The $K_s^0 K_s^0$ and the $K_s^0 K^{\pm}\pi^{\mp}$ Final States in Two-Photon Collisions at LEP and Glueball Searches

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Abstract
Formation of resonances in two-photon collisions for channels with two K-mesons in the final state is investigated with L3 detector at LEP.

1. Introduction

In the two-photon interactions $e^+e^- \to e^+e^-\gamma\gamma \to e^+e^-R$ the resonance R is produced in clean environment and has restricted quantum numbers: it is a neutral unflavoured meson with $C = +1$; for quasi-real photons ($Q^2 \approx 0$) $J \neq 1$; for $Q^2 > 0$ $J = 1$ is possible.

The cross section of the two-photon interaction is proportional to the $\gamma\gamma$ partial width of the resonance: $\sigma(\mathrm{e^+e^-} \to \mathrm{e^+e^-}R) = \mathcal{K} \cdot \Gamma_{\gamma\gamma}(R)$.

Gluonium (G) is not expected to be produced in two-photon interactions due to very small $\Gamma_{\gamma\gamma}(G)$.

Reactions with R decaying into $K_s^0K_s^0$ and $K_s^0K^{\pm}\pi^{\mp}$ are investigated using the L3 detector at LEP. Outgoing e^+e^- are undetected ("untagged events"). Only $K_s^0 \to \pi^+\pi^-$ decay is considered. $K^{\pm}$ is distinguished from $\pi^{\pm}$ by dE/dX.

2. The $K_s^0 K_s^0$ final state

This final state is studied using the full statistics collected at centre of mass energies from 91 GeV to 189 GeV (inregrated luminosity 404 pb^{-1}). $Q^2 \approx |\vec{P}_t(\pi^+\pi^-\pi^+\pi^-)|^2 < 0.1GeV^2$. Possible (lowest) quantum states are $\mathrm{J}^{PC} = 0^{++}$ and 2^{++}. 499 events are selected.

The $K_s^0K_s^0$ mass spectrum, shown in Fig.1, is dominated by the $f_2'(1525)$ resonance. The $f_2(1270) - a_2^0(1320)$ region shows the destructive $f_2 - a_2^0$ interference. A substantial (about 7 standard deviations) enhancement is observed in the 1750 MeV region. A maximum likelihood unbinned fit using three Breit-Wigner functions plus a constant is performed on the spectrum, the result of the fit is shown on Fig.1 by a continuous line and the obtained values for peaks are presented in Table1.

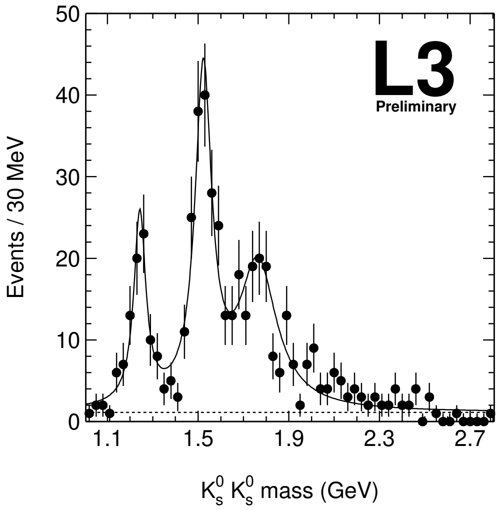

Figure 1. The $K_s^0K_s^0$ mass spectrum.

Table 1.

	$f_2 - a_2$	$f_2'(1525)$	R(1750)
Mass (MeV)	—	1523 ±8	1765±22
Width (MeV)	—	89 ±37	200±50
Nb. of events	75±15	184±27	171±26

To estimate the spin and helicity of the resonance, the angular distribution of the K_s^0 in the $K_s^0K_s^0$ center of mass is compared to the expected distribution for spin zero, spin two helicity zero and spin two helicity two cases. The χ^2 obtained are shown in Table2. For the $f_2'(1525)$ a pure helicity

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zero is excluded and the helicity two is largely dominant. In the 1750 MeV region J=2, λ=2 is also preferable.

The two-photon partial width times branching ratio for $f_2'(1525)$ is found to be

$\Gamma\gamma\gamma(f_2') \times \mathrm{BR}(K\bar{K}) = (0.093 \pm 0.018 \pm 0.022)$keV.

On Fig.1 no excess is observed in the region of $\xi(2230)$ glueball candidate. Then the upper limit is calculated: $\Gamma_{\gamma\gamma}(\xi) \times \mathrm{BR}(\xi \to K_s^0 K_s^0) < 1.5$ eV at 95% C.L. Using results of Mark III and BES collaborations on $\xi(2230)$ production in J/ψ decays [1], a lower limit on stickiness can be estimated: $S_\xi > 68$ at 95% C.L. Stickiness is proportional to the square of the ratio of resonance couplings to gg and to $\gamma\gamma$. The obtained value is much larger than the values measured for all the established $q\bar{q}$ states.

