Strong isospin breaking at production of light scalars

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Abstract

It is discussed breaking the isotopic symmetry as the tool of studying the production and nature of light scalar mesons.

Based on

1. N.N. Achasov, S.A. Devyanin and G.N. Shestakov.
   The $S^* - \delta^0/\mathrm{f}_0(980) - \mathrm{a}_0(980)$ mixing as the threshold phenomenon.
   Phys. Lett. B 88 (1979) 367–371.
2. N.N. Achasov, S.A. Devyanin and G.N. Shestakov.
   Mixing of the scalar $S^*/\mathrm{f}_0(980)$ and $\delta^0/\mathrm{a}_0(980)$ mesons and related phenomena.
   Sov. J. Nucl. Phys. 33 (1981) 715.

Based on

3. **N.N. Achasov and N.N. Shestakov.**
   Mechanisms of the reaction $\pi^- p \to a_0^0(980)n \to \pi^0\eta n$ at high energies.
   Phys.Rev. D 56 (1997) 212–220.

4. **N.N. Achasov and A.V. Kiselev.**
   Once more on the mixing of the $a_0(980)$ and $f_0(980)$ mesons.
   Phys. Lett. B 534 (2002) 83.

5. **N.N. Achasov and G.N. Shestakov.**
   Proposed search for the $a_0^0(980)$ - $f_0(980)$ mixing in polarzation phenomena.
   Phys. Rev. Lett. 92 (2004) 182001.

Based on

6. N.N. Achasov and G.N. Shestakov.
   Manifestation of the $a_0^0(980)$ - $f_0(980)$ mixing in the reaction $\pi^- p \to \eta\pi^0 n$ on a polarized target.
   Phys. Rev. D 70 (2004) 074015.

7. N.N. Achasov, A.A. Kozhevnikov, and G.N. Shestakov.
   Isospin breaking decay $\eta(1405) \to f_0(980)\pi^0 \to 3\pi$.
   Phys. Rev. D 92 (2015) 036003.

8. N.N. Achasov, A.A. Kozhevnikov, and G.N. Shestakov.
   Mechanisms of the isospin-breaking decay $f_1(1285) \to f_0(980)\pi^0 \to 3\pi$.
   Phys. Rev. D 93 (2016) 114027.

Introduction

The thirty seven years ago we discovered theoretically a threshold phenomenon known as the mixing of $a_0^0(980)$ and $f_0(980)$ resonances that breaks the isotopic invariance considerably, since the effect $\sim \sqrt{2(\mathrm{M_{K^0}} - \mathrm{M_{K^+}})/\mathrm{M_{K^0}}} \approx 0,13$ in the module of the amplitude. This effect appears as the narrow, $2(M_{K^0} - M_{K^+}) \approx 8$ MeV, resonant structure between the K^+K^- and $K^0\bar{K}^0$ thresholds,

$a_0^0(980) \to K\bar{K} \to f_0(980)$ and vice versa.

N.N. Achasov , S.A. Devyanin and G.N. Shestakov,
Phys. Lett. B 88, 367 (1979).

Nowadays this phenomenon is discovered experimentally and studied with the help of detectors

VES in Protvino and BES III in Beijing

in the processes:

Introduction

V. Dorofeev et al., Eur. Phys. J. A 38, 149 (2008), ibid 47, 68 (2011).

$$\pi^- N \to \pi^- f_1(1285) N \to \pi^- f_0(980)\pi^0 N \to \pi^-\pi^+\pi^-\pi^0 N,$$

M. Ablikim et al., Phys. Rev. D 83, 032003 (2011),
Phys. Rev. Lett. 108, 182001 (2012), Phys. Rev. D 92, 012007 (2015).

$$J/\psi \to \phi f_0(980) \to \phi a_0(980) \to \phi\eta\pi^0,$$

$$\chi_{c1}(1P) \to a_0(980)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0,$$

$$J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\, 3\pi,$$

$$J/\psi \to \phi f_0(980)\pi^0 \to \phi\, 3\pi,$$

$$J/\psi \to \phi f_1(1285) \to \phi f_0(980)\pi^0 \to \phi\, 3\pi.$$

Introduction

It has become clear,

N.N. Achasov, A.A. Kozhevnikov, and G.N. Shestakov,

Phys. Rev. D 92, 036003 (2015) and Phys. Rev. D 93, 114027 (2016),

that the similar effect can appear not only due to

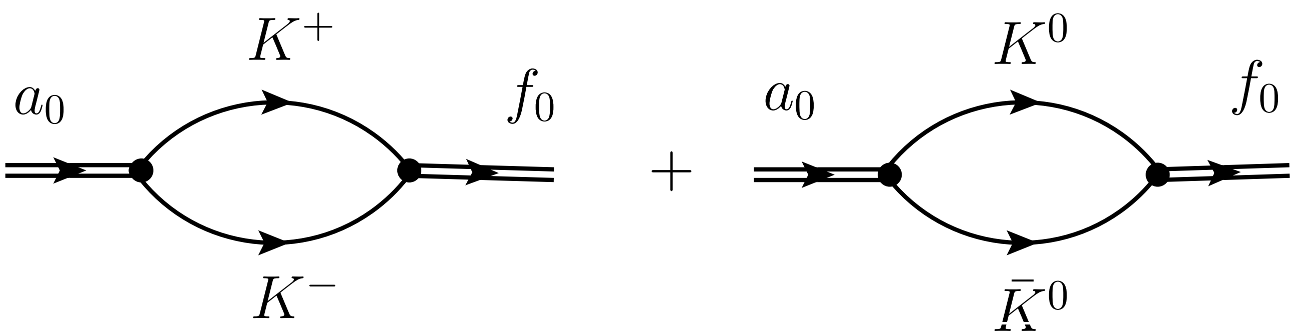
the $a_0^0(980)$ - $f_0(980)$ mixing, but also for any mechanism of the production of the $K\bar{K}$ pairs in the S wave,

$X \to K\bar{K} \to f_0(980)/a_0(980)$ [a].

