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Scalar Mesons in the Decay $\phi \to K^0\bar{K^0}\gamma$

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Abstract. We estimate the branching ratio of the $\phi \to K^0\bar{K^0}\gamma$ decay within the framework of a phenomenological approach in which the contributions of the $f_0(980)$, $a_0(980)$ scalar resonances, chiral loops and $K^*(892)$ vector meson are considered. To evaluate the contribution of the scalar resonances, we consider the kaon-loop model and the no-structure model.

1. Introduction

The $\phi \to K^0\bar{K^0}\gamma$ decay is interesting process to study because it is the only radiative decay where the f_0 and a_0 scalar mesons contribute simultaneously. This will allow to provide us valuable information on the properties of both scalar mesons. On the other side, this process could pose a background problem for testing CP-violation. The existing experimental result for the branching ratio of this decay is BR($\phi \to K^0\bar{K^0}\gamma$)$< 1.9 \times 10^{-8}$ [1]. Some theoretical predictions found in literature are BR($\phi \to K^0\bar{K^0}\gamma$)$= 1.3 \times 10^{-8}$ [2], BR($\phi \to K^0\bar{K^0}\gamma$)$= 7.6 \times 10^{-9}$ [3], BR($\phi \to K^0\bar{K^0}\gamma$)$= 5.0 \times 10^{-8}$ [4] BR($\phi \to K^0\bar{K^0}\gamma$)$= 7.5 \times 10^{-8}$ [5], BR($\phi \to K^0\bar{K^0}\gamma$)$= 4.47 \times 10^{-8}$ [6] for the $\phi \to K^0\bar{K^0}\gamma$ decay.

2. Formalism

In this work, we attempt to study the radiative $\phi \to K^0\bar{K^0}\gamma$ decay considering the kaon-loop model and no structure model for the coupling of the scalar mesons in the intermediate state to the initial vector meson. We calculate the branching ratios of the different contributions, chiral loops and K^* meson of this decay in addition to the mechanisms of the scalar mesons in the phenomenological approach. In each model of the scalar mesons, we calculate the branching ratio using the different values of the scalar meson parameters and then compare the results.

3. Results and Discussion

The values we obtain for the branching ratio in two models are shown in table 1 and table 2. We present the role of the f_0 and a_0 scalar mesons in the reaction mechanism of the radiative $\phi \to K^0\bar{K^0}\gamma$ decay in tables. Hence, the f_0 meson contribution one order stronger than the a_0 meson contribution in the structure model. Considering the total branching ratios, our predictions in two models are not different from each other. Our values obtained here are 1 order of magnitude larger than the experimental result [1] and other theoretical predictions [2,3,4,5,6].

In this work we also determine the total contributions of the scalar mesons, f_0 and a_0, and their interference as BR($\phi \to K^0\bar{K^0}\gamma$)$=4.20 \times 10^{-8}$ and BR(int.)$=-2.96 \times 10^{-7}$, BR($\phi \to K^0\bar{K^0}\gamma$)$=4.73 \times 10^{-8}$ and BR(int.)$=-5.87 \times 10^{-7}$ and BR($\phi \to K^0\bar{K^0}\gamma$)$=8.73 \times 10^{-8}$

and BR(int.)=-6.20×10^{-7} in the kaon loop model, and BR($\phi \to K^0\bar{K^0}\gamma$)=$2.42 \times 10^{-9}$ and BR(int.)=1.11×10^{-6}, BR($\phi \to K^0\bar{K^0}\gamma$)=$5.80 \times 10^{-8}$ and BR(int.)=1.99×10^{-6} and BR($\phi \to K^0\bar{K^0}\gamma$)=$5.92 \times 10^{-9}$ and BR(int.)=1.78×10^{-6} in the no structure model. For the contributions of the chiral loops and K^{*0} vector meson, we obtain the branching ratios as BR($\phi \to K^0\bar{K^0}\gamma$)=$4.92 \times 10^{-8}$ and BR($\phi \to K^0\bar{K^0}\gamma$)=$2.91 \times 10^{-11}$, respectively. The value obtained from chiral loops is in agreement with estimate in [5]. The exchange of intermediate K^{*0} vector meson is one order of magnitude larger than the value in [5] but it is still small and therefore negligible.

Table 1. The branching ratios of the $\phi \to K^0\bar{K^0}\gamma$ decay depending on different values of the coupling constants $g_{f_0K^+K^-}$ and $g_{a_0K^+K^-}$. The contributions of the scalar mesons are in the kaon loop model (KLM). Here total contribution includes also chiral loops contribution.

$g_{f_0K^+K^-}(GeV)$	$g_{a_0K^+K^-}(GeV)$	f_0	a_0	Total
[7] 4.021 ± 0.01	[7]2.747 $\pm$ 0.42	1.73×10^{-7}	4.85×10^{-8}	2.72×10^{-7}
[7] 5.873	[7]3.631	2.66×10^{-7}	9.93×10^{-8}	4.17×10^{-7}
[8] 5.919	[9]2.857	2.71×10^{-7}	5.69×10^{-8}	3.79×10^{-7}

Table 2. The branching ratios of the $\phi \to K^0\bar{K^0}\gamma$ decay depending on different values of the coupling constant $g_{\phi f_0\gamma}$ and $g_{\phi a_0\gamma}$. The contributions of the scalar mesons are in the no structure model (NSM). Here total contribution includes also chiral loops contribution.

$g_{\phi f_0\gamma}(GeV^{-1})$	$g_{\phi a_0\gamma}(GeV^{-1})$	f_0	a_0	Total
[10] 1.48 ± 0.06	[11]1.61$\pm$0.05	4.48×10^{-8}	5.06×10^{-8}	6.68×10^{-7}
[12] 2.78 ± 0.02	[12]1.83$\pm$0.03	7.37×10^{-7}	1.06×10^{-7}	3.10×10^{-6}
[12] 2.61 ± 0.02	[13]1.30$\pm$0.3	8.97×10^{-9}	1.41×10^{-7}	5.43×10^{-7}

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