Ω_c^0 baryons in the $\Omega_b^- \to \Xi_c^+ K^- \pi^-$ decay

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Abstract: We follow on the steps of the LHCb collaboration which first discovered five excited states of baryons with strangeness and charm, Ω_c^0, in *pp* collisions, by discussing the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay, a process which has been recently studied by the same collaboration obtaining four narrow Ω_c^0 states compatible with the previously found ones. We explore these new found states from a hadronic molecular viewpoint and find that two out of the four resonances, $\Omega_c(3050)^0$ and $\Omega_c(3090)^0$, might be interpreted as pentaquark states, structured as meson-baryon bound molecules.

I. INTRODUCTION

In recent years the spectroscopy in the heavy quarkonium sector, especially that of charmed baryons, has seen a remarkable progress. The latest experimental observations have challenged the conventional quark model, and some new theories have arisen to explain the internal structure of these new found states. Some of these works interpret the observed resonances as pentaquark molecules structured in a quasi-bound state of an interacting meson-baryon pair.

To this category of discoveries has contributed the LHCb search for new Ω_c^0 resonances [1]. These excited states, first found in *pp* collisions, decay strongly to the final state $\Xi_c^+ K^-$, where the Ξ_c^+ is a weakly decaying baryon. The $\Xi_c^+ K^-$ mass spectrum study revealed five excited Ω_c^0 states, $\Omega_c(3000)^0$, $\Omega_c(3050)^0$, $\Omega_c(3066)^0$, $\Omega_c(3090)^0$, and $\Omega_c(3119)^0$. One of the theoretical studies that has explored these states following the meson-baryon molecular approach [2] concludes that two out of the five Ω_c^0 states might have a molecular origin, in particular, it predicts the presence of two structures with similar masses and widths to those of the observed $\Omega_c(3050)^0$ and $\Omega_c(3090)^0$. A more recent experiment of the LHCb collaboration has provided new data on the Ω_c^0 states by studying the $\Xi_c^+ K^-$ invariant mass spectra from the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decays [3]. The new experiment has revealed four excited Ω_c^0 baryons, $\Omega_c(3000)^0$, $\Omega_c(3050)^0$, $\Omega_c(3065)^0$ and $\Omega_c(3090)^0$, compatible with the ones previously found.

In light of the above, the aim of this study is to build a model for the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay observed in the latest LHCb study and, incorporating the interaction of hadrons in the final state through the theoretical model in [2], explore the possibility that some of the Ω_c^0 observed states might be of a molecular nature.

This work is organized as follows. Within the formalism in Section II, we describe in Section II.A the model for the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay showing Dalitz plots to provide a general motivation for the theoretical and experimental studies. Section II.B presents the interaction model of [2] modified by introducing the physical states of the pseudoscalar mesons η and η' rather than their mathematical expressions η_1 and η_8. The results for the invariant mass distribution of Ω_b^- are discussed in Section III, where they are compared to the theoretical predictions from [2] as well as to the experimental data. Finally, Section IV contains our concluding remarks.

II. FORMALISM

A. Ω_b^- decay

The Dalitz plot of the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay into three bodies describes its final state in a two dimensional phase space and, together with the four-momentum conservation, provides the kinematically accessible limits of the process [4]. Also, as pointed out in [5], it provides a theoretical framework against which to compare experimental observations.