Thus a new tool to study the mechanism of production and nature of light scalars is emerged.

[a] Each such mechanism reproduces both the narrow resonant peak and sharp jump of a phase of amplitude between the K^+K^- and $K^0\bar{K}^0$ thresholds.

The $a_0^0(980)$-$f_0(980)$ mixing



$$\Pi_{a_0 f_0}(m) = \frac{g_{a_0 K^+ K^-} g_{f_0 K^+ K^-}}{16\pi} \Bigg[i \Big(\rho_{K^+K^-}(m) - \rho_{K^0\bar{K}^0}(m) \Big) - \frac{\rho_{K^+K^-}(m)}{\pi} \ln \frac{1+\rho_{K^+K^-}(m)}{1-\rho_{K^+K^-}(m)} + \frac{\rho_{K^0\bar{K}^0}(m)}{\pi} \ln \frac{1+\rho_{K^0\bar{K}^0}(m)}{1-\rho_{K^0\bar{K}^0}(m)} \Bigg]$$

$$\approx \frac{g_{a_0 K^+ K^-} g_{f_0 K^+ K^-}}{16\pi} \Bigg[i \Big(\rho_{K^+K^-}(m) - \rho_{K^0\bar{K}^0}(m) \Big) \Bigg],$$

where $m \geq 2m_{K^0}$, in the region $0 \leq m \leq 2m_K$,

The $a_0^0(980)$-$f_0(980)$ mixing

$\rho_{K\bar{K}}(m) = \sqrt{1 - 4m_K^2/m^2}$ should be replaced by $i|\rho_{K\bar{K}}(m)|$. In the region between the K^+K^- and $K^0\bar{K}^0$ thresholds, which is the 8 MeV wide,

$$|\Pi_{a_0 f_0}(m)| \approx \frac{|g_{a_0 K^+K^-} g_{f_0 K^+K^-}|}{16\pi}\sqrt{\frac{2(m_{K^0} - m_{K^+})}{m_{K^0}}}$$

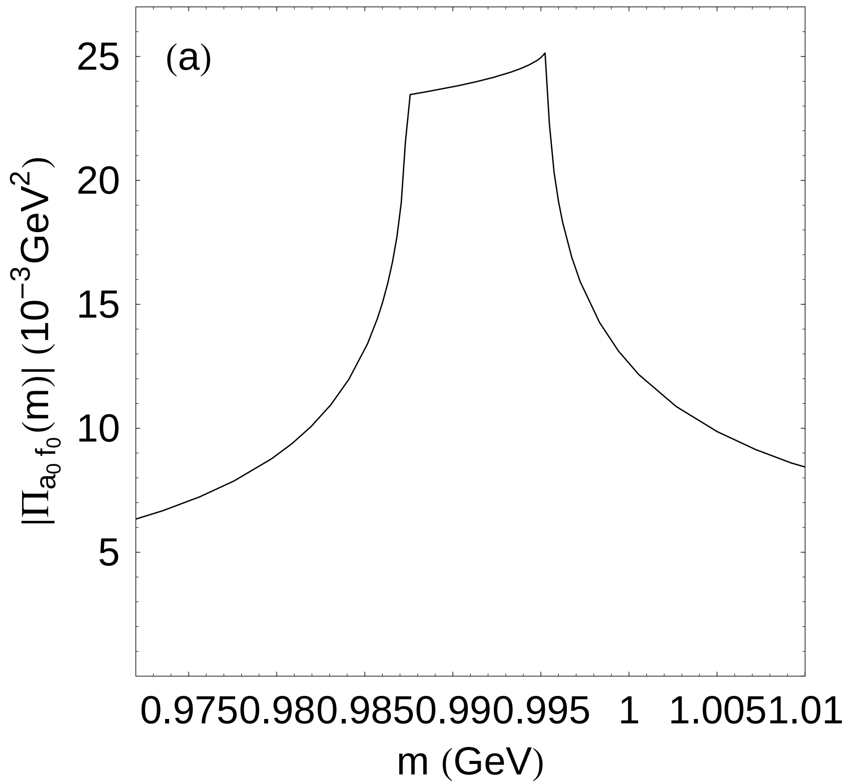
$$\approx 0.127|g_{a_0 K^+K^-} g_{f_0 K^+K^-}|/16\pi \simeq 0.03\ \text{GeV}^2$$

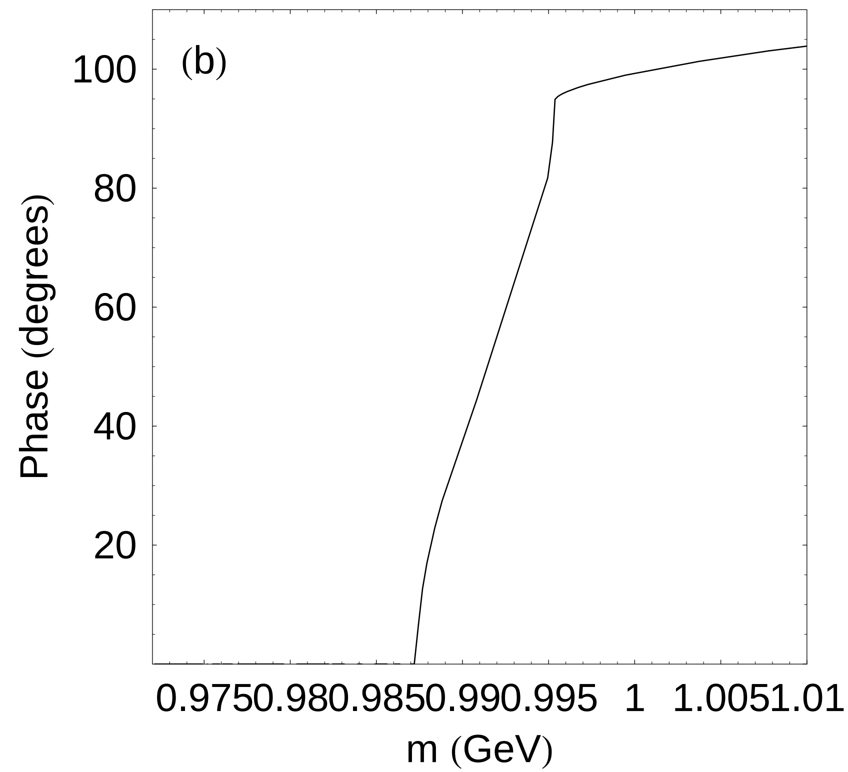
$$\approx m_K\sqrt{m_{K^0}^2 - m_{K^+}^2} \approx m_K^{3/2}\sqrt{m_d - m_u}\,.$$

