Interference between ϕ and $\Lambda(1520)$ photoproduction channels

The ϕ-$\Lambda(1520)$ interference effect in the $\gamma p \rightarrow K^+K^-p$ reaction has been measured for the first time in the energy range from 1.673 to 2.173 GeV at SPring-8 **BL33LEP** [1]. The relative phases between ϕ and $\Lambda(1520)$ production amplitudes were obtained in the kinematic region where the two resonances overlap. The measurement results support the occurrence of strong constructive interference when K^+K^- pairs are observed at forward angles but destructive interference for proton emission at forward angles. This fact suggests possible exotic structures such a hidden-strangeness pentaquark state, a new Pomeron exchange or rescattering processes via other hyperon states.

ϕ-meson production has the unique feature within gluon dynamics of being a result of OZI suppression due to the dominant $s\bar{s}$ structure of the ϕ meson, which is predicted to proceed via a Pomeron trajectory with $J^{PC} = 0^{++}$. Cross sections for diffractive ϕ photoproduction are thus predicted to increase smoothly with photon energy, as shown in Fig. 1(a). However, a bump structure at $\sqrt{s} = 2.1$ GeV in forward differential cross sections was first reported by the LEPS collaboration [2]. Recent theoretical studies have related this to a coupling between the ϕp and $K^+\Lambda(1520)$ channels, because the bump structure was observed to be very close to the threshold of $\Lambda(1520)$ production. The ϕ-$\Lambda(1520)$ interference may also account for the bump structure, but it has not yet been measured in K^+K^-p photoproduction. Despite extensive experimental effort devoted to the photoproduction of ϕ mesons near the threshold, the nature of the bump structure has not yet been explained in detail.

The experiment was carried out using the LEPS detector at BL33LEP. Linearly polarized photons with energies from 1.5 to 2.4 GeV were incident on a 15 cm liquid-hydrogen target, in which K^+, K^- and p particles were produced and then passed through the LEPS spectrometer (Fig. 2).

The measured K^+K^- and K^-p mass spectra for the selected K^+K^-p events were fitted with lineshapes from processes simulating the ϕp, $\Lambda(1520)K^+$ and non-resonant K^+K^-p channels. The best-fit lineshapes for ϕ, $\Lambda(1520)$ and non-resonant K^+K^-p well reproduce the K^+K^- and K^-p mass spectra, as shown in Fig. 3.

The fits with Monte Carlo lineshapes were based on the events beyond the ϕ-$\Lambda(1520)$ interference region in which the two resonances appear. The fit results were then interpolated into the interference region, keeping the magnitudes of the Monte Carlo lineshapes determined from the fit. This simultaneous fit with Monte Carlo lineshapes is a self-consistent method of reproducing the measured K^+K^- and K^-p mass spectra.

Forward differential cross sections for the ϕ and $\Lambda(1520)$ production channels were measured using the best-fit results with Monte Carlo lineshapes in the ϕ and $\Lambda(1520)$ mass bands except for the interference region. We reconfirmed the existence of the bump structure around $E_\gamma = 2.0$ GeV. The differential cross sections for $\Lambda(1520)$ photoproduction in the forward

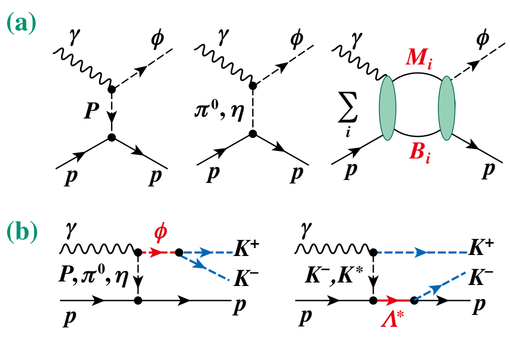

Fig. 1. **(a)** Diagrams showing the dominant photoproduction of ϕ meson from proton. **(b)** Photoproduction of K^+K^-p via ϕ and $\Lambda(1520)$ resonances produced by Pomeron and K/K^* exchanges, respectively.

