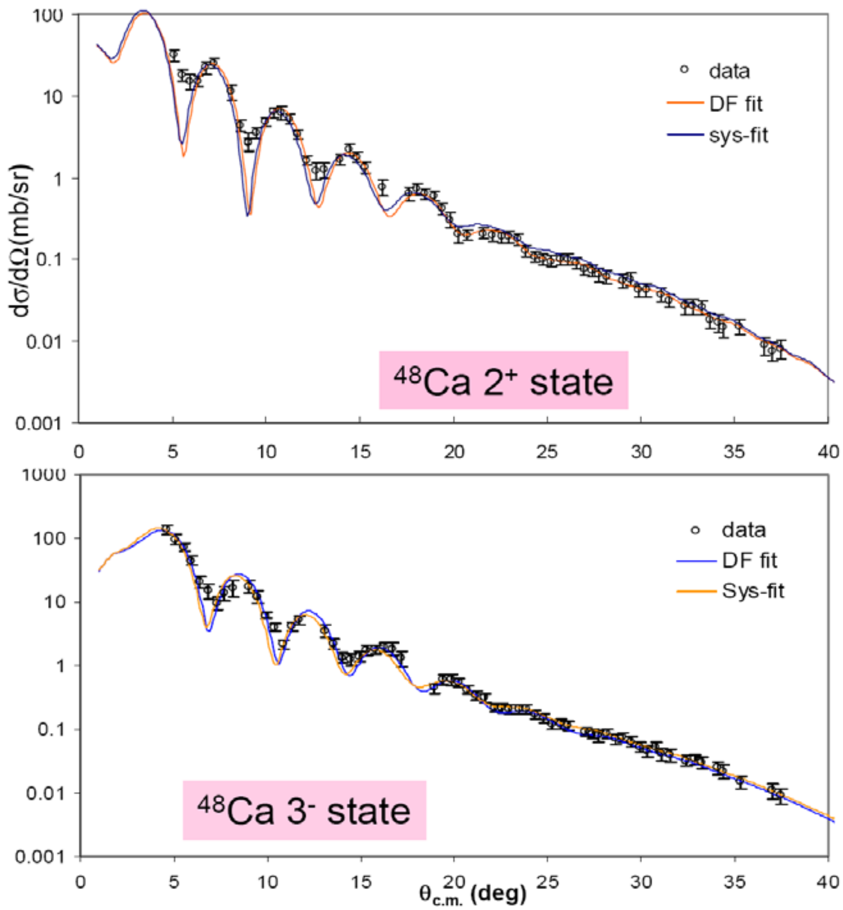

FIG. 2. The differential cross sections calculated with folding model using two sets of parameters for inelastic scattering to 2^+ and 3^- states of ^{48}Ca.

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