THE OPTICAL POTENTIAL FOR ^{6}Li SCATTERING AT 154 MeV

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The optical-model (OM) analysis of 99 MeV ^{6}Li elastic scattering data (see preceding contribution) showed no pronounced preference for a particular value V, the central strength of the real potential, within the set of discrete, phase-equivalent values V ∿ 100, 150, 200, 250 MeV. Essentially similar results were obtained by DeVries et al.[1] in their OM analysis of 135 MeV ^{6}Li + ^{28}Si scattering data measured at the Lawrence Berkeley Lab (LBL).

For light-ion (e.g. ^{4}He) scattering it has been found that the optical potential is determined unambiguously by data extending at least up to the nuclear rainbow angle θ_R.[2] Even though the LBL data extends to θ_{cm} = 67° (which corresponds approximately to θ_R for 135 MeV ^{6}Li + ^{28}Si scattering) and exhibits a structureless large-angle fall-off akin to the refractive nuclear rainbow effect observed for ^{4}He scattering, unambiguous determination of V was not possible. A plausible reason for this failure is that the stronger absorption of ^{6}Li ions reduces the sensitivity of the scattering to the real central potential to the extent that nuclear rainbow scattering in fact is not observable for ^{6}Li or is so weak that measurements must be extended far beyond the calculated rainbow angle. In order to look once more for evidence of a nuclear rainbow in ^{6}Li elastic scattering, we undertook a measurement of ^{6}Li + ^{28}Si scattering at 154 MeV. At this energy the V = 150 MeV potential predicts $\theta_R \simeq 62°$ with a cross section $\sigma(\theta_R) \simeq 0.8$ μb/sr. With the expected 154 MeV ^{6}Li beam intensity it seemed practical to measure a cross section of order 0.1 μb/sr (i.e., to go about 10° beyond θ_R).

The measurement was carried out in the 64" scattering chamber. A natural Si target (92% ^{28}Si) of ∿ 13 mg/cm^2 thickness was used. The scattered ^{6}Li ions were detected in two ΔE+E Si surface-barrier detector telescopes (500 + 2000 μm) with angular acceptances Δθ of 0.9° and 2.3°, respectively, at forward and backward angles (the latter value of Δθ resulted in a kinematic energy broadening of 1.8 MeV for the elastic group at ∿ 70°, equal to the energy of the first excited state in ^{28}Si and hence just resolved from the latter). The mass resolution of the simple ΔE vs. ΔE+E particle identification spectrum was inadequate to resolve ^{7}Li from ^{6}Li, but the large negative Q-value (-9.92 MeV) for the ^{28}Si(^{6}Li,^{7}Li) reaction effectively eliminated the need for clean ^{7}Li rejection. Changes in beam direction on target were monitored with a pair of fixed detectors at $\theta_L = \pm 12.5°$.

Unfortunately, the available ^{6}Li beam intensity (from 1 to 5 enA) was about a factor of 4 smaller than expected. Consequently the angular distribution had to

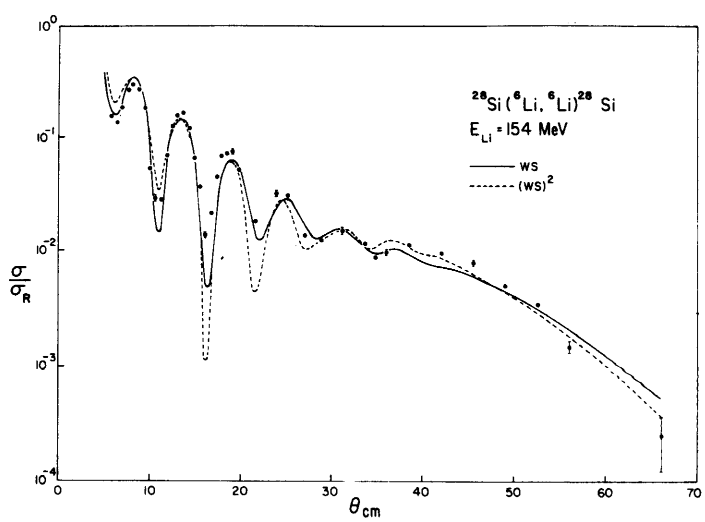

Figure 1.

Table 1

Form-factor	V	r_o	a_o	W	r_w	a_w	$J_R/6A$	$J_I/6A$
WS	160	0.725	0.835	50	0.85	1.11	271	150
$(WS)^2$	155	0.93	1.20	65	1.01	2.00	256	154

be terminated at θ_{cm} = 66° (σ = 0.4 μb/sr) in order to conclude the experiment within the allocated running time.

The angular distribution obtained is displayed in fig. 1. Representative errors are indicated at some angles. The diffractive oscillations are seen to die out around 35° followed by the indication of a broad hump preceding the smooth fall-off beyond 45° which is characteristic of the onset of refractive scattering. The solid curve in fig. 1 is an OM calculation (using real and imaginary Woods-Saxon potentials) which provides the best overall fit to the data although it does not do very well in reproducing the hump in the data around 40° and the slope of the fall-off beyond.

