ASSOCIATIVE PHOTOPRODUCTION OF ROPER RESONANCE WITH VECTOR MESONS

T. BABACAN, H. BABACAN, A. GOKALP and O.YILMAZ

Physics Department, Middle East Technical University, 06531 Ankara, Turkey

ABSTRACT

We examine the associative photoproduction of Roper resonance with vector mesons, $\gamma+N\rightarrow N^*(1440)+V$, in the near threshold region by using the analogy with the processes of "elastic" vector meson photoproduction, $\gamma+N\rightarrow N+V$. Different production mechanisms are suggested. In addition to standart σ- and π-exchanges in the t-channel, the baryonic exchanges in the s- and u-channel are taken into account as well. We calculate the differential cross-section and beam asymmetry on proton and neutron targets for the reaction $\gamma+N\rightarrow N^*(1440)+\omega$. All calculations are performed at E_γ= 2.5 GeV.

The recent study [1] on the associative photoproduction of Roper resonance with vector mesons, $\gamma+N\rightarrow N^*(1440)+V$, in the near threshold region indicates the importance of the pseudoscalar (π) exchange for t-channel in associative ω-meson photoproduction but it does not give a clear information about the relative role of different possible threshold mechanisms on the production of $N^*(1440)$. Therefore, in additon to standart σ- and π-exchanges in the t-channel, we consider the baryonic resonances in the s- and u-channel .

For t-channel, the pseudoscalar (π) and scalar exchanges (σ), Fig.1(a), are considered The pseudoscalar exchange amplitude can be obtained from the Lagrangian,

$$\mathbf{L}_\pi = g_{\omega\pi\gamma}\,\varepsilon^{\mu\nu\alpha\beta}\partial_\mu V_\nu\,\partial_\alpha A_\beta \pi \ - i\, g_{\pi NN^*}\overline{N}^*\gamma_5 \pi N \tag{1}$$

where A_μ is the photon field. Following Ref. [1,2] , we use the coupling constants as $g^2_{\omega\pi\gamma}$ = 3.315 and $g^2_{\pi NN}/4\pi$=3.4. The form factors that we have used are as follows:

$$F_{\pi NN^*} = \frac{\Lambda_\pi^2 - M_\pi^2}{\Lambda_\pi^2 - t}, \qquad F_{\omega\pi\gamma} = \frac{\Lambda_{\omega\pi\gamma}^2 - M_\pi^2}{\Lambda_{\omega\pi\gamma}^2 - t}, \tag{2}$$

where Λ_π = 0.7 and $\Lambda_{\omega\pi\gamma}$ = 0.77 in GeV unit. [3]

The scalar (σ) exchange amplitude can be obtained from the Lagrangian,

$$\mathbf{L}_\sigma = \frac{e\, g_{\omega\sigma\gamma}}{M_\omega}(\partial^\mu V^\nu\,\partial_\mu A_\nu - \partial^\mu V^\nu\,\partial_\nu A_\mu)\sigma \ + g_{\sigma NN^*}\overline{N}^* N\sigma \tag{3}$$

The form factors for this exchange are given as,

$$F_{\sigma NN^*} = \frac{\Lambda_\sigma^2 - M_\sigma^2}{\Lambda_\sigma^2 - t}, \qquad F_{\omega\sigma\gamma} = \frac{\Lambda_{\omega\sigma\gamma}^2 - M_\sigma^2}{\Lambda_{\omega\sigma\gamma}^2 - t} \tag{4}$$

where $\Lambda_\sigma = 1.0$ GeV, $\Lambda_{\omega\sigma\gamma} = 0.9$ GeV, $M_\sigma = 0.5$ GeV and the coupling constant, $g^2_{\sigma NN}/4\pi = 0.34$ [1,2] .

Finally, the baryonic resonaces in the s- and u-channel , Figure 1 (b,c), are considered. The Lagrangian for the (s+u) nucleonic resonances can be given by

$$\mathbf{L}_S = \overline{N}^* \left[g^V_{\omega NN^*} \gamma_\mu V^\mu - \frac{g^T_{\omega NN^*}}{M_N + M^*} \sigma_{\mu\nu} \partial^\nu V^\mu \right] N - e\overline{N}^* \left[Q_N \gamma_\mu A^\mu - \frac{\kappa_N}{2M_N} \sigma_{\mu\nu} \partial^\nu A^\mu \right] N$$

