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Determination of the analysing power for the $\vec{p}p \to pp\eta$ reaction using the WASA-at-COSY detector system

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Abstract. High statistics measurements of the analyzing power for the $\vec{p}p \to pp\eta$ reaction were performed with the WASA-at-COSY detector at the Cooler Synchrotron COSY. The η meson was produced at two excess energies: Q = 15 MeV and Q = 72 MeV, and it was registered using the missing and invariant mass techniques. The determined analyzing power is consistent with zero for Q = 15 MeV implying the dominance of s wave and an insignificant contribution of the Sd partial wave. However, at Q = 72 MeV the angular distribution of the analyzing power reveals a strong interference of Ps and Pp partial waves. Moreover, the available theoretical predictions for the angular dependence of the analyzing power strongly deviate from our experimental results.

1 Introduction

The aim of the presented studies is the determination of the analyzing power $A_y(\theta)$ for the reaction $\vec{p}p \to pp\eta$, which can provide the information about the production mechanism of the η meson and meson-nucleon final state interaction. So far the total and differential cross sections for the η meson production in nucleon-nucleon collisions [1] have been determined precisely [2–14]. However A_y has been determined only by the DISTO [15] and COSY-11 [16–18] collaboration with large uncertainties. The presented experiment was conducted using the azimuthally symmetric WASA-at-COSY detector [19] and a polarized proton beam provided by COSY colliding with a proton target at two beam momenta: 2026 MeV/c and 2188 MeV/c corresponding to 15 MeV and 72 MeV excess energies, respectively. The polarization degree was measured using proton-proton elastic scattering reaction, registered simultaneously with the main reaction. The determined value of the polarization amounts to about 65%, and it was stable over the whole experiment [20, 21]. Compared to the previous COSY-11 experiments with about 2000 events only [16], WASA-at-COSY collected nearly 400 000 events with an η meson identified.

2 Analyzing power of the η meson

The analyzing power A_y was determined by measuring the $pp \to pp\eta$ reaction and two neutral particles originating from the η meson decays: $\eta \to \gamma\gamma$ and $\eta \to 3\pi^0$. Values of $A_y(\theta)$ were determined for spin up and spin down mode and both decay channels separately.

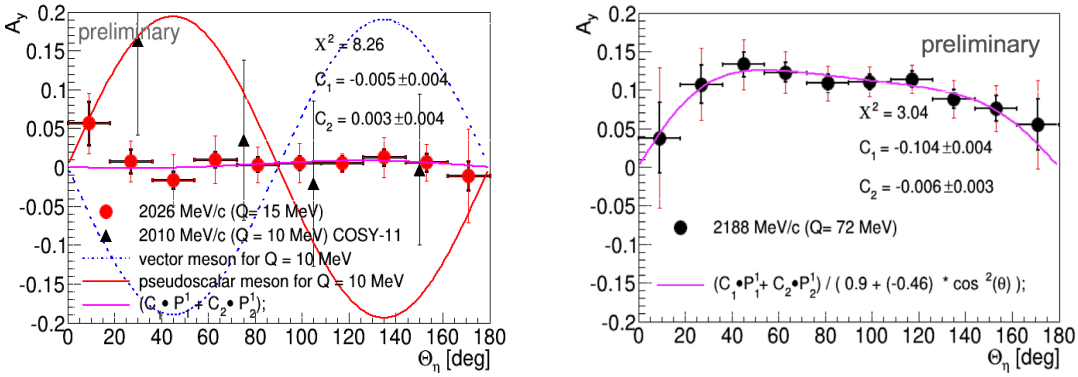

Figure 1. Analyzing power of the η meson as a function of the centre-of-mass emission angle of the η meson θ_η. (Left) Angular distribution of A_y for excess the energy 15 MeV, where superimposed lines indicate theoretical predictions: vector dominance model [22] for 10 MeV - solid red line; pseudoscalar model [23, 24] - dashed blue line. (Right) Angular distribution of A_y for 72MeV, where the superimposed solid pink line denotes the fit of A_y with the sum of the two associated Legendre polynomials P_1^1 and P_2^1.

The analyzing power was determined for ten angular θ intervals together with statistical and systematic uncertainties (Fig. 1). The obtained angular dependence of the analyzing power agrees with the previous experiments. However it differs from the theoretical predictions based on the pseudoscalar or vector meson dominance models [22, 24].

Figure 1 shows the obtained results based on the measured experimental data with superimposed lines corresponding to a fit of the formula:

$$A_y \frac{d\sigma}{d\Omega} = C_1 \cdot sin\theta_\eta + C_2 \cdot cos\theta_\eta sin\theta_\eta \tag{1}$$

with $C_1 = \Im(A_{Ps} A^*_{Pp})$ and $C_2 = \Im(A_{Ss} A^*_{Sd})$ treated as free parameters of the fit.

3 Result

The elaborated angular dependence of the analyzing power agrees with previous results obtained by the COSY-11 experiment but disagrees with the theoretical predictions [23, 24]. The analysis using the associated Legendre polynomials shows that $Ss\ Sd$ and $Pp\ Ps$ interference is not present for Q = 15 MeV. For the higher excess energy (72 MeV), the observed Sd partial wave contribution is also negligible. However, a contribution of $Ps\ Pp$ interference is large which indicates that at Q = 72 MeV the η meson is produced in the s and p wave, but a contribution from the d wave is negligible.

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