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Deuteron Break-up on Proton Target at $P_D = 2.95$ GeV/c.

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A classical method to determine the deuteron internal structure is the study of the break-up of the deuteron by protons at energies of several hundred MeV (1-4). At these energies the incident-particle wavelength is smaller than the deuteron radius, so the process can be related to the free nucleon-nucleon interaction. The momentum of the recoiling (spectator) nucleon lies within the range allowed by the Fourier transform of the deuteron wave function.

The experimental data on the $pd \to ppn$ reaction, although very poor at medium energy, show a good agreement with the predictions of the impulse approximation for the spectator momentum distribution up to 250 MeV/c. There is evidence for an apparent excess of large-momentum components, compared with the usual deuteron wave functions (1), which are relatively channel dependent (5). Many efforts to explain this behaviour have been made including various corrections to the spectator model. They have taken into account the double-scattering effect (6), in which the two deuteron nucleons appear to shadow one another; the off-energy shell effects, the final-state

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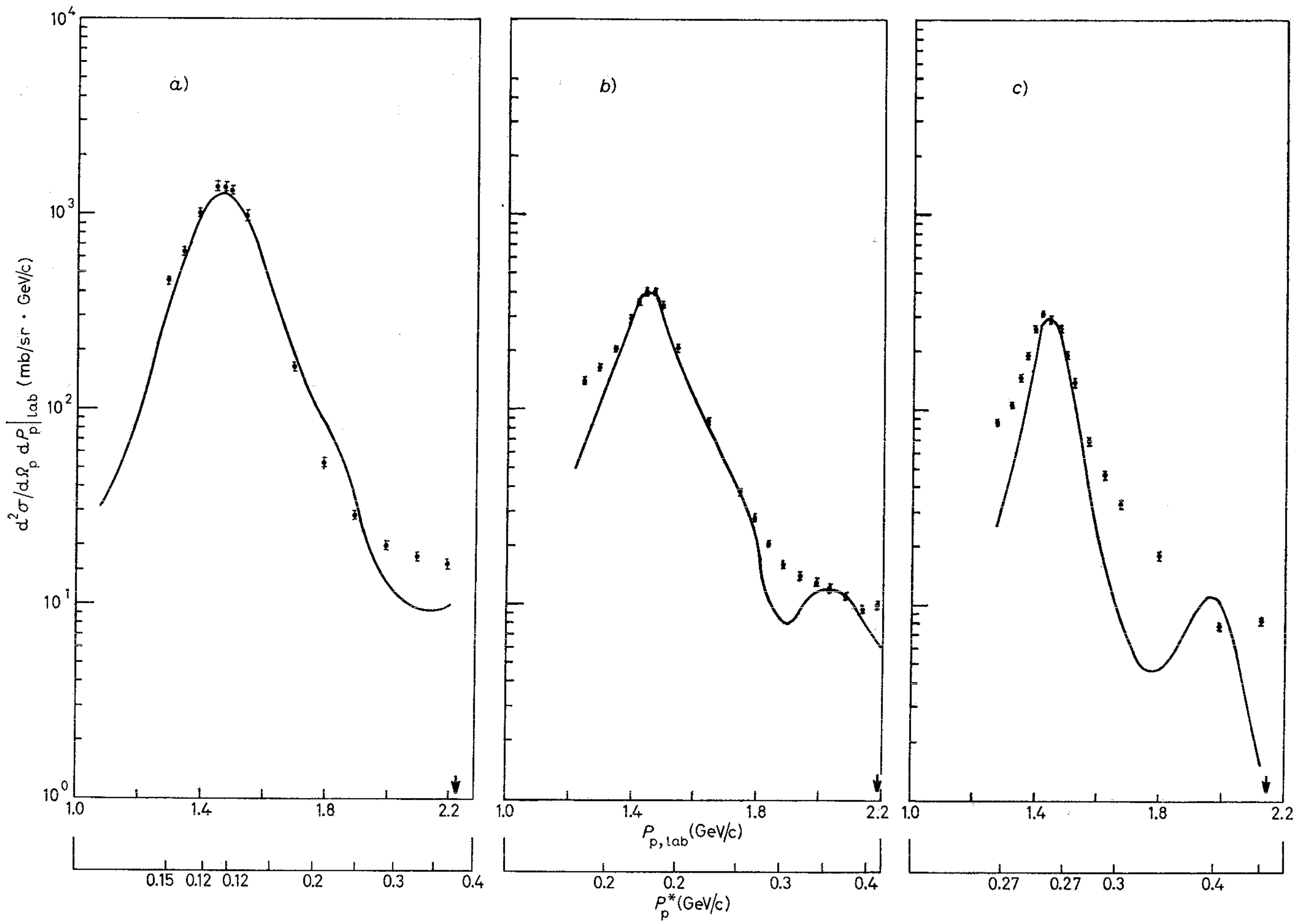

Fig. 1. – Momentum spectra of protons from 2.95 GeV/c deuterons on hydrogen in the laboratory system. ɸ experimental data. The solid lines represent the Glauber model prediction. The lower scales show the proton momenta in the rest system of the deuteron (P_p^*). The arrows indicate the kinematic points fo the dp backward elastic scattering; *a)* $\theta_{p,lab} = 4.6°$, *b)* $\theta_{p,lab} = 7.4°$, *c)* $\theta_{p,lab} = 10.3°$.

interaction (7), and the binding-energy corrections (8). Lately, a theoretical approach claims the importance of the mesonic degree of freedom in the final state of the nucleon pair and of contributions from intermediate isobar states (9).