Note that

$|\Pi_{\rho^0\omega}| \approx |\Pi_{\pi^0\eta}| \approx 0.003\ \text{GeV}^2 \approx (m_d - m_u) \times 1\text{GeV}.$

The $a_0^0(980)$-$f_0(980)$ mixing





The $a_0^0(980)$-$f_0(980)$ mixing

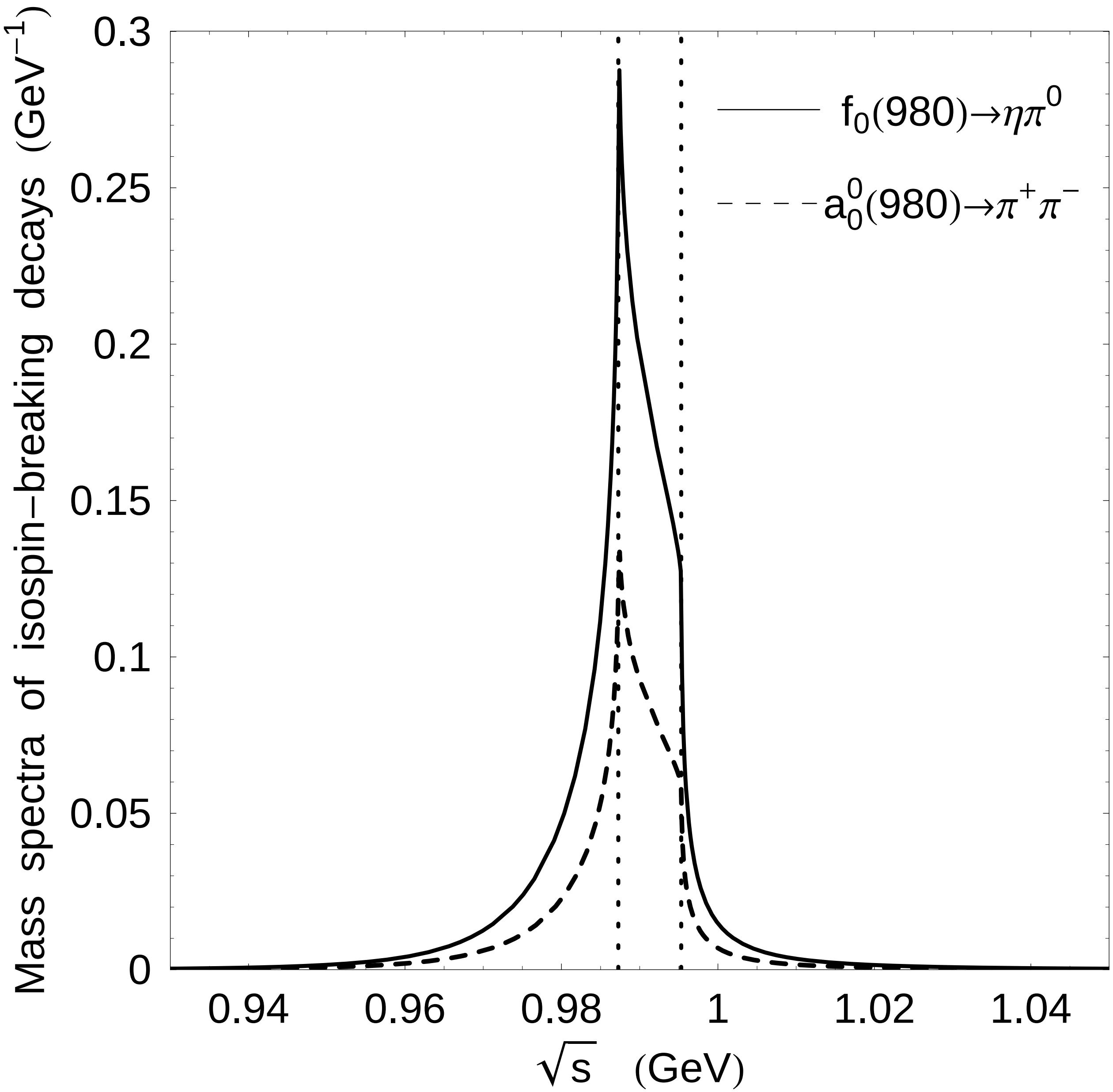
$$BR(f_0(980) \to K\bar{K} \to a_0^0(980) \to \eta\pi^0) =$$

$$\int \left| \frac{\Pi_{a_0^0 f_0}(m)}{D_{a_0^0}(m) D_{f_0}(m) - \Pi^2_{a_0^0 f_0}(m)} \right|^2 \frac{2m^2 \Gamma_{a_0^0 \to \eta\pi^0}(m)}{\pi} dm \approx 0.3\%$$

$$BR(a_0^0(980) \to K\bar{K} \to f_0(980) \to \pi\pi) =$$

$$\int \left| \frac{\Pi_{a_0^0 f_0}(m)}{D_{a_0^0}(m) D_{f_0}(m) - \Pi^2_{a_0^0 f_0}(m)} \right|^2 \frac{2m^2 \Gamma_{f_0 \to \pi\pi}(m)}{\pi} dm \approx 0.2\%$$

