Measurement of ϕ-meson photoproduction near threshold with linearly polarized photons

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The low-energy ϕ-meson photoproduction is expected to provide a unique way of studying "exotic" production mechanisms and/or the Pomeron exchange process since conventional meson exchanges are suppressed by the OZI-rule. A candidate for exotic mechanism is a trajectory associated with the 0^+ glueball [1]. Search for the exotics at low energy is important since its contribution is expected to decrease rapidly with increasing photon energy, and the contribution from the Pomeron exchange increases. Presence of the exotic mechanism may lead to a non-monotonic behavior of the energy dependence of the cross section in near-threshold region. In addition to the possible exotic mechanism, a pseudo-scalar meson exchange, a scalar meson exchange [2, 3] and a f'_2-meson exchange [4] are possible to contribute to the reaction near the threshold. Spin observables are useful to determine the relative contributions of the natural-parity exchange (Pomeron, 0^+ glueball, scalar-meson), unnatural-parity exchange (π, η mesons) and helicity-flip processes (f'_2-meson etc.). A K^+ distribution $W(\cos\theta, \phi, \Phi)$ of $\phi \to K^+K^-$ decay is a function of the spin-density matrix elements, where θ, ϕ and Φ stand for polar angle, K^+ azumithal angle and the angle between the photon polarization and the production plane (for the definition, see Ref. [5]). The relative contribution between the natural parity exchange and unnatrual parity exchange is related to the density matrix element $\bar{\rho}^1_{1-1}$ which is extracted from the W($\phi - \Phi$) distriubtion. Near the threshold, spin-flip amplitudes are predicted to play a more important role [6], which is seen in the $\cos\theta$ dependence of $W(\cos\theta)$ as a deviation from $3/4\sin^2\theta$ and the modulations in the $W(\phi+\Phi), W(\phi)$ and $W(\Phi)$ distributions.

We took data using a liquid hydrogen target with linearly polarized photons at SPring-8/LEPS facility. The details of the experiment and data analysis are described in Ref. [7]. The differential cross sections $d\sigma/dt$, where $t \equiv (p_\phi - p_\gamma)^2$, were measured and fitted by a form $(d\sigma/dt)_{t=-|t|_{min}} e^{b(t+|t|_{min})}$, where $(d\sigma/dt)_{t=-|t|_{min}}$ and b were fitting parameters. Figure 1 shows the energy dependence of $(d\sigma/dt)_{t=-|t|_{min}}$ when b was assumed to be energy independent ($b = 3.38 \pm 0.23\ GeV^{-2}$). The energy dependence of $(d\sigma/dt)_{t=-|t|_{min}}$ showed a non-monotonic behavior, i.e. a peaking structure appeared around $E_\gamma = 2$ GeV. The data was compared with the prediction of a model which includes the Pomeron exchange and π, η exchange processes without any exotic mechanisms [6]. The dashed curve in Fig. 1 represents the model prediction with a normalization factor which was obtained by the least square fit to the data points. The model does not describe the data points in this energy region. To understand a reason of the peaking structure in the cross section, the decay angular distributions were measured for $-0.2 < t + |t|_{min} \leq 0$ GeV^2 at two different energies: $1.973 < E_\gamma < 2.173$ GeV (near the cross section peak) and $2.173 < E_\gamma < 2.373$ GeV (above the cross section peak). Figure 2 (left panel) shows the angular distribution $W(\cos\theta)$. At both energies, $W(\cos\theta)$ follows $\sim 3/4\sin^2\theta$ which indicates the dominance of the helicity conserving process. Thus, a contribution from the f'_2-meson exchange, which is predicted to introduce a large spin-flip [6], is small. Figure. 2 (right panel) shows the $W(\phi - \Phi)$ distribution. $\bar{\rho}^1_{1-1}$ was found to be 0.189 ± 0.024 and 0.197 ± 0.030 for

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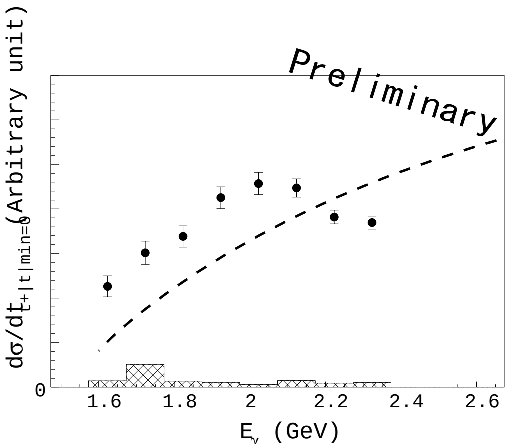

Figure 1: Energy dependence of $(d\sigma/dt)_{t=-|t|_{min}}$. The closed circles indicate the LEPS data. The dashed curve shows the prediction from the model [6]. The hatched histogram are the estimated systematic errors.

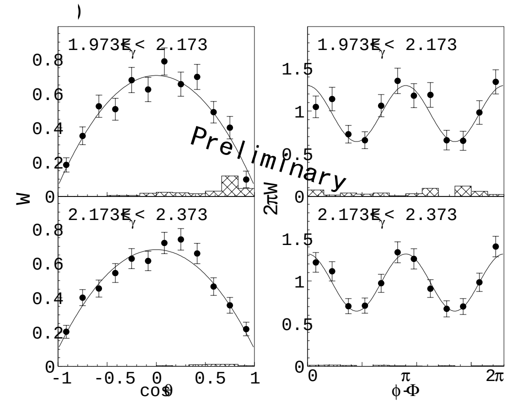

Figure 2: Decay angular distributions for -0.2< $t+|t|_{min}$. The solid curves indicate a fit to the data. Systematic errors are shown in hatched histogram

$2.173 < E_\gamma < 2.373$ GeV and $1.973 < E_\gamma < 2.173$ GeV, respectively. The positive value for $\bar{\rho}^1_{1-1}$ implies that a contribution from the unnatural parity exchange (π, η exchange) is not dominant. The relative contribution between natural parity exchange and unnatural parity (π, η-meson) exchange was observed to be nearly the same for the two energy bins. Taking into acount that the contribution from Pomeron exchange is expected to be almost constant in this energy range, the peaking structure of the cross section can not be explained by unnatural-parity exchange processes only. A possible explanation of this effect might be related to the 0^+ glueball exchange. However a fit suggested by Ref. [1] failed to reproduce the peaking structure with the proposed set of parameters. Further measurement in the wider energy range as well as theoretical studies would help to understand the underlying mechanism of the peaking structure.

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