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Coulomb Effects in Antiproton-Proton Polarization†

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For the nucleon-nucleon (N-N) system the correct description of polarizations and other spin observables below $E_{lab} \approx 1$ GeV has become a decisive test for N-N interaction models [1]. Up till now only refined meson-exchange potentials succeeded in reproducing the spin structure of the N-N interaction satisfactorily [2]. As a consequence one may consider meson-exchange to be a reliable concept as long as not too small distances are probed.

By G-parity transformation the meson-exchange mechanism can be transferred to the antinucleon-nucleon ($\bar{N}$-N) system. The annihilation, however, which in addition to the elastic interaction comes into play there, can complicate the spin structure. Because of the presence of annihilation in the $\bar{N}$-N system also quark-degrees-of-freedom might here play a more prominent role than in N-N scattering. These fairly unexplored aspects should be revealed by examination of N-N and $\bar{N}$-N spin observables and by comparing them to experimental data. Furtheron such an analysis could provide a check for the validity of the G-parity transformation [3].

For N-N and $\bar{N}$-N scattering the largest data bases and the most accurate experiments exist for the proton-proton (p-p) and antiproton-proton ($\bar{p}$-p) systems, respectively. For these systems, however, one has to disentangle Coulomb and strong interaction effects in order to be able to perform a study of the purely hadronic interactions.

Following the lines of a former investigation of p-p spin observables [4] we present in this contribution results concerning the influence of Coulomb effects on $\bar{p}$-p polarizations. In particular we compare p-p and $\bar{p}$-p polarizations with respect to the influence from the pure Coulomb amplitude and from the Coulomb distortion of the hadronic interaction. For the description of the N-N interaction we take the Paris potential [5]. The $\bar{N}$-N interaction is described by our coupled-channel separable potential model [6], which for the elastic interaction contains the G-parity transformed Paris N-N potential [7] and has a purely phenomenological annihilation.

Fig. 1 shows the predictions of the Paris potential [5] for the p-p polarization at E_{lab} = 10 MeV [4]. The effect of the pure Coulomb amplitude can be seen by comparing the solid and dashed-dotted lines, whereas the Coulomb-distortion effect is represented by the difference of the dashed-dotted and dashed lines the latter being the polarization from the hadronic interaction alone (we remark that a thorough discussion also of the energy dependence of the various Coulomb effects in the p-p system can be found in Ref. 4). Analogous results as for p-p scattering in Fig. 1 are shown for the $\bar{p}$-p case in Fig. 2.

It is obvious that the polarization for $\bar{p}$-p is greater than for p-p scattering by two orders of magnitude. This is largely due to the absence of the Pauli principle for $\bar{p}$-p scattering. This makes the $^3S_1$ - $^3D_1$ state contribute significantly (cf. also neutron-proton scattering [8]), contrary to p-p scattering where this very state is missing. Similarly all P-waves are present in the $\bar{p}$-p system and moreover they are much larger for $\bar{p}$-p than for p-p already at low energies.

The influence from the Coulomb amplitude is different in both cases due to the opposite sign of the Coulomb interaction for p-p and $\bar{p}$-p. The Coulomb-distortion effect, however, goes into the same direction for both p-p and $\bar{p}$-p scattering. Its importance relative to the magnitude of the purely hadronic polarization is about the same in both cases ($\approx$15 - 20 % at most). Of course, the absolute value of the contribution from the Coulomb distortion is much larger in $\bar{p}$-p than in p-p scattering. Certainly it is not negligible in neither case and has to be taken into account especially in low-energy p-p as well as $\bar{p}$-p polarization studies.

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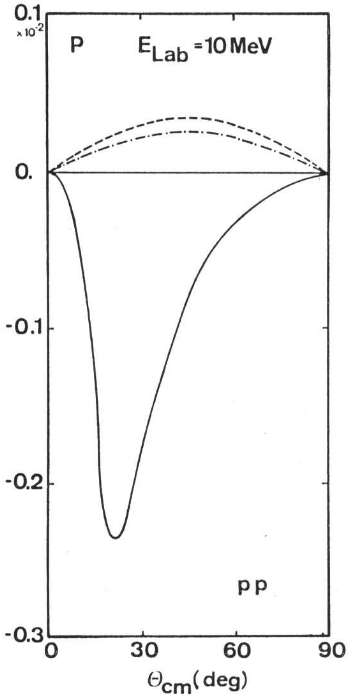

Figure 1: Paris potential predictions for the p-p polarization. The solid line represents the full result including all Coulomb effects. The dashed-dotted line is the Coulomb-distorted nuclear result and the dashed line the purely hadronic one.

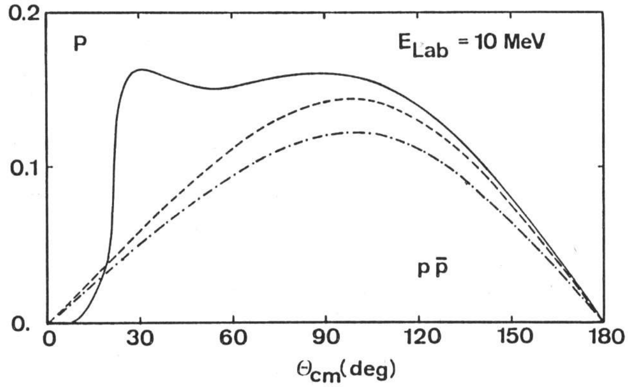

Figure 2: Predictions for the $\bar{p}$-p polarization of our $\bar{N}$-N interaction model (Ref. 6). The distinction of the curves is the same as in Fig. 1.

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