Mass spectra



Polarization Phenomena

The phase jump suggest the idea to study the $a_0^0(980)$-$f_0(980)$ mixing in polarization phenomena. If a process amplitude with a spin configuration is dominated by the $a_0^0(980)$-$f_0(980)$ mixing then a spin asymmetry of a cross section jumps near the $K\bar{K}$ thresholds. An example is

$$\pi^- p_\uparrow \to \left(a_0^0(980) + \mathrm{f}_0(980)\right) n \to a_0^0(980) n \to \eta\pi^0\, n.$$

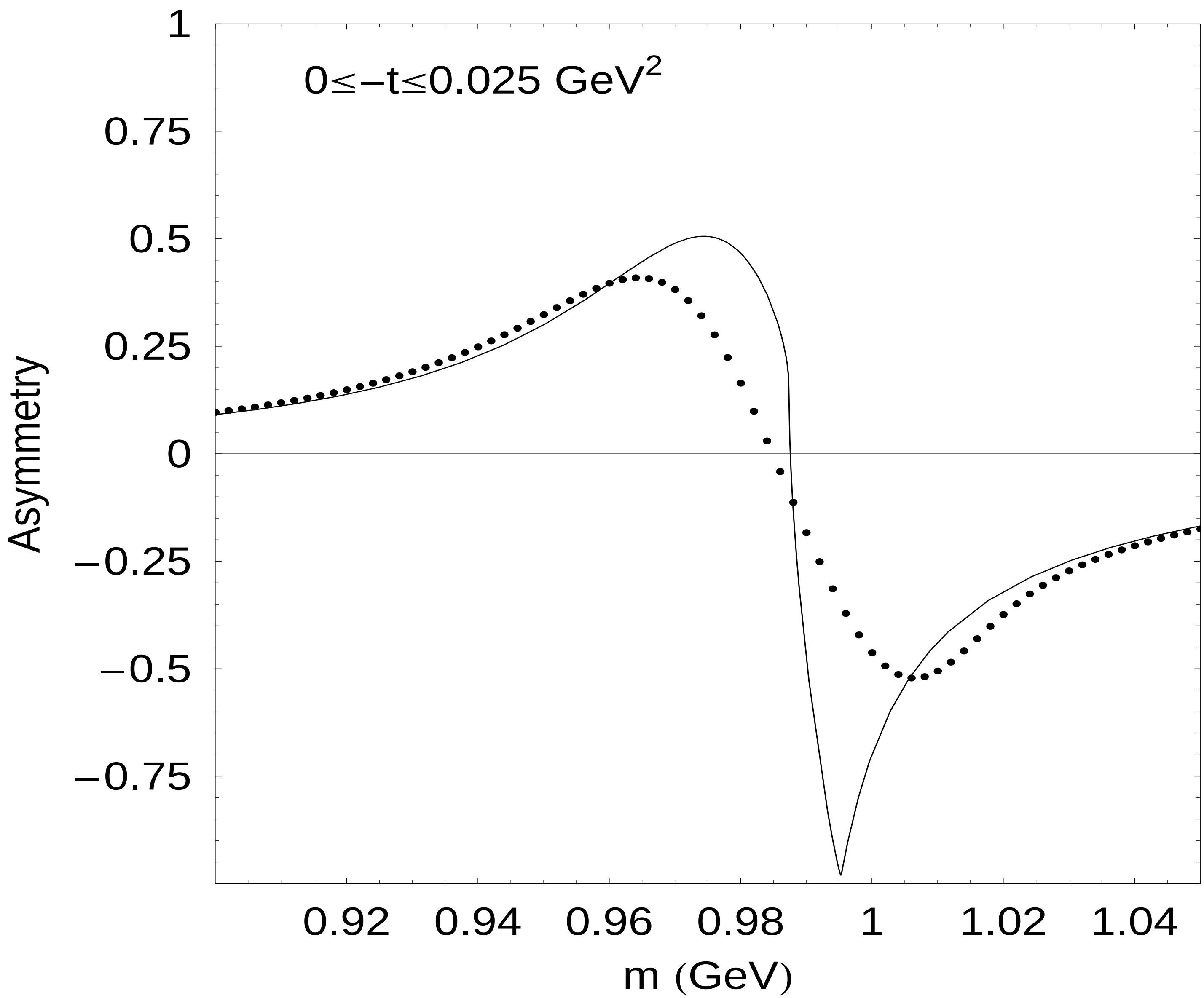
$$\frac{d^3\sigma}{dt\,dm\,d\psi} = \frac{1}{2\pi}[\,|M_{++}|^2 + |M_{+-}|^2 + 2\,\Im(M_{++}M^*_{+-})\,P\cos\psi\,]$$