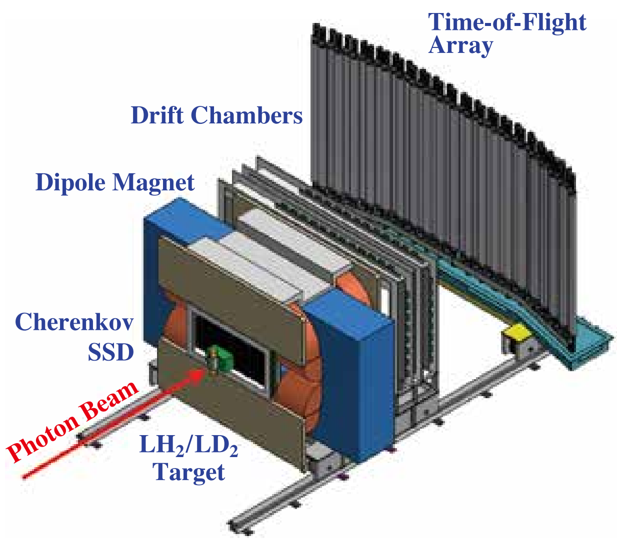

Fig. 2. Schematic view of the LEPS experimental setup for the photoproduction of hadrons at BL33LEP beamline.

angular regions are compared with the previous LEPS results [3]. Interestingly, the two cross-section results show the bump structure at the same E_γ, which may indicate a strong correlation between ϕ and $\Lambda(1520)$. However, the difference between the cross sections obtained with and without the interference region is not large enough to account for the bump structure. For forward K^+K^- events in the energy region of $1.973 < E_\gamma < 2.073$ GeV, the integrated event yield in the interference region approaches close to the maximum bound for the ϕ-Λ interference. Moreover, the relative phase flips its sign as a function of photon energy E_γ. For K^-p events, the relative phase in the energy region of $1.973 < E_\gamma < 2.073$ GeV clearly remains at a positive value, while in other energy regions it indicates destructive interference.

In summary, the photoproduction of the $\gamma p \to K^+K^-p$ reaction was measured using the LEPS detector at energies from 1.57 to 2.40 GeV. The ϕ-$\Lambda(1520)$ interference measurement is a good probe for studying the origin of enhanced production cross sections for ϕ and $\Lambda(1520)$ near $\sqrt{s} = 2.1$ GeV. We observed clear ϕ-$\Lambda(1520)$ interference effects in the energy range from 1.673 to 2.173 GeV. The data obtained in the present study provide the first-ever experimental evidence for the ϕ-$\Lambda(1520)$ interference effect in ϕ photoproduction. The relative phases suggest strong constructive interference for K^+K^- pairs observed at forward angles, while destructive interference results from the emission of protons at forward angles. The nature of the bump structure may originate from interesting exotic structures such as a hidden-strangeness pentaquark state, a new Pomeron exchange or rescattering processes via other hyperon states.

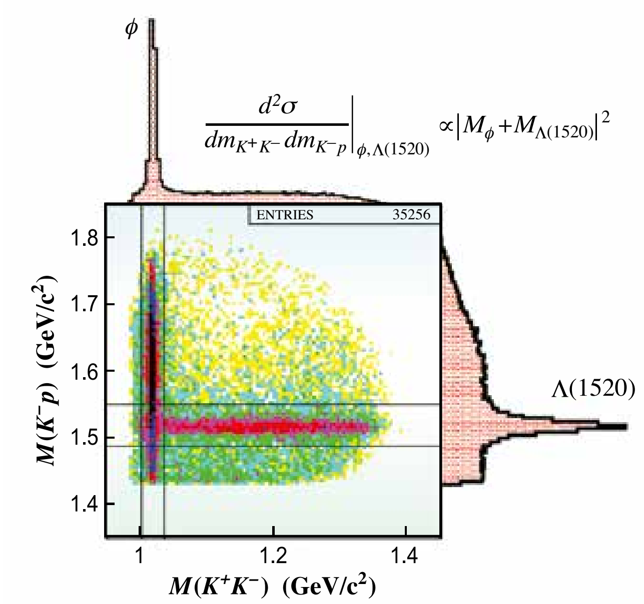

Fig. 3. Scatter plot of the invariant mass of the K^+K^- system *versus* that of the K^-p system with projections onto each invariant mass axis.

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