K^+ Meson Photoproduction Off Neutron at BL33LEP

A nucleon is composed of three quarks. For example, a proton is composed of two up (u) quarks and one down (d) quark. A neutron is composed of one u quark and two d quarks. There are additionally four other types of quarks, that is, charm (c), strange (s), top (t), and bottom (b), which are produced by high-energy collisions. All the quarks discovered so far are listed in Table 1. On the other hand, an anti-nucleon is composed of three anti-quarks. There are six types of anti-quarks, namely, $\bar{u}$, $\bar{d}$, $\bar{c}$, $\bar{s}$, $\bar{t}$, and $\bar{b}$, in total.

Table 1. Discovered quarks

Charge \ Generation	1	2	3
+2/3e	u	c	t
−1/3e	d	s	b

We have constructed beamline **BL33LEP** to study the meson production reactions using a linearly polarized high-energy photon beam. The photon beam is produced by the backward Compton scattering of an ultraviolet Ar laser from 8 GeV electrons. The energy range of tagged photons is from 1.5 to 2.4 GeV, and the photon polarization is typically 90% at 2.4 GeV. When the photons strike liquid hydrogen (LH_2) and deuterium (LD_2) targets, mesons are produced. We can see the s quark and $\bar{s}$ anti-quark pair production in this energy range. We studied the production mechanism of the K^+ meson, which is composed of a u quark and an $\bar{s}$ anti-quark. In the reaction, a hyperon, which is composed of three quarks including one s quark, is also produced.

The production mechanism of the K^+ meson is important for understanding the role of nucleon resonances. Experimental information on excited nucleons and excited Δ resonances has been obtained primarily in studies of π meson production. Constituent quark models predict more nucleon resonances than have been observed experimentally. This is mysterious and these unobserved nucleon resonances are called “missing resonances.” Quark model studies suggest that these resonances can couple to s quark channels, such as $K^+\Lambda$, $K^+\Sigma^0$, and $K^+\Sigma^-$, which have not been well studied.

Theoretically, K^+ meson photoproduction is

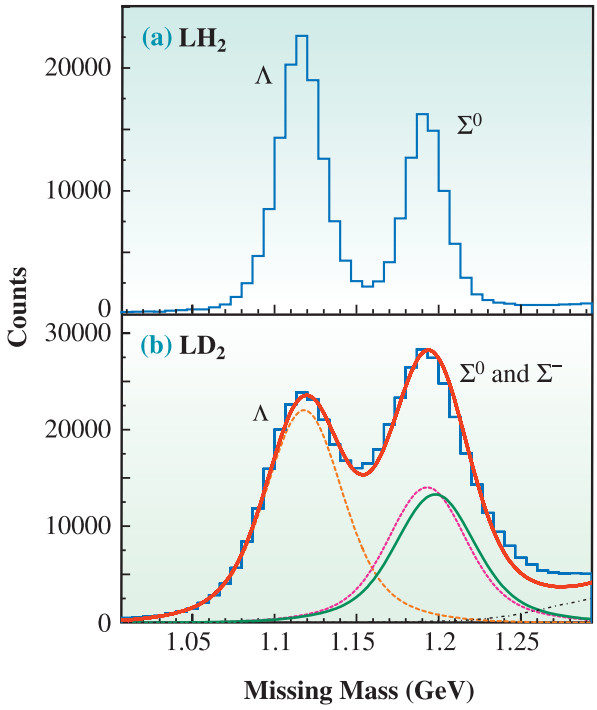

Fig. 1. Missing mass spectra obtained for K^+ photoproduction off **(a)** LH_2 and **(b)** LD_2 targets. Produced hyperons are identified.

described in terms of particle exchanges, such as nucleon, excited nucleon, and Δ resonance in the s channel, hyperon and excited hyperon in the u channel, and K meson and excited K meson in the t channel. The photon beam asymmetry has a unique feature; At a small |t| and at high energies, its value is +1 or -1 if the excited K meson or K meson is exchanged, respectively.

Recently, we have studied K^+ photoproduction off proton and found evidence of a nucleon resonance at the center of a mass energy (W) of about 1.95 GeV. The experimental data were limited to $K^+\Lambda$ and $K^+\Sigma^0$ productions off the proton. No experimental result has yet been published for K^+ photoproduction off a neutron. We obtained data on the $\gamma n \rightarrow K^+\Sigma^-$ reaction for the first time [1].

Figure 1 shows the missing mass spectra for the $p(\gamma,K^+)X(LH_2)$ and $N(\gamma,K^+)X(LD_2)$ reactions. The contribution from $K^+\Sigma^-$ production was obtained from the yield difference between the LH_2 and LD_2 data. Figure 2 shows photon beam asymmetry. It is interesting that the asymmetry for the $K^+\Sigma^-$ differs largely from that for the $K^+\Sigma^0$. The reaction mechanism differs between the two productions. The small asymmetry for $K^+\Sigma^0$ may imply the existence of nucleon resonances in this energy range.

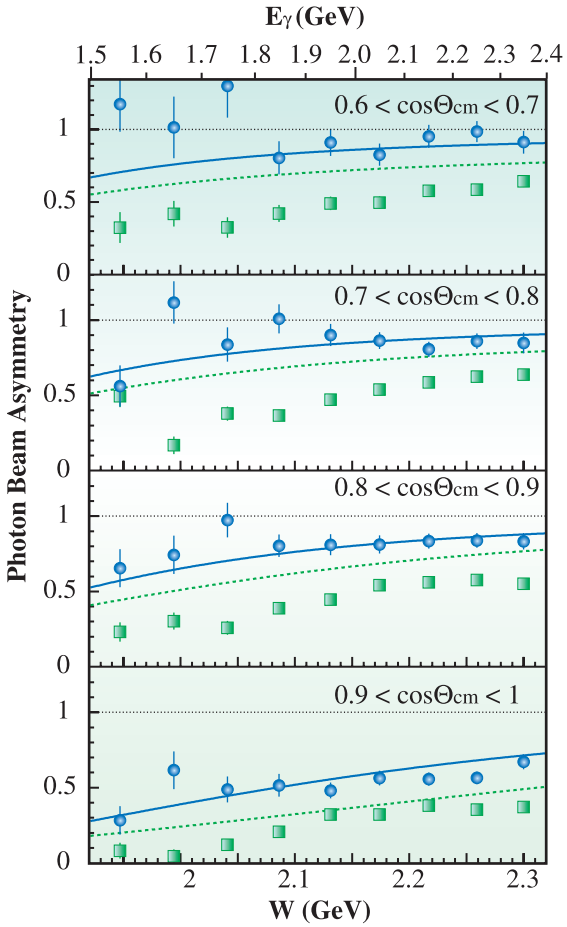

Fig. 2. Photon beam asymmetry for $\gamma n \rightarrow K^+\Sigma^-$ (circles) and $\gamma p \rightarrow K^+\Sigma^0$ (squares). The solid and dashed curves are the Regge model calculations for $K^+\Sigma^-$ and $K^+\Sigma^0$, respectively.

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