The dimensionless normalized spin asymmetry

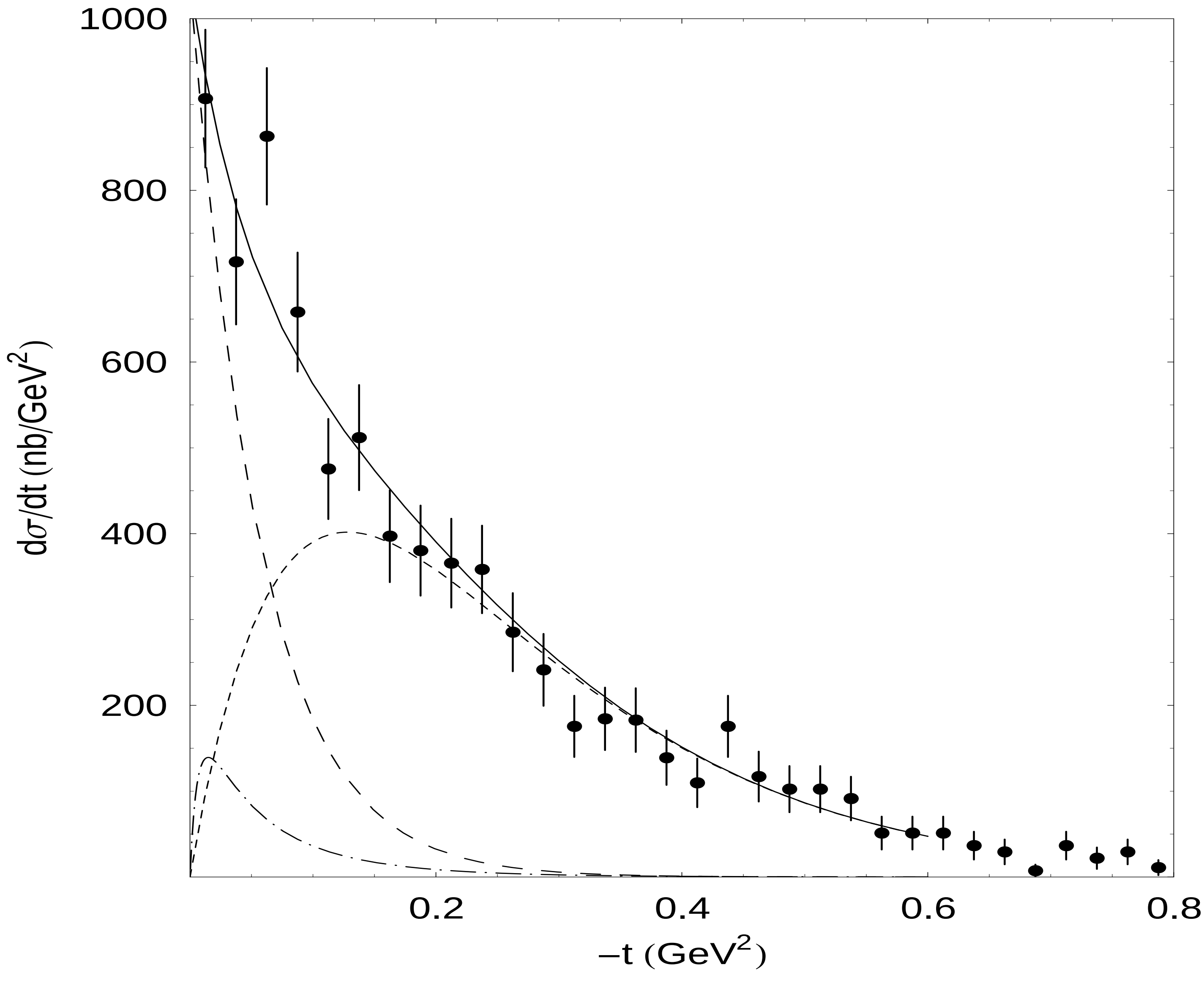
$A(t,m) = 2\,\Im(M_{++}M^*_{+-})/[\,|M_{++}|^2 + |M_{+-}|^2\,]$,

$-1 \le A(t,m) \le 1$.

Spin Assymetry



Cross Sections



$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

Estimated are the contributions of the following mechanisms responsible for the decay
$f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$:

1) the contribution of the $a_0^0(980) - f_0(980)$ mixing,
$f_1(1285) \to a_0(980)\pi^0 \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$,

2) the contribution of the transition
$f_1(1285) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$,
arising due to the pointlike decay $f_1(1285) \to K\bar{K}\pi^0$,

3) the contribution of the transition
$f_1(1285) \to (K^*\bar{K} + \bar{K}^*K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$, where $K^* = K^*(892)$, and

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

4) the contribution of the transition
$f_1(1285) \to (K_0^* \bar{K} + \bar{K}_0^* K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980) \to \pi^+\pi^-\pi^0$,
where $K_0^* = K_0^*(800)$ (or κ) and $K_0^*(1430)$.

These mechanisms break the conservation of the isospin due to the nonzero mass difference of the K^+ and K^0 mesons.

They result in the appearance of the narrow resonance structure in the $\pi^+\pi^-$ mass spectrum in the region of the $K\bar{K}$ thresholds, with the width $\approx 2m_{K^0} - 2m_{K^+} \approx 8$ MeV.

The observation of such a structure in experiment is the direct indication on the $K\bar{K}$ loop mechanism of the breaking of the isotopic invariance.

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

We point out that existing data should be more precise, and it is difficult to explain them using the single specific mechanism from those listed above.

Taking the decay $f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ as the example, we discuss the general approach to the description of the $K\bar{K}$ loop mechanism of the breaking of isotopic invariance.