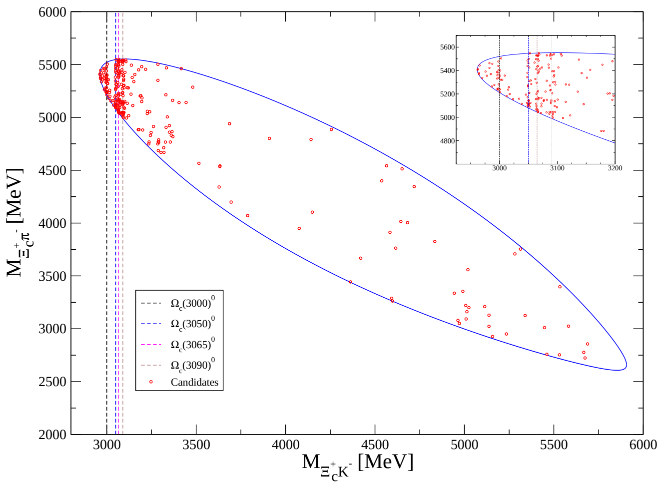

FIG. 1: Dalitz plot for $M_{\Xi_c^+ \pi^-}$ as a function of $M_{\Xi_c^+ K^-}$. The inset shows an expanded view of the upper left corner where the vertical bands correspond to the Ω_c^0 states found in the $\Xi_c^+ K^-$ channel.

The $M_{\Xi_c^+ \pi^-}$ vs $M_{\Xi_c^+ K^-}$ Dalitz plot is shown in Fig.1. We observe that the states discovered by the LHCb collaboration fall inside the kinematically allowed region in the invariant mass of $\Xi_c^+ K^-$ states.

Keeping in mind the Dalitz diagram as a general motivation and following [6] and [7], we now discuss the model for the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay. The process can be divided into three steps: the first two describe the weak decay mechanism $\Omega_b^- \to \pi^- MB$, where MB is the meson-baryon system with strangeness $S = -2$ and charm $C = 1$, and the hadronization process. Then, the final-state interaction takes place and the Ω_c^0 baryons are generated dynamically.

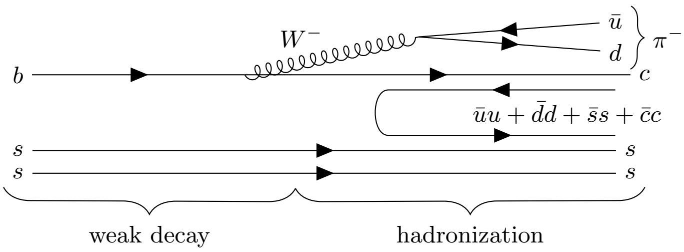

FIG. 2: Diagram of the weak decay $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ via a hadronization mechanism. The full lines correspond to quarks, while the wavy line corresponds to the $W-$boson.

The decay process begins with the Ω_b^- flavor function:

$$|\Omega_b^-\rangle = |bss\rangle.$$

Fig.2 shows that, in the weak decay step, the b quark of the Ω_b^- transitions to a c quark and a quark-antiquark pair $d\bar{u}$ which forms the π^- meson. Subsequently, the virtual css three-quark state undergoes a process of hadronization:

$$|H\rangle = |css\rangle.$$

Since the possible resonances are generated from the interaction of pseudoscalar mesons ($J^P = 0^-$) and baryons of the ground state octet ($J^P = 1/2^+$) in $s-$wave, the spin-parity of the resonance state will be $J^P = 1/2^-$. Furthermore, since the two $s-$quarks act as spectators (so their angular momentum is fixed at $L = 0$) and the final-state parity is negative, the $c-$quark must be in $L = 1$. Therefore, the $c-$quark must be involved in the hadronizing mechanism, as depicted in Fig.2.

After hadronization, the quark flavor state is

$$\begin{aligned} |H\rangle &= |c(\bar{u}u + \bar{d}d + \bar{s}s + \bar{c}c)ss\rangle \\ &= |c\bar{u}uss + c\bar{d}dss + c\bar{s}sss + c\bar{c}css\rangle \\ &= \sum_{i=1}^{4} |\phi_{4i} q_i(ss)\rangle , \end{aligned}$$

where we define

$$q = \begin{pmatrix} u \\ d \\ s \\ c \end{pmatrix}, \quad \phi = qq^t = \begin{pmatrix} u\bar{u} & u\bar{d} & u\bar{s} & u\bar{c} \\ d\bar{u} & d\bar{d} & d\bar{s} & d\bar{c} \\ s\bar{u} & s\bar{d} & s\bar{s} & s\bar{c} \\ c\bar{u} & c\bar{d} & c\bar{s} & c\bar{c} \end{pmatrix}.$$

