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Feedback of Dispersion Relations Plus Giant Resonances on Nucleon Elastic Scattering from ^{40}Ca*

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There exists an accumulation of experimental evidence for a non-diffraction-like pattern in proton elastic scattering at backward angles for light and medium mass nuclei[1,2]. This backward-angle anomaly, which is most pronounced in ^{16}O and ^{40}Ca, cannot be explained in terms of conventional spherical optical model (SOM) or coupled-channel (CC) calculations[1]. However, it is thought to be tied to nuclear structure effects[2]. Several attempts have been made to explain the observed anomaly. For instance, Kobos and Mackintosh[3] have dramatically improved the fits to proton elastic scattering observables by inserting ℓ-dependent terms in the optical model potential (OMP), but consequently introduced an abundance of free parameters in their SOM analysis. On the other hand, Pignanelli et al.[4] have shown that coupling the ground state to giant resonances in the framework of the coupled-channel formalism has a large impact on the predicted cross sections at backward angles for ^{16}O and ^{40}Ca.

More recently, the idea of performing CC calculations that include both coupling to giant resonances and dispersion-relation effects has been explored[5] at Ohio University for nucleon scattering from ^{16}O in the energy interval 18-46 MeV. A fairly good description of available differential cross section measurements is achieved at all angles, provided the optical potentials in the ingoing and outgoing channels are properly evaluated at negative and positive energies, as well as in the vicinity of the Fermi energy, a region that has been studied at length by Mahaux and Ngô via dispersion relations[6].

The present work deals with a similar analysis performed for ^{40}Ca. In contrast with the work described in Ref. 5, which simulated dispersion-relation corrections to the real potential by requiring the real potential depth to follow the energy dependence of the real volume integral as predicted in the Fermi energy region, we took advantage of the detailed information -- depths and radial shapes -- published in Ref. 6 for the dispersion-relation corrections to the real potential for ^{40}Ca. First, a conventional CC analysis, with couplings only to low-lying collective states, has been made for all existing nucleon scattering and reaction measurements up to 80 MeV. From this analysis, which includes our recent neutron scattering measurements[7] for $\sigma(\theta)$ and $A_y(\theta)$ performed at TUNL in the energy range from 10 to 17 MeV, we obtained highly-constrained OMP parameters. Even though the description of all the measurements is reasonably good, discrepancies persist at backward angles. An illustration of the conventional CC calculation, made with systematic energy dependencies of the OMP, is given in Fig. 1 (solid curves) for the 16.9 MeV neutron scattering measurements of $\sigma(\theta)$ and $A_y(\theta)$ made at TUNL.

Introducing the dispersion-relation corrections[6] to the real potential for both the incoming and outgoing channels, as mediated by coupling to the low-lying 3^- state as well as to identified 2^+ (17.8 MeV) and 3^- (31 MeV) T=0 states, generally improves the $\sigma(\theta)$ and $A_y(\theta)$ predictions (see dashed curve in Fig. 1.) An extensive reanalysis of existing $\sigma(\theta)$ and $A_y(\theta)$ measurements, for both neutrons and protons, will require more evaluation of the theory of dispersion relations.

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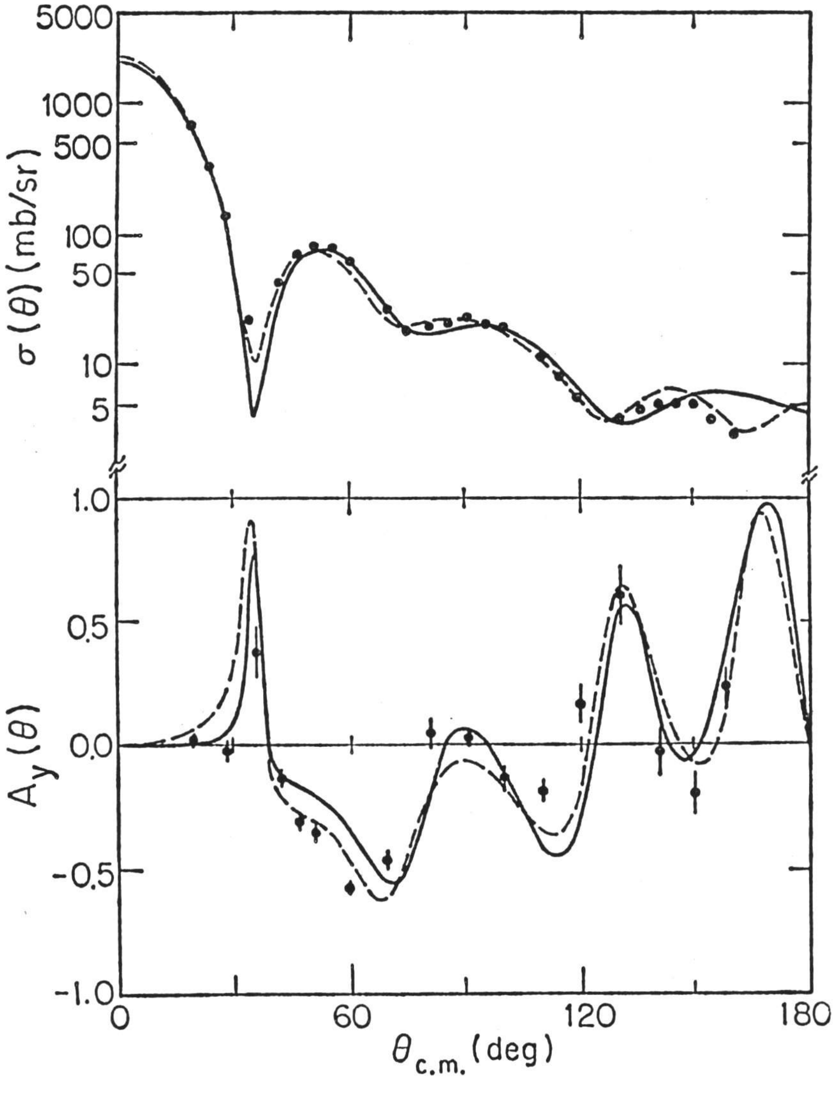

Fig. 1 Comparison of $^{40}Ca(n,n)^{40}Ca$ data to coupled-channel calculations at E_n=16.9 MeV. The solid curve includes coupling to low-lying states only; the dashed curve includes coupling to giant resonances and dispersion-relation corrections.

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