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Short Communication

Exotic meson $1^{-+}\pi_1$ (1600) should be hybrid state

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ABSTRACT
We discuss the arguments concerning the π_1 (1600) with the de-cay channel $f_1\pi^-$. Which state will the exotic π_1 (1600) be? Generally speaking, we have glue ball, hybrid ($q\bar{q}g$) and tetraquarks ($q\bar{q}q\bar{q}$) states exclude the $q\bar{q}$ state. Here we will mostly believe that the π_1 (1600) should agree with the hybrid model with several reasons.

KEYWORDS: meson, hybrid state, glue ball etc.

INTRODUCTION

From the experiment at VES, COPMASS (CERN), several isovector $J^{PC}=1^{-+}$ exotic mesons have been identified. In this paper we care about the resonance π_1 (1600) claimed to be decaying into $f_1\pi^-$. No glue ball interpretation can be retained when the resonance has isospin1. So we just have two possibilities: the hybrid state $q\bar{q}g$ or the tetra-quarks states.

Hybrids have been studied, using the flux-tube model [1], the MIT bag model [2] and QCD sum rules [3]. In the flux-tube model, ordinary mesons and baryons correspond to quarks moving in an effective potential generated by the (adiabatically varying) ground state of the flux tubes [1].

These models predict that the lightest hybrid mesons will be $J^{PC}=1^{-+}$ meson, in 1.4-2.1 GeV mass range [1-4]. We get the table 2 after compared the relative branching ratio of $1^{-+} \rightarrow f_1\pi^-$, $\rho\pi$ with the VES [7], COMPASS [8] Results and hybrid state prediction.

TABLE 1: The relative branching ratio in $\pi^- f_1$ (1285) and $\pi^-\rho$ (770) channel

BR(π_1(1600))	πf_1(1285)	$\pi\rho$(770)	$\pi\eta$(570)	$\pi\eta$ (980)
COMPASS	1	$\pm$	—	—
VES	1	1.6	—	—
Hybrid	60	96	0.06	0.12

The relative branching ratio of $1^{-+} \rightarrow f_1\pi^-$ and $1^{-+} \rightarrow \rho\pi$ channels are in nice agreement with the hybrid state prediction and VES result.

Analysis

In order to believe the 1^{-+} should be hybrid state. Here we divide into two steps: First we need to believe it is a resonance. Then we together the theory proof with the experiment analysis as the relative branching ratio which has been list in the table 1.1.

Is this really a resonance?

In π_1 (1600) decays into f_1 (1285) π^-, one child meson has orbital angular momentum L=1 and the other one has L=0, such decay modes are predicted to be strong for hybrid mesons [7]. From the intensity (figure 1.1), its mass falls well below the mass rang where hybrid mesons are expected. And the evidence for a 1^{-+} light exotic with a mass between 1.7GeV in the intensity.

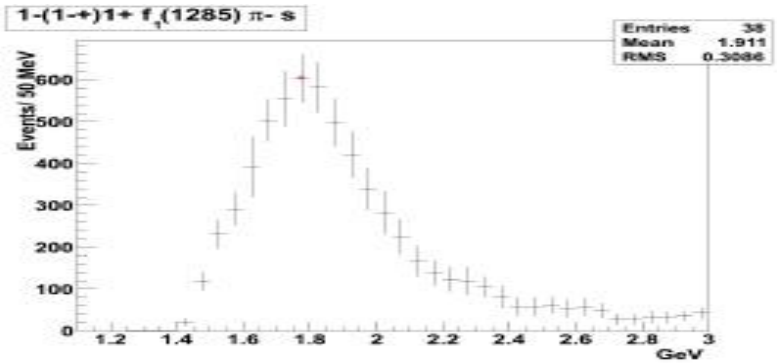

FIGURE 1: Intensity of exotic 1^{-+}

Here we can mostly believe that the 1^{-+} wave should the resonance. Should $1^{-+}\pi_1$ (1600) be hybrid state?

1) One difficulty with interpreting this state as a hybrid is about 500- 600 MeV mass difference between the $\pi_1(1400)$ mass and flux tube, LGT and MBCGH estimates of mass 1.9-2.1 GeV [4]. In other hand, it appears difficult to accommodate the $\pi_1(1400)$ as hybrid state in the context of recent QCD sum rules calculations, the lightest hybrid in this case being approximately with mass 1.6 GeV. And the same time from bag models we obtained the range mass values 1.3-1.7[5]. All these models agree with that at the mass rang 1.6-1.7 GeV may have a hybrid state.
2) The observation of π_1 (1600) decay into $\eta\,\pi$ and $f_1\pi$ but less-observation of the $\eta\pi$ decay model. In discussions it is often argued that this pattern proves the gluish nature of the pi1 (1600), since η has strong coupling to the gluon fields. So the hybrid mesons may decay preferentially into $\eta\,\pi$ and not into $\eta\pi$. This also can be confirmed by the Branching ratio of BR $(1^{-+} \rightarrow \pi f_1)$/ BR $(1^{-+} \rightarrow \eta\pi)$ which is a large number at the mass 1.7 GeV.

As for the $q\bar{q}q\bar{q}$ possibility

Mass results of 1^{-+} $q\bar{q}q\bar{q}$ are around 1.7 GeV and Bag model does not predict the low-laying $q\bar{q}q\bar{q}$ states with I=1 as π_1 (1600) [9].

CONCLUSION

Now if we take all these reasons which we have cited above into account, π_1 (1600) (if it has really exotic quantum numbers) should be a hybrid meson.

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