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Measurement of the Line Shape of Narrow Resonances

Abstract

In the past decade a lot of experimental effort has been put into searching for new forms of bound states beyond the standard treatment of mesons as quark-antiquark systems, and baryons as three-quark systems. All this was triggered by the discovery of the $X(3872)$ and the $D_{s0}^{*}(2317)^{+}$ in 2003, and got additional momentum by the discovery of charged states that decay to final states containing a pair of a heavy quark and its antiquark - those states clearly contain at least four quarks and are thus exotic. In particular for the $X(3872)$ and the $D_{s0}^{*}(2317)^{+}$, we are talking of isospin violating decays, and very narrow resonances whose width measurement is beyond what the $e^{+}e^{-}$ colliders BaBar and Belle could measure. In fact, we actually know only upper limits at 90% confidence level of their widths, and very little is known about the line shape of these narrow states.

The LHCb experiment gave an important contribution in measuring the quantum numbers of the $X(3872)$: $\mathrm{J^{PC}} = 1^{++}$. Assuming this is true, the measurement of its mass suggests that it is either a loosely bound hadronic molecule (whose constituents are a superimposition of $D^{(*)}\bar{D}$ and $D\bar{D}^{(*)}$) or a virtual state of these 2 charmed mesons. In any case, the $X(3872)$ binding energy is so small that the decay width of D^{*} has a significant impact on the line shape of the $X(3872)$ resonance.

A method should be identified to measure precisely the line shape of the $X(3872)$ and/or the $D_{s0}^{*}(2317)^{+}$.