3. The $K_s^0 K^\pm \pi^\mp$ final state

The $K_s^0 K^\pm \pi^\mp$ final state is analysed at LEP II energies $\sqrt{S}$=160 - 189 GeV with integrated luminosity L=250 pb^{-1}. For $Q^2 \approx |\vec{P}_t(\pi^+\pi^- K^\pm\pi^\mp)|^2 < 10$ GeV^2 2086 events are selected. Possible (lowest) quantum states are J^{PC} = 0^{-+} and 1^{++}.

The mass distribution for $K_s^0 K^\pm \pi^\mp$ system shows (the first time in untagged events) a peak in the region of 1440 MeV. Peak is fitted by gaussian plus smooth background. Gaussian parameters for R(1440) are M = 1.465 $\pm$ 0.031 GeV and σ = 0.045 ± 0.005 GeV.

In Fig.2 mass disptibutions are shown for different regions of P_t^2 . These spectra permit to extract a dependence of the resonance formation cross section on Q^2. This dependence can not be described by a pure J^P = 0^- or J^P = 1^+ state. A fit using a combination of these two states gives a contribution of 49$\pm$1 events to the first state and of 63$\pm$6 events to the second (systematic errors are not included).

The two photon width of the $\eta(1440)$ is determined using events with P_t^2 <0.05 GeV^2. In this P_t^2 region the state with J^P = 0^- largely dominates. The obtained value $\Gamma_{\gamma\gamma} \cdot BR(K\bar{K}\pi)$=166$\pm$52 eV is in agreement with the upper limit (< 1200 eV) by the CELLO Collaboration [2].

From this measurement the value of the stickiness is $S_{\eta(1440)}$ = 9.5$\pm$3.0 . Thus there is no evidence for a glueball nature of the $\eta(1440)$.

Table 2.

	J=0	J=2, λ=2	J=2, λ=0
$f_2'(1525)$			
(χ^2 for 7 d.o.f.)	22.5	4.2	28.5
R(1750)			
(χ^2 for 8 d.o.f.)	17.9	7.2	26.3

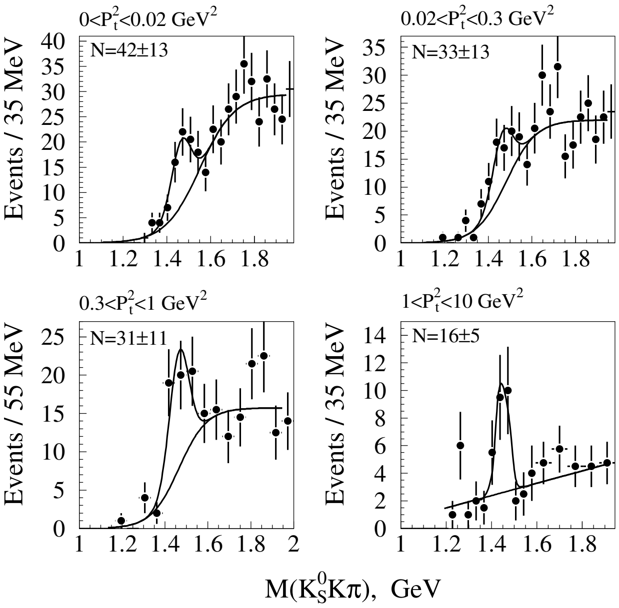

Figure 2. The $K_s^0 K^\pm \pi^\mp$ mass as a function of P_t^2.

4. Conclusions

The following features are observed:

In the $K_s^0 K_s^0$ system: 1) Formation of $f_2'(1525)$, J$^{PC}(\lambda)$=$2^{++}(2)$; 2) $f_2 - a_2$ destructive interference; 3) Enhancement of 7σ in the 1750 MeV region: both 0^{++} and 2^{++} can be present; 4) No signal for the $\xi(2230)$, $\Gamma_{\gamma\gamma}(\xi) \times \mathrm{BR}(\xi \to K_s^0 K_s^0)$ <1.5 eV, $S_\xi >$ 68 at 95% C.L.

In the $K_s^0 K^\pm \pi^\mp$ system: 1) Resonance(1440) is for the first time observed in non-tagged $\gamma\gamma$ collisions; 2) Presence of both 0^{-+} and 1^{++} components is required by the Q^2 distribution of the data; 3) For the $\eta(1440)$ J^{PC} = 0^{-+} $BR(K\bar{K}\pi)$=166$\pm$52 eV; 4) $S_{\eta(1440)} = 9.5 \pm 3.0$, the gluonium hypothesis is not confirmed.

This analysis is described in more detail in paper 8-4, contributed to the conference (see the Web page of the conference http://www.physics.helsinki.fi/∼abstract/papers/papers8.html).

Acknowledgements

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References

[1] BES Collab. 1996 *Phys. Rev. Lett.* **76** 3502; Mark III Collab. 1986 *Phys. Rev. Lett.* **56** 107.

[2] CELLO Collab. 1989 *Z. Phys.* **C 42** 367.