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DIRECT RECONSTRUCTION OF THE AMPLITUDES OF THE \( pp \rightarrow d\pi^+ \) REACTION AT 447, 515
AND 580 MeV

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Résumé : La reconstruction directe des amplitudes de diffusion de la réaction \( pp \rightarrow d\pi^+ \) a été
realisée par le groupe de Genève à 447, 515 et 580 MeV à 8 angles centre-de-masse du deuton,
compris entre 52.5° et 87.5°. Les résultats définitifs à 580 MeV sont présentés.

Abstract : The Geneva group has performed a direct, model independent, reconstruction of
the scattering amplitudes of the \( pp \rightarrow d\pi^+ \) reaction at 447, 515 and 580 MeV at 8 deuteron
center-of-mass angles between 52.5° and 87.5°. Final results at 580 MeV are presented.

1 Introduction

The first amplitude reconstruction published by the Geneva group [1] was challenged by the result of the
measurement of the spin transfer coefficient \( K_{SS} \) performed at TRIUMF[2]. This forced us to check the
analysis and allowed us to uncover that an error in the sign of the longitudinal and sideways polarizations
of the primary proton beam had occurred during the analysis of the spin transfer coefficients. This error lead
to a sign inversion in the asymmetries \( \varepsilon_s(X), \varepsilon_2s(X), \varepsilon_s(Z) \) and \( \varepsilon_2s(Z) \) (see [1] for a complete description
of the formalism used here). The amplitude analysis has now been redone with the correct signs for the
four above asymmetries.

2 The Amplitude Analysis

Six complex amplitudes are necessary to fully describe the scattering matrix of the \( pp \rightarrow d\pi^+ \) reaction.
One overall phase being experimentally unreachable, one has to determine 11 real quantities : 6 modules
and 5 phases. In our case, the analysing powers of the Carbon polarimeter which analysed the deuteron
polarisation were unknown (except for \( T_{20} \) which we took equal to 0 [3]) and had to be treated as free
parameters in the analysis, raising the number of unknowns to 14.

Over the years, the Geneva group had measured many observables for the \( pp \rightarrow d\pi^+ \) reaction, starting
with differential cross section[4] continuing with analysing powers \( A_{on} \) and \( A_{no} \) and spin correlation coeffi-
cients \( A_{nn}, A_{ss}, A_{kk} \) and \( A_{sk}[5][6] \) and finally ending with spin transfer coefficients \( \varepsilon_s(0), \varepsilon_2s(0), \varepsilon_c(\pm y),\varepsilon_2c(\pm y), \varepsilon_s(X), \varepsilon_2s(X), \varepsilon_s(Z) \) and \( \varepsilon_2s(Z) \)[1]. A total of 17 observables was then measured at each energy
and angle. In addition, the Pauli principle allow us to express the above \( \varepsilon \)'s measured at an angle \( \pi - \theta \) by
means of the amplitudes at angle \( \theta \). One could then add 10 new observables \( \varepsilon(\pi - \theta) \) by introducing only
3 new parameters, the 3 polarimeter analysing powers at \( \pi - \theta \). The amplitude analysis consisted finally
in fitting 27 measured observables by means of 17 free parameters.

3 Results and Discussion

Figure 1 shows the polarimeter effective analysing powers obtained from the analysis compared with two
measurements carried out at Saclay with experimental set-up similar to the Geneva polarimeter[3] [7].
Figures 2 and 3 show the reconstructed amplitudes compared with theoretical calculations due to Locher[8] [9], the Lyon group[10], Blankleider[11], Niskanen[12] and Rinat[13] and with two partial waves analyses due to Bugg[14] and Watari[15]. It is visible that the theoretical calculations have problems reproducing the data: the difference between the modules of amplitudes A and C is underestimated and large discrepancies exist between the different predictions for amplitudes D, E and F. Moreover, most theoretical calculations tend to minimize the modules of these amplitudes. All these feature confirm the tendency already pointed out [1] [9], that the proton-proton spin triplet strength is underestimated by the theoretical models.

References

[7] B. Bonin et al. POMME, a medium energy deuteron polarimeter based on semi-inclusive d–Carbon scattering. Submitted to N.I.M.

Figure 2: Modules of the helicity amplitudes at 580 MeV in $\sqrt{mb/sr}$ vs. $\theta_{cm}$. The data at 0° and 90° are from E. Aprile-Giboni et al. Nucl. Phys. A415(1984)391.
Figure 3: Phases of the helicity amplitudes at 580 MeV in radian vs. $\theta_{e.m.}$.