(5)

$$\mathbf{L}_U = \overline{N}^* \left[g^V_{\omega NN^*} \gamma_\mu V^\mu - \frac{g^T_{\omega NN^*}}{M_N + M^*} \sigma_{\mu\nu} \partial^\nu V^\mu \right] N - e\overline{N}^* \left[Q_N \gamma_\mu A^\mu - \frac{\kappa_{N^*}}{2M^*} \sigma_{\mu\nu} \partial^\nu A^\mu \right] N$$

where κ_N is the anomalous magnetic moment of the nucleon ($\kappa_p = 1.79$ $\kappa_n = -1.91$), $g^T_{\omega NN^*}$ and $g^V_{\omega NN^*}$ are the tensor and vector coupling constants, respectively. κ_{N^*} is the anomalous magnetic moment of the $N^*(1440)$, and, for the simplicity, in our calculations we take

$\kappa_{N^*} = \kappa_N$, $g^V_{\omega NN^*} = 0$

The differential cross-section and beam asymmetry for the Roper resonce, $\gamma + N \rightarrow N^*(1440) + \omega$, are calculated at $E_\gamma = 2.5$ GeV. The values of the coupling constants, $g^T_{\omega NN^*}$ and $g_{\omega\sigma\gamma}$, are 3.41 and 0.13. The value of the latter coupling constant is taken from reference [4,5]. The results for our model calculations are shown in Figure 2. From the curves, it can be concluded that the σ-exchange contribution is so small that the behaviour of the graphs for π and (π+σ) terms does not change in both differential cross-section and beam asymmetry, and, the dominance of the s+u nucleonic term contribution is obvious as the value of |t| (momentum transfer) increases.

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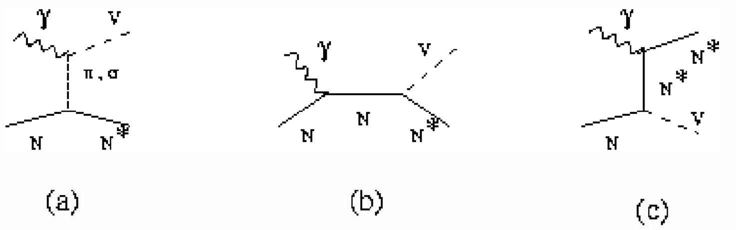

Figure 1: Three mechanisms for vector meson (V= w) photoproduction involving the excitation of the N* (1440) resonance:
(a) one-boson exchange, (b) and (c) s- and u-channel intermediate nucleon diagrams.

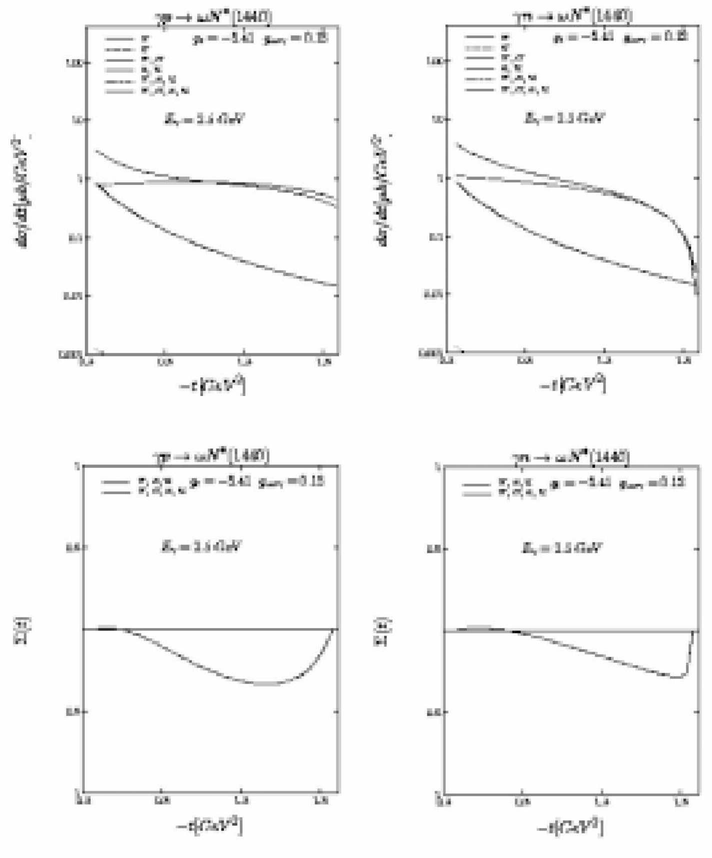

Figure 2 : Differential cross-section and beam asymmetry for inelastic ω meson photoproduction on proton and neutron tagets at E_γ = 2.5 GeV