1) The matter is that the $J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi\eta\pi^0$ and $\chi_{c1}(1P) \to a_0^0(980)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ decays are described by the $a_0^0(980)$-$f_0(980)$ mixing well enough:

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

$$\frac{BR(J/\psi \to \phi f_0(980) \to \phi a_0^0(980) \to \phi \eta \pi^0)}{BR(J/\psi \to \phi f_0(980) \to \phi \pi \pi)}$$

$$= (0.60 \pm 0.20(stat.) \pm 0.12(sys.) \pm 0.26(para.))\%$$

$$\approx \frac{BR(f_0(980) \to K\bar{K} \to a_0^0(980) \to \eta \pi^0)}{BR(f_0(980) \to \pi\pi)},$$

$$\frac{\mathrm{BR}(\chi_{c1}(1P) \to a_0^0(980)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0)}{\mathrm{BR}(\chi_{c1} \to a_0^0(980)\pi^0 \to \eta\pi^0\pi^0)}$$

$$= (0.31 \pm 0.16(\mathrm{stat.}) \pm 0.14(\mathrm{sys.}) \pm 0.03(\mathrm{para.}))\%$$

$$\approx \frac{\mathrm{BR}(a_0^0(980) \to K\bar{K} \to f_0(980) \to \pi^+\pi^-)}{\mathrm{BR}(a_0^0(980) \to \eta\pi^0)}.$$

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

As for the $f_1(1285) \to f_0(980)\pi^0 \to 3\pi$ decay, its description requires the "terrible" $a_0^0(980)$-$f_0(980)$ mixing:

$$\frac{\mathrm{BR}(\mathrm{f_1(1285)} \to \mathrm{a_0^0(980)}\pi^0 \to \mathrm{f_0(980)}\pi^0 \to \pi^+\pi^-\pi^0)}{\mathrm{BR}(\mathrm{f_1(1285)} \to \mathrm{a_0^0(980)}\pi^0 \to \eta\pi^0\pi^0)}$$

$$= (2.5 \pm 0.9)\%$$

$$\approx \frac{\mathrm{BR}(\mathrm{a_0^0(980)} \to \mathrm{K\bar{K}} \to \mathrm{f_0(980)} \to \pi^+\pi^-)}{\mathrm{BR}(\mathrm{a_0^0(980)} \to \eta\pi^0)},$$

and, as a result, the inconvenient coupling constants of the scalar mesons with the pseudo-scalar mesons in the many cases:

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

$$\frac{g^2_{f_0\pi^+\pi^-}}{4\pi} = 1.2 \text{ GeV}^2, \quad \frac{g^2_{f_0K^+K^-}}{4\pi} = 5.7 \text{ GeV}^2,$$

$$\frac{g^2_{a_0^0\eta\pi^0}}{4\pi} = 1.9 \text{ GeV}^2, \quad \frac{g^2_{a_0^0K^+K^-}}{4\pi} = 9.9 \text{ GeV}^2.$$

For example, due to the very strong coupling of $a_0^0(980)$ with the $K\bar{K}$ channel, the width of the $a_0^0(980)$ resonance in the $\eta\pi^0$ mass spectrum turns out to be near 15 MeV.

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

2) The pointlike decay $f_1(1285) \to K\bar{K}\pi^0$ gives

$$\frac{BR(f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0)}{BR(f_1(1285) \to K\bar{K}\pi)} = 0.0022$$

instead of the experimental value

$$\frac{\mathrm{BR}(\mathrm{f}_1(1285) \to \mathrm{f}_0(980)\pi^0 \to \pi^+\pi^-\pi^0)}{\mathrm{BR}(\mathrm{f}_1(1285) \to \mathrm{K}\bar{\mathrm{K}}\pi)} = 0.033 \pm 0.010\,.$$

The $\pi^+\pi^-$ mass spectrum in the decay
$f_1(1285) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$
looks similar to the curves in the $a_0(980)$-$f_0(980)$ mixing.

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

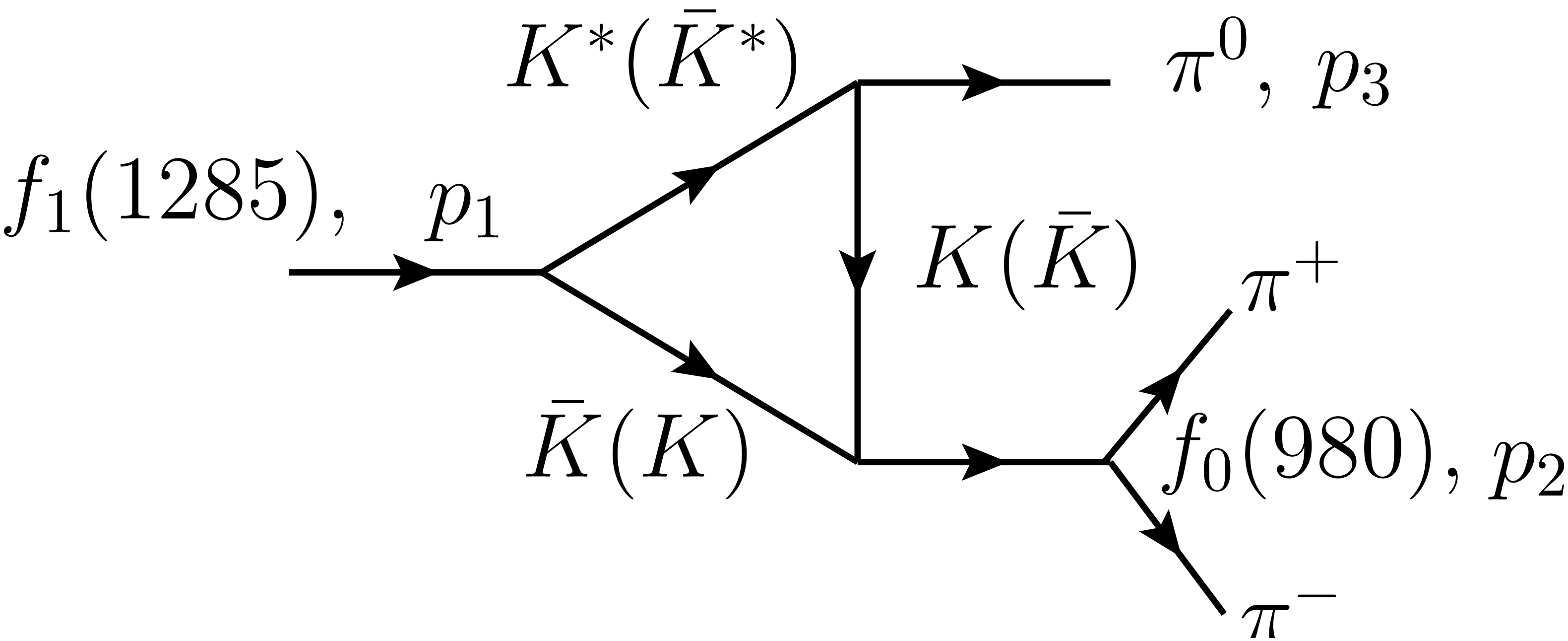
However, it is clear that the pointlike mechanism of the decay $f_1(1285) \to K\bar{K}\pi$ cannot by itself provide the considerable probability of the $f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ transition.