The experimental study of the deuteron break-up has been substantially improved, especially at small-momentum transfer, by the recent availability of medium-energy deuteron beam. This configuration, using a hydrogen target, allows one to avoid cuts in the spectator proton distribution, due to a loss of small-velocity components (3). Moreover, the contributions of $\mathcal{N}$-$\mathcal{N}$ elastic and inelastic interactions are easier separable.

We have performed a measurement of the process

$$d+p \to p+X$$

at the Saclay Synchrotron «Saturne», by a 2.95 GeV/c deuteron beam, that corresponds to incident protons of $T_p = 810$ MeV in the opposite beam-target configuration. The experimental apparatus is the same used in the study of the deuteron-proton coherent interaction (10). A typical beam of $(1 \div 2.5) \cdot 10^{11}$ deuterons/pulse was focused on a liquid-hydrogen target with a thickness of 5.9 cm. Momentum spectra of the protons scattered at the laboratory angles of 4.6°, 7.4° and 10.3° have been measured by an achromatic double focusing spectrometer, and with a $\pm 1.2\%$ resolution (FWHM). Protons were identified by a 14 meters time of flight between two pairs of scintillation counters placed at the intermediate image and at the final image, respectively. The absolute monitoring, the method of which has already been described (11) was within $\pm 10\%$.

The experimental results are shown in fig. 1, as $d^2\sigma/(d\Omega_p \, dP_p)$ in the system with the hydrogen target at rest (laboratory system) *vs.* $P_{p,lab}$. The data have been corrected accounting for empty-target background, nuclear absorption and spectrometer efficiency.

The appearing large peaks centred at the half of incident momentum are characteristic of quasi-two-body reaction, broadened by a Fermi motion. The contribution of the elastic $\mathcal{N}$-$\mathcal{N}$ interaction is unambiguously isolated, since the inelastic $\mathcal{N}$-$\mathcal{N}$ region is kinematically confined at the left-hand side of the spectrum. In the right-hand side, the exploration has been carried up to the kinematic limit of the backward elastic dp scattering.

The explored region of spectator proton momenta ranges, in the frame with the deuteron at rest, between $118 \div 400$; $190 \div 415$; $265 \div 450$ MeV/c for 4.6°, 7.4° and 10.3°, respectively. The experiment, however, is not able to isolate the contribution of the spectator proton (fig. 2*a*)) from other contributions where the deuteron proton is scattered off (fig. 2*b*), *c*)) or exchanged with the target proton (the latter effect being presumably small at our energy).

In fig. 1 is also reported the result of a calculus performed in the framework of Glauber multiple scattering model, taking into account single and double scattering. The three corresponding diagrams are shown in fig. 2. The effect of the final-state interaction between proton and neutron from the broken deuteron has been neglected n the calculus. The deuteron wave function, including the S- and D-waves, have been

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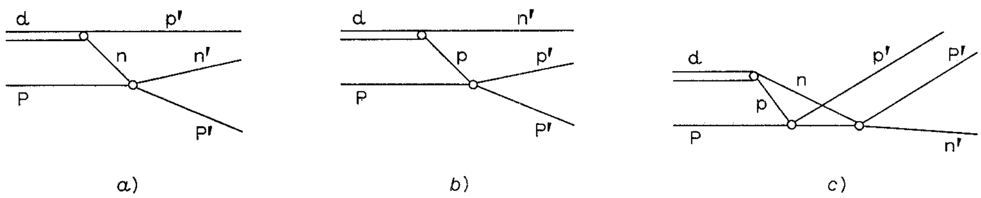

Fig. 2. – Glauber model diagrams: *a*) single neutron-proton scattering; *b*) single proton-proton scattering; *c*) double scattering. d: denotes the incident deuteron; P: the target proton; and p, n: the proton and the neutron of deuteron, respectively.

taken in the form given by HUMBERSTON (12), that yields a D-wave probability of $\sim 7\%$. The nucleon-nucleon scattering amplitude has been taken in the form of a spin independent Gaussian

$$f(q) = \frac{ik\sigma(1 - i\alpha)}{4\pi} \exp\left[-\frac{1}{2}aq^2\right],$$

k, q being the $\mathcal{N}$-$\mathcal{N}$ c.m. momentum and the momentum transfer, respectively, σ the total $\mathcal{N}$-$\mathcal{N}$ cross-section and α the Re/Im ratio for the forward amplitude. We have taken $\sigma_{pp} = 47$ mb; $\sigma_{np} = 40$ mb; $a = 3.9\ \text{GeV}^{-2}$; $\alpha_{pp} = -0.01$; $\alpha_{np} = -0.48$ as appropriate values for a $\mathcal{N}$-$\mathcal{N}$ interaction at 1.5 GeV/c.

The experimental data and the calculus are in excellent accordance at 7.4° while at 4.6° and 10.3° there is disagreement in normalization. The theoretical results presented in fig. 1 have been normalized to the maxima of the experimental peaks, *i.e.* in the kinematic points of the lowest momentum of the spectator. The general trend of the data is well reproduced until ~ 250 MeV/c of momentum in the system of the deuteron at rest; on the contrary there is indication of an excess of contributions of high momentum.

Furthermore our calculation gives a dip at 7.4° and 10.3° in the right-hand side of the spectrum which is, however, absent in the experimental data. This minimum, much more deep if only S-wave contribution is taken into account, is very sensitive to the properties of the deuteron wave function, and could be filled at a larger D-wave probability. It is also probable that the processes neglected in the calculus (*e.g.* final-state interaction) may be perhaps responsible for filling out this dip.

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