Diffraction pd-scattering at COSY energies

Yu. Uzikov[a,b,*]

Diffraction theory of hadron-nucleus scattering at high energies (see [1] and references therein) is used here to calculate the cross section of pd-scattering in forward direction at energies 0.6–2.5 GeV. This cross section can be used to determine the luminosity in experiments with a deuteron target at ANKE, where for beam energies T_p =0.6–2.5 GeV the forward detector system registers protons with scattering angles of $\theta_{\rm cm} = 10^\circ - 20^\circ$.

The pd-scattering cross section $\mathrm{d}\sigma^{sc}/\mathrm{d}\Omega$ consists of elastic ($\mathrm{d}\sigma^{el}/\mathrm{d}\Omega$) and inelastic ($\mathrm{d}\sigma^{inel}/\mathrm{d}\Omega$) terms. The general expression for $\mathrm{d}\sigma^{sc}/\mathrm{d}\Omega$ was obtained in Ref. [1] in closure approximation, which includes the sum over the complete set of final pn states. Final-state pn-interaction (fsi) is properly taken into account in this approach. The cross sections $\mathrm{d}\sigma^{sc}/\mathrm{d}\Omega$ and $\mathrm{d}\sigma^{el}/\mathrm{d}\Omega$ are written in [1] in terms of the deuteron elastic form factor $S(q)$, the deuteron wave function $\phi(\mathbf{r})$ and the pN-scattering amplitudes $f_{pN}(\mathbf{q})$,

$$f_{pN}(\mathbf{q}) = \frac{k}{4\pi}\sigma_N(i+\alpha_N)\exp\,[-\frac{1}{2}\beta_N\, q^2], \qquad (1)$$

where σ_N, α_N and β_N are the parameters of the pN amplitude determined from the experimental data. The inelastic cross section can be calculated as

$$\frac{d\sigma^{inel}}{d\Omega} = \frac{d\sigma^{sc}}{d\Omega} - \frac{d\sigma^{el}}{d\Omega}\ . \qquad (2)$$

In the numerical calculations presented here we use for the deuteron nuclear density, (i) the one-gaussian approximation, (ii) the renormalized S-component of the Reid soft-core (RSC) wave function, and (iii) the three gaussian (ABB) form factor from Ref. [2]. The parameters of the pN-scattering amplitudes are taken from Ref. [3].

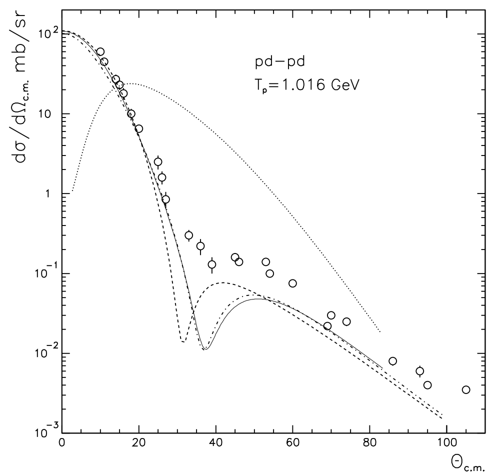

Fig. 1: Experimental data [4] on the elastic $pd \to pd$ cross section vs scattering angles $\theta_{\rm cm}$ at T_p = 1.016 GeV in comparison with those obtained from Glauber theory with (i) the one gaussian w.f. (dashed line), (ii) the renormalized S-wave RSC w.f. (dashed-dotted), and (iii) the ABB-formfactor from [2] (solid). The inelastic cross section calculated with the ABB form factor is showm by the dotted line.

Examples of the numerical results are shown in Figs. 1 and 2. The full set of calculated cross sections, covering the COSY beam energies, can be found elsewhere [5]. The calculated elastic cross section at c.m. scattering angles $\theta_{\rm cm}$<30° is in a good agreement with the data at energies available at COSY (Fig. 1). The experimental data on the inelastic cross section of pd scattering ($pd \to pnp$) at 0.95 GeV [2] are also in a reasonable agreement with the present calculation (Fig. 2). As shown in Fig. 1, the elastic and inelastic cross sections are comparable at scattering angles $\theta_{\rm cm} \sim 10^\circ - 20^\circ$. We found that the inelastic cross section from Eq. (2) coincides with that obtained on the basis of the approximation from Ref. [2]. According to an explicite formula

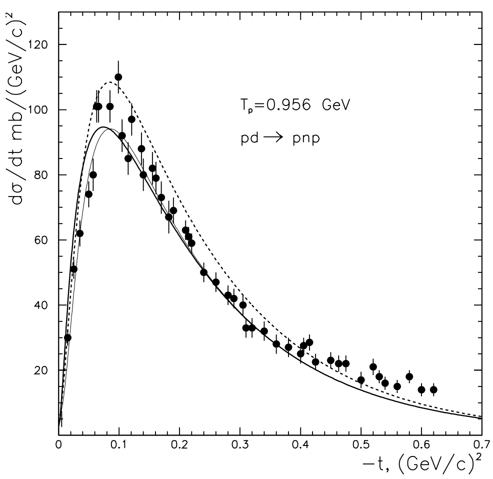

Fig. 2: Experimental data [2] on the inelastic $pd \to pnp$ cross section at T_p = 0.956 GeV in comparison with the Glauber calculations using (i) the RSC form factor (full thick), (ii) the ABB form factor (full thin), and (iii) according to approximation from [2] with the ABB formfactor [2] (dashed).

for $\mathrm{d}\sigma^{inel}/\mathrm{d}\Omega$ from Ref. [2], the inelastic cross section vanishes at zero transferred momentum due to orthogonality of the deuteron bound state and the pn-scattering wave function in the spin-triplet state. This feature is not taken into account in the Born approximation (or spectator model), which leads to a wrong result in the fsi region.

References:

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[a] JINR, Dubna, Russia.
[b] Kazakh State University, Almaty, Kazakhstan.
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