3) The transition $f_1(1285) \to (K^*\bar{K} + \bar{K}^*K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ gives the shape of the $\pi^+\pi^-$ spectrum practically coincides with the corresponding spectrum caused by the $a_0^0(980) - f_0(980)$ mixing, but its

$$\mathrm{BR}(\mathrm{f}_1(1285) \to \mathrm{f}_0(980)\pi^0 \to \pi^+\pi^-\pi^0) \approx 0.0255\%$$

is much less then the experimental value

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$



$\mathbf{BR(f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0) = (0.30 \pm 0.09)\%.}$

$f_1(1285) \to f_0(980)\pi^0 \to 3\pi$

So, the $f_1(1285) \to (K^*\bar{K} + \bar{K}^*K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ transition mechanism alone is also insufficient to understand the experimental data.

4) The variant $f_1(1285) \to (K_0^*(800)\bar{K} + \bar{K}_0^*(800)K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ is rejected by the spectra in the $f_1(1285) \to K\bar{K}\pi$.

As for $f_1(1285) \to (K_0^*(1430)\bar{K} + \bar{K}_0^*(1430)K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$, it provides the results similar to $f_1(1285) \to (K^*\bar{K} + \bar{K}^*K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ and consequently cannot describe the data alone.

The consistency condition

$$\mathcal{M}_{f_1(1285)\to f_0(980)\pi^0}(s) = g_{f_0K^+K^-}\{A(s) \times i[\rho_{K^+K^-}(s) - \rho_{K^0\bar{K}^0}(s)] + B(s)[\rho^2_{K^+K^-}(s) - \rho^2_{K^0\bar{K}^0}(s)] + O[\rho^3_{K^+K^-}(s) - \rho^3_{K^0\bar{K}^0}(s)] + \cdots\}.$$

With a good accuracy

$$\mathcal{M}_{\mathrm{f_1(1285)\to f_0(980)}\pi^0}(\mathrm{s}) = \mathrm{g_{f_0K^+K^-}A(s)i}[\rho_{\mathrm{K^+K^-}}(\mathrm{s}) - \rho_{\mathrm{K^0\bar{K}^0}}(\mathrm{s})].$$

The amplitude $A(s)$ contains the information about all possible mechanisms of production of the $K\bar{K}$ system with isospin $I = 1$ in S wave in the process $f_1(1285) \to K\bar{K}\pi$.

The consistency condition

From the data on $f_1(1285) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ one can extract the information about $|A(s)|^2$ in the region of the K^+K^- and $K^0\bar{K}^0$ thresholds.

$$\frac{d\Gamma_{f_1(1285)\to f_0(980)\pi^0\to\pi^+\pi^-\pi^0}(s)}{d\sqrt{s}}$$

$$= \frac{1}{16\pi}|\mathcal{M}_{f_1\to f_0\pi^0}(s)|^2\, p^3(s)\, \frac{2s\Gamma_{f_0\to\pi^+\pi^-}(s)}{\pi|D_{f_0}(s)|^2}\,.$$

$$\frac{d\Gamma_{f_1\to K^+K^-\pi^0}}{d\sqrt{s}} = \frac{2\sqrt{s}}{\pi}\rho_{K^+K^-}(s)\, p^3(s)\, |A(s)|^2\,.$$

$$\Gamma_{f_1\to f_0\pi^0\to\pi^+\pi^-\pi^0} = |A(4m^2_{K^+})|^2\, 2.59\times 10^{-6}\ \text{GeV}^5.$$

$J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\pi^+\pi^-\pi^0$

According to BESIII, the mass and width of the $\eta(1405)$ peak in the $\pi^+\pi^-\pi^0$ channel are 1409.0 ± 1.7 MeV and 48.3 ± 5.2 MeV, respectively, while the branching ratio is

$$BR(J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\pi^+\pi^-\pi^0) = (1.50 \pm 0.11 \pm 0.11) \cdot 10^{-5}\,.$$

In addition, the BESIII gives the ratio

$$\frac{BR(\eta(1405) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0)}{BR(\eta(1405) \to a_0^0(980)\pi^0 \to \eta\pi^0\pi^0)} = (17.9 \pm 4.2)\%\,,$$

that rules out practically the explanation of the discovered effect by means of the $a_0(980)$-$f_0(980)$ mixing.

