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$^{16}_0\text{O} + ^{40}\text{Ca}$ Inelastic Scattering and the Elastic Scattering Wave Function

K. E. Rehm,^{*} W. Henning, J. R. Erskine and D. G. Kovar

Argonne National Laboratory, Argonne, Illinois 60439[†]

The distorted waves, as determined from elastic-scattering data, are an essential ingredient in direct-reaction calculations. Failures in such calculations to reproduce experimental data have often been overcome by ad hoc changes in the optical-model parameters. The obvious question raised is whether an optical potential as determined from the asymptotic behavior of elastic scattering indeed generates correct elastic-scattering wave functions at the nuclear surface where the direct reactions take place. In particular it has been argued¹ that the strong surface localization in heavy-ion direct reaction and the fact that the magnitude is comparable to elastic scattering for the surface partial waves, require explicit coupling of the direct channels to the elastic channel.

We have measured the $^{16}_0\text{O} + ^{40}\text{Ca}$ inelastic scattering at 60-MeV incident energy and found evidence in support of this latter argument. The measurements were extended over a large angular range and in particular to very forward angles. The ratio of cross sections between extreme forward and backward angles proved very useful in studying the underlying reaction mechanism.

The results, experiment and calculations, are summarized in Fig. 1. The dashed lines are DWBA calculations with code PTOLEMY,² the solid lines

^{*}Max-Kade Fellow. Present address: Physik-Department, Technische Universität München, W. German.

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coupled-channels calculations with code CHUCK.³ A macroscopic collective form factor was used in all calculations, with charge deformation lengths δ_c from measured $B(E\lambda)$ values and nuclear deformation lengths δ_N generally in agreement with light-ion values. The shapes of the angular distributions were insensitive to values of δ_c and δ_N within reasonable limits.

The DWBA curves were calculated with optical-model parameters that were obtained from fits to elastic scattering. Discrepancies between inelastic data and DWBA calculations are observed, increasing with increased multipolarity and with the dominance of nuclear over Coulomb excitation.

Various coupled-channel calculations were performed; the predicted shapes generally agreed very well with the data (solid lines in Fig. 1). The most significant observation was that the large discrepancy between data and DWBA calculation observed for the 5^- transition is removed after the coupling of the strongly-excited 3^- state to the ground state is explicitly taken into account; at the same time the effect of the direct 3^- to 5^- coupling is negligible. This shows that it is the effect of the strongly-coupled 3^- state on the elastic-scattering wave function at the nuclear surface which has to be treated explicitly. This effect cannot in general be accounted for by an average absorptive part of the optical potential that is determined from the asymptotic behavior of elastic scattering. This seems of particular importance in view of the failure of DWBA in many heavy-ion transfer calculations. The ad hoc changes made in many cases in optical-model parameters in order to reproduce transfer data with DWBA calculations, may find a natural explanation in the phenomenon observed in this work.

¹W. Henning, J. P. Schiffer, D. G. Kovar, S. Vigdor, B. Zeidman, Y. Eisen, and H.-J. Körner, Phys. Lett. 58B, 129 (1975).

²D.H. Gloeckner, M. H. Macfarlane, and S. C. Pieper, Argonne Informal Report ANE-76-11 (1976).

³P. D. Kunz (unpublished); ORNL modified version.

