Tensor Target Analysing Powers in Coherent π^0 Photoproduction on Deuteron

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Introduction

Deuteron being the simplest nuclei with one proton and one neutron can be used to study photodisintegration, photoproduction and electroproduction processes. For each of these processes there are many reaction channels. Photoproduction reaction channels end up with elementary particles and mesons. $\pi-$meson production happens in four reaction channels, the incoherent photoproduction processes being, $\gamma + d \to n + n + \pi^+$; $\gamma + d \to n+p+\pi^0$; $\gamma+d \to p+p+\pi^-$ and the coherent photoproduction process being $\gamma+d \to d+\pi^0$. These photoproduction processes are of great interest to theoretical studies [1–3] and experimental measurements [4–6].

In the recent years sum rule like Gerasimov - Drell - Hearn was verified for pion photoproduction reactions [5, 7–9]. In addition, there are experimental studies [10, 11] to study double pion photoproduction as well. Partial Wave Analyses models like Mainz Unitary Isobar Model (MAID) [12, 13], Scattering Analysis Interactive Dial-In (SAID) [14] and Bonn-Gatchina (Bn-Ga) [15] have been used to study pion photoproduction reaction. Measurements on Tensor Analysing Powers for π^0 photoproduction [6, 16–25], π^- photoproduction [26–28], Asymmetry [7, 29–31] and Polarization Observables [32–34] were carried out in efforts to achieve higher agreement with theoretically available data. Measurement of Tensor Analyzing Power T_0^2 in $\gamma+d \to d+\pi^0$ performed at $VEPP-3$ storage rings showed discrepancy for $E_\gamma > 350\ MeV$ [19], for $E_\gamma > 400\ MeV$ [35]. Using diagrammatic approach [1] satisfactory agreement was obtained for T_0^2 with $VEPP-3$ data [19, 35]. Yet there was discrepancy between theoretical predictions and experimental data. We may quote "The quality of agreement between theory and experiment decreases at higher photon energies, hence an improvement in theoretical models seems to be needed." [19].

Theoretical study of pion photoproduction on deuterons was carried out [3] using the model independent formalism developed for photodisintegration of deuterons [36, 37]. We propose to extend this study to analyze the Tensor Target Analyzing Power A_0^2 in terms of the multipole amplitudes for coherent π^0 photoproduction channel in hope to explain the discrepancy.

Theoretical Formalism

Using the same notations as in [3], the reaction matrix can be written as,

$$M(\mu) = \sum_{\lambda=0}^{2} \left(S^\lambda(1,1) \cdot \mathcal{F}^\lambda(\mu)\right). \qquad (1)$$

With initially unpolarized photons and polarized deuteron target the differential cross section can be written as

$$\frac{d\sigma}{d\Omega} = \frac{1}{6}Tr[M\rho M^\dagger] = \frac{d\sigma_0}{d\Omega}[1 + \sum_{k=1}^{2}(t^k \cdot A^k)] \qquad (2)$$

where, ρ is the density matrix for the polarized deuteron target, $\frac{d\sigma_0}{d\Omega}$ is the unpolarized differential cross section, t_q^k are Fano Statistical Tensors and A_q^k denote the Tensor target Analyzing Powers.

Limiting ourselves to lower order partial wave amplitudes $l = 0, 1$, the Tensor Target

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Analyzing Power A_0^2 can be written as,

$$A_0^2 = \frac{\sqrt{3}}{2} \sum_{\lambda,\lambda',\mu} \mathcal{B}^\lambda \left(\mathcal{F}^\lambda(\mu) \otimes \mathcal{F}^{\dagger\lambda'}(\mu)\right)_0^2 \quad (3)$$

where $\mathcal{B}^\lambda = [\lambda][\lambda']W(121\lambda; 1\lambda')$.

The measurements and theoretical analysis of the Tensor Analyzing Powers will give a better insight about the coherent channel of pion photoproduction process on deuteron. A detailed analysis will be presented.

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