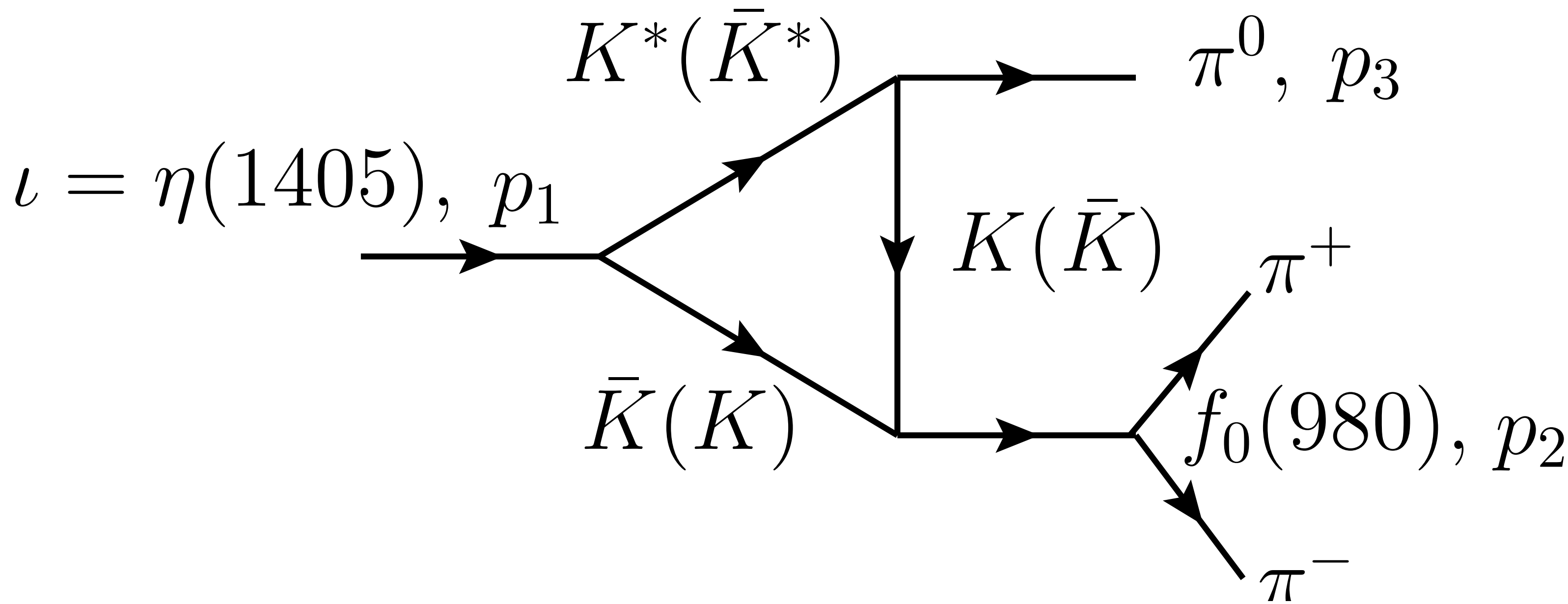
$J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\pi^+\pi^-\pi^0$

We discuss the possibility of the theoretical explanation of the large breaking of isotopic invariance in the decay $\eta(1405) \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$ by means of the anomalous Landau thresholds (the logarithmic triangle singularities) which are in the transition

$$\eta(1405) \to (K^*\bar{K} + \bar{K}^*K) \to (K^+K^- + K^0\bar{K}^0)\pi^0 \to f_0(980)\pi^0 \to \pi^+\pi^-\pi^0$$

and show that the account of the finite width of the K^* ($\Gamma_{K^*\to K\pi} \approx 50$ MeV) smoothes the logarithmic singularities in the amplitude and results in the suppression of the calculated decay width of $\eta(1405) \to f_0(980)\pi^0 \to 3\pi$ by the factor of $6-8$ as compared with the case of $\Gamma_{K^*\to K\pi}$ = 0.

$\eta(1405) \to K^*\bar{K} + c.c. \to K\bar{K}\pi^0 \to f_0(980)\pi^0 \to 3\pi$



In the region of the $\eta(1405)$ resonance all intermediate particles in the loop of triangle diagram can lie on their mass shells. That is, in the hypothetical case of the stable K^* meson the logarithmic singularity appears in the imaginary part of the triangle diagram.

$J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\pi^+\pi^-\pi^0$

The accounting of the finite width of the K^* resonance, i.e., the averaging of the amplitude over the resonance Breit-Wigner distribution in accord with the spectral Källén-Lehmann representation for the propagator of the unstable K^* meson, smoothes the logarithmic singularities of the amplitude and hence makes the compensation of the contributions of the $K^{*+}K^- + K^{*-}K^+$ and $K^{*0}\bar{K}^0 + \bar{K}^{*0}K^0$ intermediate states more strong.

This results in both the diminishing of the calculated width of the decay $\eta(1405) \to \pi^+\pi^-\pi^0$ by a number of times in comparison with the case of $\Gamma_{K^*\to K\pi}$ = 0, and in the concentration of the main effect of the isospin breaking in the domain of the $\pi^+\pi^-$ invariant mass between the $K\bar{K}$ thresholds.

$J/\psi \to \gamma\eta(1405) \to \gamma f_0(980)\pi^0 \to \gamma\pi^+\pi^-\pi^0$

Assuming the dominance of the $\eta(1405) \to K^*\bar{K} + c.c. \to K\bar{K}\pi^0$ decay, one obtains

$$\mathrm{BR}(\mathrm{J}/\psi \to \gamma\eta(1405) \to \gamma\mathrm{f}_0(980)\pi^0 \to \gamma 3\pi) \approx 1.12 \cdot 10^{-5},$$

that reasonably agrees with experiment.

CONCLUSION

We also analyze the difficulties related with the assumption of the dominance of the $\eta(1405) \to (K^*\bar{K} + \bar{K}^*K) \to K\bar{K}\pi$ decay mechanism and discuss the possible dynamics of the decay $\eta(1405) \to \eta\pi\pi$.

The decisive improvement of the experimental data on the $K\bar{K}$, $K\pi$, $\eta\pi$, and $\pi\pi$ mass spectra in the decay of the resonance structure $\eta(1405/1475)$ to $K\bar{K}\pi$ and $\eta\pi\pi$, and on the shape of the resonance peaks themselves in the $K\bar{K}\pi$ and $\eta\pi\pi$ decay channels is necessary for the further establishing the $\eta(1405) \to 3\pi$ decay mechanism.

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