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Dynamical Deuteron Polarization Potential at 23 MeV from the Elastic Scattering of Polarized Deuterons+)

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The central part of the effective deuteron-nucleus interaction near E_d = 20 MeV has been investigated by a model unrestricted Fourier-Bessel (FB) analysis of the elastic scattering of polarized deuterons. For this purpose a careful measurement of the scattering from ^{116}Sn has been performed in the angular range from 7.5° to 145° at the Munich tandem accelerator. We have selected a heavy closed shell nucleus, since there CC-effects in the elastic scattering due to virtual collective target excitations are strongly reduced and need not be taken into account explicitely.

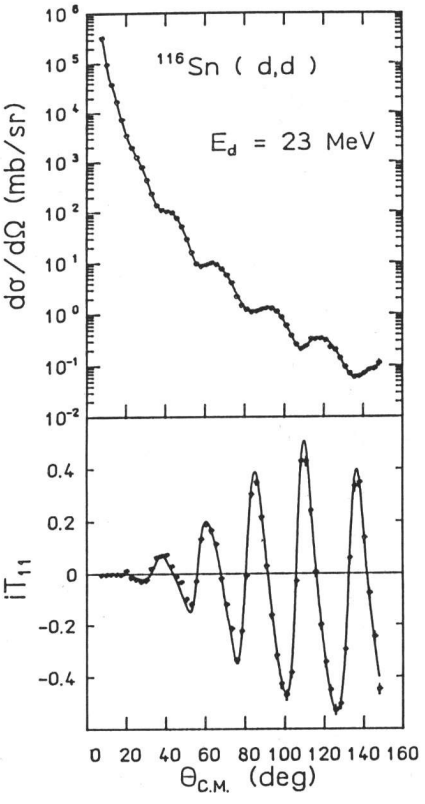

Fig.1: data and FB-analysis for the elastic scattering from ^{116}Sn

The inclusion of FB-terms in the central part of the optical potential leads to a substantial improvement in the description of the observables (solid lines in fig.1) compared to a convential optical model analysis. The real central part of the effective scattering potential resulting from the FB-analysis is shown in fig.2. The dashed area gives the uncertainties of the potential shape as deduced[1] in the fitting procedure from the χ^2-error matrix. The error band stays small even in the interior of the target nucleus. This is strikingly different from comparable studies with strongly absorptive probes like high energy protons and alphas, where the error band blows up at small radii. The observed behaviour is, however, in agreement with earlier findings[2] on the high optical transparency of deuteron scattering. Another remarkable feature of the FB-result is, that its radial distribution is close to the Woods-Saxon shape of the global optical potential of Daehnick et al.[3], which in turn is compatible with nucleon optical potentials concerning the geometry of the real central part.

The uniqueness of the fit and the convergency of the FB-ansatz with regard to maximum number of FB-terms and cut-off radius have been investigated by varying starting and fit conditions. The $iT_{11}(\theta)$-data have been found to be crucial for a reliable analysis, especially for fixing the potential at the nuclear surface, where the spin-orbit interaction plays a substantial role.

The FB-potential is compared in fig.2 to double folding calculations ("frozen density" approximation) using the density-dependent M3Y-interaction including exchange[4], which has been applied successfully[4] for nucleon, alpha and heavy ion scattering. The deuteron density is taken from the Reid soft core wavefunction. The mass distribution of ^{116}Sn (fig.2) is gained from the experimental proton distribution and the DME-prediction[5] for the neutron distribution, which agrees with high energy proton scattering[5]. The resulting

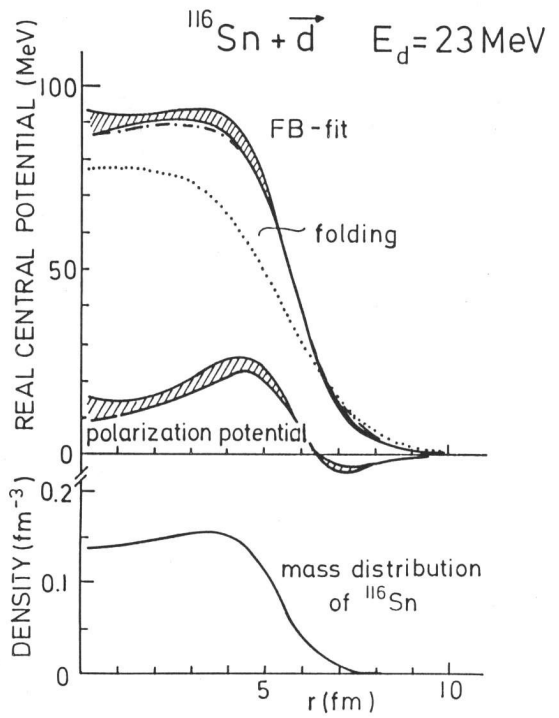

Fig.2: top: real part of the central potential from the FB-analysis in comparison with frozen density folding (dotted line) and 2N-folding (dash-dotted line). middle: polarization potential due to breakup. bottom: mass distribution of ^{116}Sn as used in the folding calculations.

folding potential (dotted curve in fig. 2) resembles closely the single folding Watanabe potential though it is slightly more diffuse due to the dependence of the effective nucleon-nucleon interaction on the deuteron density, which is not taken into account in the Watanabe ansatz. The striking feature of the folding potential is its very large surface diffuseness compared to that of the FB-potential.

Since virtual target excitations are very small for ^{116}Sn, the FB-potential stays essentially unchanged, if these CC-effects are treated explicitely[6]. Since also the folding concept works quite well for nucleon scattering, the failure of the folding potential to reproduce the FB-potential has to be addressed to the deuteron break-up. The dynamical polarization potential, which accounts for the coupling between elastic and breakup channels, is therefore given in fig.2 by the difference of folding and FB-potentials. Both magnitude and shape of the polarization potential agree remarkably well with the prediction of M. Nakano et al.[7] on the basis of a CC-treatment of the deuteron breakup.

The peculiar shape of the polarization potential causes the effective real central potential to be much less diffuse than the folding predicts. In the microscopic picture of the folding concept this means that the deuteron inside the target nucleus apparently looks much smaller than it is in the asymptotic region. Guided by this picture and with the empiral finding in mind that the geometries of nucleon and deuteron optical potentials coincide for the real central part, we performed a folding calculation using simply a delta function for the effective deuteron point density ("2N-folding"). The result is shown by the dash-dotted curve in fig.2 with a renormalization constant of $\lambda = 0.90$, which is close to the values found for nucleon scattering[4]. With this ansatz we get a strikingly good description of the FB-potential. We note that essentially the same finding is observed[8] at E_d = 52 MeV.

As an important side aspect we find in the 2N-folding a justification for the implicit folding concept applied[2] in inelastic deuteron scattering for the derivation of neutron moments.

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