The ρ and ω mesons production in the γp reaction

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The ρ-ω interference has been well studied in the pion decay channel [1]. The information about this interference in the e^+e^- decay exist only for the γ-C reaction due to Biggs et al., [2] and for the γ-Be reaction due to Alvenslaben et al., [3]. The interference phases derived in the pionic and electromagnetic decay channels are different and this discrepancy is never understood.

Recently, the ρ-ω interference has drawn considerable attention stemming from the different results of in-medium modification studies of the ω meson. The transparency measurement done by Woods et al., [4] shows the boarding of ω meson (detected through $\omega \to e^+e^-$) in heavy nuclei, resulting the absorption cross section of the ω meson equal to 150 mb. In another experiment of this kind done by Kotulla et al. [5], the absorption cross section of the ω meson (detected through the decay $\omega \to \pi^0\gamma$) is found much less, i.e., 70 mb. Therefore, the ρ-ω interference in the electromagnetic decay channel in the γp reaction (which is not studied yet) could shed some light on the importance of the ρ-ω interference when interpreting the transparency ratio measured for the ω meson. To be mentioned, proposal is there at Jeffereson Laboratory for the measurement of the above reaction.

To study the ρ-ω interference in the γp reaction in the dilepton decay, the differential cross section of the dilepton invariant mass distribution spectrum has been calculated. The mechanism of this reaction can be visualized as $\gamma p \to V(\rho,\omega)$; $V \to e^+e^-$, i.e., this reaction consists of three parts: (i) the ρ and ω mesons production in the γp reaction, (ii) the propagation of these mesons, and (iii) the decay of them in the e^+e^- channel. The propagation of the ρ and ω mesons is described by the relativistic form. The decay of these mesons is illustrated by the corresponding Lagrangian.

The production of the ρ and ω mesons is accounted by the vector meson dominance model (VMD). According to it, the invariant reaction amplitude is given by

$$M_{\gamma N\to VN} = \frac{\sqrt{\pi\alpha}}{\gamma_V} M_{VN\to VN}, \qquad (1)$$

where α is the electromagnetic fine structure constant. Value of γ_ρ and γ_ω, as extracted from the measured $V\to e^+e^-$, are equal to 2.48 and 8.53 respectively [6]. The diagonal matrix element, i.e., $M_{VN\to VN}$, is related to the elastic scattering amplitude $f_{VN\to VN}$. The experimentally determined values for it has been used.

It may be mentioned that Eq.(1) describes well the ω meson production at higher energy. At lower energy, the off-diagonal term of VDM is needed to be considered, i.e.,

$$M_{\gamma N\to \omega N} = \frac{\sqrt{\pi\alpha}}{\gamma_\rho} M_{\rho N\to \omega N}. \qquad (2)$$

The reaction amplitude $M_{\rho N\to\omega N}$ can be calculated using one pion exchange interaction between the meson and nucleon.

The process described by Eq.(1) involves natural parity exchange where as the reaction in Eq.(2) proceeds because of the unnatural parity exchange since one pion exchange interaction is involved there. Therefore, the differential cross section for the dielectron invariant mass distribution in the $\gamma p \rightarrow V(\rho,\omega)$; $V \rightarrow e^+e^-$ reaction consists of two parts:

$$\frac{d\sigma}{dm} = \frac{d\sigma}{dm}|_{Eq.(1)} + \frac{d\sigma}{dm}|_{Eq.(2)}. \qquad (3)$$

The first part of the above equation originates due to Eq.(1) where as the second part occurs because of Eq.(2).

Due to lack of space, only the calculated results for the ω meson ($\omega \rightarrow e^+e^-$) mass *m* distribution spectrum is presented. In Figure, it is shown that at lower energy, i.e., E_γ=1.5 GeV, the ω meson production due to the mechanism described in Eq.(2) [see dot-dot-dash curve] is significantly larger than that described in Eq.(1) [denoted by dot-dash curve]. At higher energy, as shown for E_γ=8.0 GeV, it goes other way. The calculated results, presented in this figure, shows the contribution of the second part in Eq.(3), which arises due to Eq.(2), decreases with the increase in the beam energy, and it can be neglected for E_γ > 10 GeV.

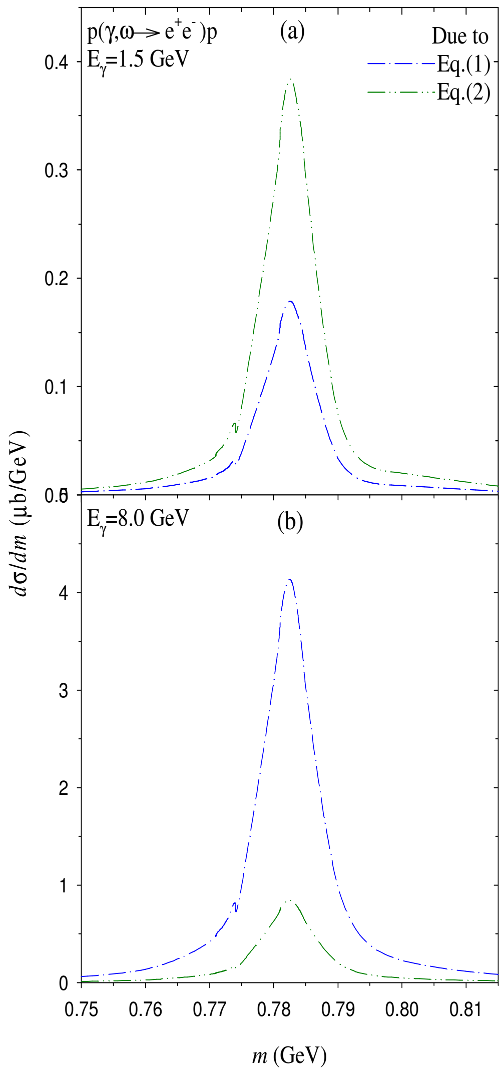

Figure: ω meson or dielectron invariant mass (*m*) distribution spectra, see text.

References

[1] H. Alvensleben et al., Nul. Phys. B 25 333 (1970); Phys. Rev. Lett. **27** 888 (1971).
[2] P. J. Biggs et al., Phys. Rev. Lett. **24** 1197 (1970).
[3] H. Alvensleben et al., Phys. Rev. Lett. **25** 1373 (1970).
[4] M. H. Wood et al., Phys. Rev. Lett. **105** 112301 (2010).
[5] M. Kotulla et al., Phys. Rev. Lett. **100** 192302 (2008).
[6] Swapan Das, Phys. Rev. C (press).