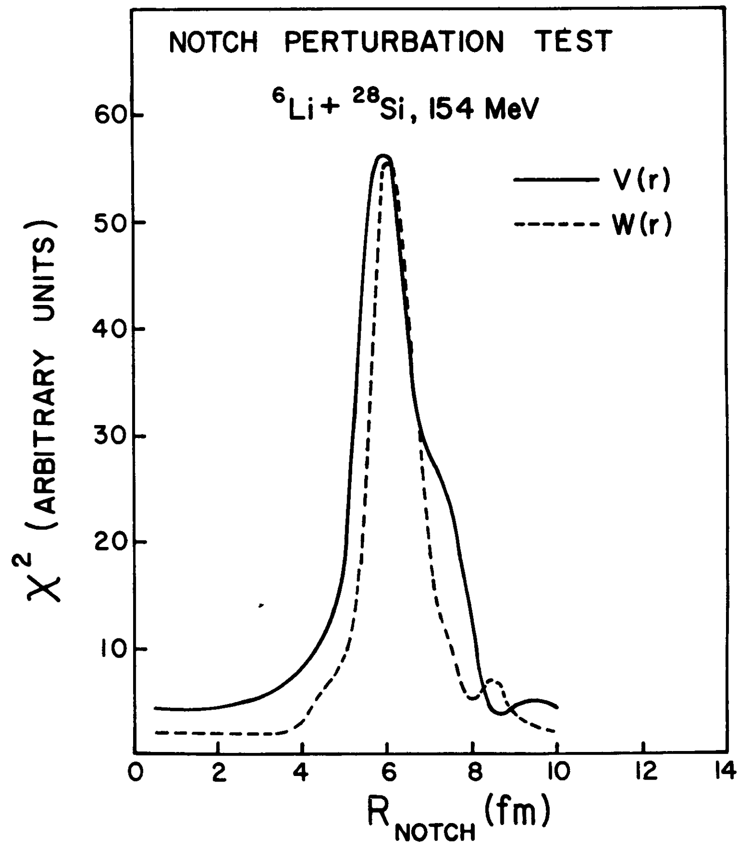

Figure 3.

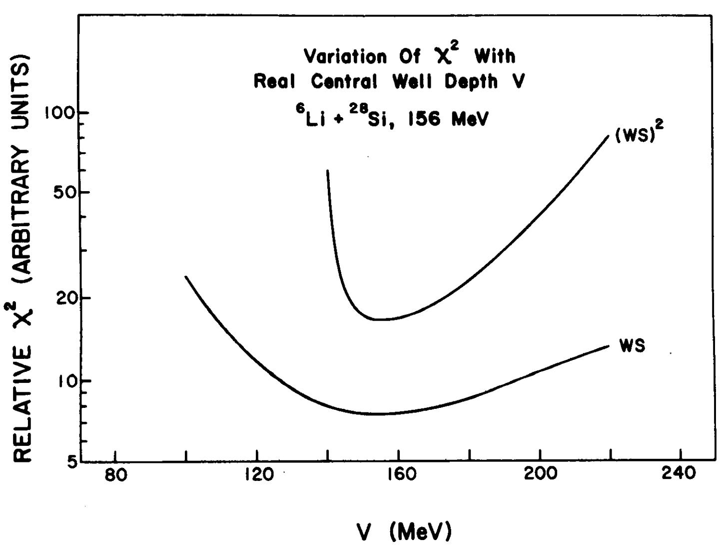

Figure 2.

The dashed curve was calculated using Woods-Saxon-squared formfactors (both real and imaginary potentials). This type of formfactor has been found to provide a better representation of the large-angle refractive ^{4}He scattering,[3] and is seen to provide a somewhat improved fit also to the large-angle ^{6}Li scattering data. The potential parameters for these curves are given in Table 1 (all strengths are in MeV, geometry parameters in fm) along with the volume integrals per nucleon of real and imaginary potentials (in MeV-fm^3).

This parameter set is by no means a unique representation of the ^{6}Li scattering potential at this energy. We find that the present data can, in fact, be fit with a broad continuum of real central well depths, V ∿ 120-200 MeV, for the WS formfactor (see fig. 2), with a corresponding but narrower range for the radius parameter, r_0 ∿ 0.80 - 0.65 fm. This result is in contrast to the multitude of discrete parameter sets which one encounters at lower ^{6}Li energies (e.g., see preceding report on 99 MeV ^{6}Li scattering). For the $(WS)^2$ case the range of acceptable real central strengths is somewhat reduced to V ∿ 145-180 MeV. Although the ^{6}Li potential cannot be determined unambiguously from the present data, a real central potential with V ∿ 150-160 MeV appears to be the most likely candidate for the still-elusive "unique" ^{6}Li optical potential. We conclude that even at 154 MeV ^{6}Li energy, where the data exhibit strong evidence for a nuclear rainbow at large angles, the relatively strong absorption apparently precludes probing the central region of the potential with any appreciable sensitivity. The notch perturbation test of the radial potential distribution (defined in the preceding contribution to this report), when applied to the present data, demonstrates that the ^{28}Si nucleus appears effectively "black" to the incident 154 MeV ^{6}Li ions inside of about 4 fm, as illustrated in fig. 3.

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1) R.M. DeVries et al., Phys. Rev. Letts. 39, 450 (1977).

2) D.A. Goldberg and S.M. Smith, Phys. REv. Letts. 29, 500 (1975); D.A. Goldberg, S.M. Smith, and G.F. Burdzik, Phys. Rev. C10, 1367 (1974).

3) D.A. Goldberg, Phys. Letts. 55B, 59 (1975); P.L. Roberson et al., University of Maryland Report TR-79-038 (1978).