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A survey of parameterisations used in amplitude analysis

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Abstract

When an experiment publishes an amplitude model, it enivitably comes with it's own parametrisation of models describing the amplitude model. We attempt to document some parametrisations used by various experiments in $D^0 \to K^0_S K^+ K^-$ models.

Contents

1 Introduction

When an experiment publishes a new amplitude analysis of a decay it often follows that it has used it's own parameterisation for the models involved in the amplitude analysis. This can be troublesome when trying to recreate amplitude models for various studies. In this we aim to document some of the parameterisations used by different experiments so they can be reproduced.

1.1 Phenomenological parameterization of the D0 decay amplitude

A three-body decay $X \to ABC$ can be described as a superposition of quasi-two-body decays $X \to RC$, $R \to AB$. We can first describe the general expressiom for the decay of a particle X into daughters ABC amplitude

$$d\Gamma = \frac{|\bar{\mathcal{M}}|^2}{32(2\pi)^3 M_X^3} dm_{BC}^2 dm_{AC}^2, \tag{1}$$

where $\mathcal{M}$ is the amplitude at some particular point in phase space, and $|\bar{\mathcal{M}}|^2$ is the amplitude averaged over the spin states of X.

Let us consider X being a D^0 meson, and look at its amplitude. We can write the amplitude as

$$\mathcal{M}\left(ABC|R\right) = \sum_{m_\lambda} \langle AB|R_{m_\lambda}\rangle T_R\left(\sqrt{s_{AB}}\right)\langle CR|D^0\rangle \tag{2}$$

$$= Z_\lambda\left(\vec{p},\vec{q}\right) B_{D^0}^{\prime L}\left(p\right) B_R^{\prime L}\left(q\right) T_R\left(\sqrt{s_{AB}}\right). \tag{3}$$

Here $\vec{q}$ and $\vec{p}$ are the momenta of A and C in the R and X rest frame respectively. Each term will be described in more detail presently.

When more than one resonance R, comtributes to the decay, we sum coherently over the amplitudes for all the intermediate resonances,

$$\mathcal{M}\left(ABC\right) = c_0 + \sum_R c_R \mathcal{M}\left(ABC|R\right), \tag{4}$$

where c_j are the corresponding complex coefficients, and c_0 is a complex constant modeling no resonant contributions, which is often zero.

The function $Z_\lambda\left(\vec{p},\vec{q}\right)$ describes the angular distribution of the decay products, whule B_i^L are the form factors, which are commenly parameterised using the Blatt-Weisskopf penetration for factors.

Finally $T_R\left(\sqrt{s_{AB}}\right)$ is the propagat, this is where most experiment differ in there parameterisations.

2 Angular distribution

There are two formalisms to be considered for the angular distribution: Zemach and Helicity. The Zemach formalism is as follows,

$$Z_0 = 1, \tag{5}$$

$$Z_1 = m_{AC}^2 - m_{BC}^2 + \frac{\left(m_{D^0}^2 - m_C^2\right)\left(m_B^2 - m_A^2\right)}{m_{AB}^2}, \tag{6}$$

$$Z_2 = -\frac{1}{3}\left(m_{AB}^2 - 2m_{D^0}^2 - 2m_C^2 + \frac{\left(m_{D^0}^2 - m_C^2\right)^2}{m_{AB}^2}\right)\left(m_{AB}^2 - 2m_A^2 - 2m_B^2 + \frac{\left(m_A^2 - m_B^2\right)^2}{m_{AB}^2}\right) + \left(m_{BC}^2 - \right. \tag{7}$$

as is found in [1]. For the Helicity formalism m_R^2 is used in place of m_{AB}^2.

2.1 Blatt-Weisskopf penetration factors

The common parameterisation of the Blatt-Weisskopf form factors is,

$$B_0(q) = 1, \tag{8}$$

$$B_1(q) = \sqrt{\frac{2z}{z+1}}, \tag{9}$$

$$\tag{10}$$

References

[1] CLEO Collaboration, H. Muramatsu *et al.*, *Dalitz analysis of $D^0 \to K_S^0\pi^+\pi^-$*, Phys. Rev. Lett. **89** (2002) 251802.