STUDIES OF KNOCK-OUT REACTIONS: $^{40}Ca(p,2p)^{39}K$ REVISITED

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The nucleon knock-out group has continued its program of studying reaction mechanisms and the approximations used in the analysis of nucleon-nucleus scattering using the (p,2p) reaction. This reaction is ideally suited for such studies since the kinematic conditions can be adjusted to isolate approximately the desired effects. In the present work, the focus is on the ability of the (p,2p) reaction to discriminate clearly among phase-shift equivalent proton distorting potentials which differ significantly in the nuclear interior.

In the standard "energy-sharing" (ES) knock-out geometry the two scattering angles are fixed and the ratio of the two outgoing proton energies is allowed to vary to select different values of recoil momentum. However, this geometry does not allow unambiguous identification of optical model potentials; calculated shapes of triple-differential cross-sections as a function of recoil momentum are quite insensitive to changes in the optical potential parametrizations used, although the normalization factors C^2S exhibit considerable sensitivity.

Preliminary calculations by this group have indicated that greater sensitivity to distinctly different optical model potentials can be obtained if instead of the ES geometry the "fixed-condition geometry" FCG-B suggested by Ioannides and Jackson[1] is used with careful choice of recoil momentum. In this geometry the two scattering angles are adjusted to maintain a constant magnitude and direction of the recoil momentum, which implies that the energy sharing parameter $\lambda = E_1/(E_1 + E_2)$ is changed for each angle pair. If the ratio $d^3\sigma(\lambda)/d^3\sigma(\lambda_0)$ is plotted against λ, where $d^3\sigma(\lambda)$ is the triple differential cross-section as a function of λ, then the shape of the resulting curve is found to show considerable sensitivity to the choice of optical potentials. This is illustrated in Fig. 1 where the curve labeled WS uses the conventional Woods-Saxon shape

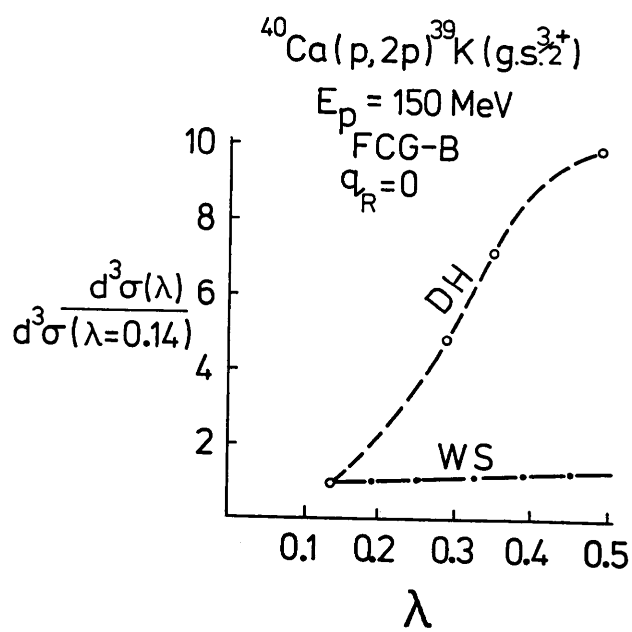

Figure 1. Plot of the calculated cross section ratio versus energy sharing parameter λ for two choices of optical potentials. The differences between potentials are described in the text.

parametrization[2] and the curve labeled DH uses non-Woods-Saxon potential shapes calculated in the relativistic Dirac-Hartree model of the optical potential.[3] Both parameter sets provide excellent fits to elastic scattering data yet result in considerably different shapes of "ratio vs. λ".

Encouraged by these observations we performed a $^{40}Ca(p,2p)^{39}K$ experiment this year at 150 MeV in an attempt to put at least two data points on a "ratio vs. λ" plot and thus restrict the selection of an appropriate distorting potential from a set of otherwise phase-equivalent optical model parameterizations. Outgoing proton energies were measured with two hyper-pure germanium detector telescopes. Limited beam time and the need to obtain good statistics restricted us to examining only two angle pairs which were chosen to be +42°/-42° and +30°/-54°. For zero target recoil and 150 MeV incident beam energy these correspond to $\lambda = 0.5$ and $\lambda = 0.28$, respectively. Examining a smaller value of λ was not possible because the range of the high-energy outgoing proton would have exceeded the stopping thickness of our telescopes.

By this choice of geometry and fixed recoil momentum of zero for $\ell \neq 0$ (e.g., d-state) knock-out we are forcing the reaction to sample the bound-state wavefunction in a region of configuration space where the contributions to the cross section arise primarily from distortion of the incident and outgoing proton waves by the nuclear medium. Since the energies of the final-state protons vary rapidly with λ, distortion effects should induce large variations in the cross section ratio. The reaction will have enhanced sensitivity to the nuclear interior and hence to the parametrization of the incident and scattered waves inside the nuclear potential. In this geometry the variations in the nucleon-nucleon interaction with λ are minimized.

Since successfully obtaining the data, an ambitious general-purpose event-tape sorting program has been written at Melbourne, and analysis of the data is now in progress. Results will be available in the near future.

1) A. Ioannides and D.F. Jackson, Nucl. Phys. A308, 305 (1978).

2) A. Nadasen et al., Phys. Rev. C 23, 1023 (1981).

3) L.G. Arnold et al., Phys. Rev. C 25, 936 (1982).