The Decay $D^0 \to \bar{K}^0 \phi$

ARGUS Collaboration


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The decay $D^0 \rightarrow \bar{K}^0 \phi$ has been investigated using data accumulated by the ARGUS experiment, which operates at around 10 GeV centre-of-mass energies in the DORIS II $e^+ e^-$ storage ring at DESY. The decay $D^0 \rightarrow \bar{K}^0 \phi$ is a signature for flavor annihilation by $W$-exchange in weak decays. It is shown that this decay occurs at $(15.5 \pm 3.3)\%$ of the rate for the well established decay $D^0 \rightarrow K^+ \pi^-$. This translates into a branching ratio for $D^0 \rightarrow \bar{K}^0 \phi$ of $(1.18 \pm 0.25 \pm 0.17)\%$.

The decay $D^0 \rightarrow \bar{K}^0 \phi$ was first observed by the ARGUS Collaboration in 1985 with the unexpectedly large branching ratio of $(1.43 \pm 0.45)\%$ [1]. This implied that indeed the $W$-exchange diagram (Fig. 1) [2] is important, despite the fact that this process should be helicity and color suppressed. Because this diagram can only contribute to the $D^0$ decay rate, such an enhancement offers a possible explanation for the observed lifetime differences between charged and neutral $D$ mesons. In view of the importance of the decay $D^0 \rightarrow \bar{K}^0 \phi$, we have repeated the analysis with the total available sample of 152 pb$^{-1}$ collected by the ARGUS collaboration [3]. The new ARGUS vertex chamber [4] was operational for about 50 pb$^{-1}$ of this running, and results in a considerable improvement of data quality, most notably, a 60% increase in the efficiency for reconstructing $K^-$ from secondary vertices.

Using our standard criteria for event selection and particle identification [1, 3], we obtain the invariant $K^0 S K^+ K^-$ mass spectrum shown in Fig. 2, which exhibits a clean $D^0$ signal of 205 $\pm$ 38 events at a mass of $(1.864.3 \pm 1.5)$ MeV/c$^2$, with a RMS width of $(7.3 \pm 1.5)$ MeV/c$^2$. No further cut is applied. The 2-body contributions to the 3-body decay $D^0 \rightarrow \bar{K}^0 K^+ K^-$ can be determined by investigating the $K^+ K^-$ subsystem. By requiring $|M(K^0 S K^+ K^-) - M(D^0)| < 16.2$ MeV/c$^2$ we obtain the $K^+ K^-$ invariant mass spectrum shown in Fig. 3 (points with error bars). Clearly visible is a prominent $\phi$ signal with the expected mass and shape. Only the

![Graph](image1)

Fig. 1. $W$-exchange diagram for the decay $D^0 \rightarrow \bar{K}^0 \phi$

![Graph](image2)

Fig. 2. $K^0 S K^+ K^-$ mass spectrum for events from $e^+ e^-$ interactions at centre-of-mass energies around 10 GeV

![Graph](image3)

Fig. 3. $K^+ K^-$ mass spectrum for events with $|M(K^0 S K^+ K^-) - M(D^0)| < 16.2$ MeV/c$^2$ (points with error bars). The hatched histogram gives the contribution which is not correlated with a $D^0$ meson

![Graph](image4)

Fig. 4. Distribution of the helicity angle $\theta$ in the decay $D^0 \rightarrow K^0 S \phi$, $\phi \rightarrow K^+ K^-$. The candidates are defined by $|M(K^0 S K^+ K^-) - M(D^0)| < 16.2$ MeV/c$^2$ and $|M(K^+ K^-) - M(\phi)| < 6.6$ MeV/c$^2$. The contribution to this angular distribution which is not correlated with a $D^0$ meson has already been subtracted.