Since ϕ is the quark-antiquark representation of the $SU(4)$ pseudoscalar meson matrix, we can rewrite it in terms of the physical mesons as

$$\phi = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta + \frac{1}{\sqrt{6}}\eta' & \pi^+ & K^+ & \bar{D}^0 \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta + \frac{1}{\sqrt{6}}\eta' & K^0 & D^- \\ K^- & \bar{K}^0 & -\frac{1}{\sqrt{3}}\eta + \sqrt{\frac{2}{3}}\eta' & D_s^- \\ D^0 & D^+ & D_s^+ & \eta_c \end{pmatrix}$$

where we have introduced the ordinary mixing between the $SU(3)$ singlet and octet states for the η and η', instead of their expressions η_1 and η_8 as it is done in [2]. From [8], the physical states are a mixture of singlet and octet as follows:

$$\begin{aligned} \eta &= \cos\theta \eta_8 + \sin\theta \eta_1 \\ \eta' &= -\sin\theta \eta_8 + \cos\theta \eta_1 , \end{aligned} \tag{1}$$

where θ is defined as the mixing angle, whose value is customarily taken such that eq.(1) becomes:

$$\eta = \frac{1}{3}\eta_1 + \frac{2\sqrt{2}}{3}\eta_8, \qquad \eta' = \frac{2\sqrt{2}}{3}\eta_1 - \frac{1}{3}\eta_8 .$$

The effect of the mixing is very small but we have taken it into account.

We can then rewrite the hadronized state as

$$|H\rangle = D^0 uss + D^+ dss + D_s^+ sss + \eta_c css .$$

Given that the pair of $s-$quarks must be in a symmetric state of spin, $S = 1$, we note that the found states will only overlap with baryons in which the $s-$quarks are also found in a symmetric state. These will be the octet of mixed symmetric baryons, 8_{M_s} or any baryon in the decuplet. Using the representations for the octet states of three quarks in [8], the triplet uss will overlap with the Ξ^0 baryon since they both have the same quark composition, giving

$$\langle uss|\Xi^0\rangle = \langle uss| - \frac{1}{\sqrt{6}}[s(us + su) - 2uss]\rangle = \frac{2}{\sqrt{6}} .$$

Similarly, the triplet dss will overlap with the Ξ^- baryon

$$\langle dss|\Xi^-\rangle = \langle dss| - \frac{1}{\sqrt{6}}[s(ds + sd) - 2dss]\rangle = \frac{2}{\sqrt{6}} .$$

The triplet sss is completely symmetric. It belongs to the decuplet and corresponds to the Ω^- baryon

$$\langle sss|\Omega^-\rangle = 1 .$$

Finally, given that the mixed-symmetry $20-$plets contain $4SU(3)$ octets made out of (u, d, s), (u, d, c), (u, s, c) and (d, s, c), we see that the triplet css belongs to the latter two. In both cases

$$\langle css|\Omega_c^0\rangle = \langle css|\frac{1}{\sqrt{6}}[s(sc + cs) - 2css]\rangle = -\frac{2}{\sqrt{6}} .$$

The final hadronized state can be expressed as

$$|H\rangle = \frac{2}{\sqrt{6}}|D^0\Xi^0\rangle + \frac{2}{\sqrt{6}}|D^+\Xi^-\rangle + |D_s^+\Omega^-\rangle - \frac{2}{\sqrt{6}}|\eta_c\Omega_c^0\rangle .$$

We note here that, as it is mentioned in [7], in order for the phase convention in [8] and the one inherent in the baryon octet matrix (which is used in the chiral Lagrangians) to be compatible, one must change the phase of the Ξ^0 baryon. Consequently, the hadronized state consistent with the chiral convention will be

$$|H\rangle = -\frac{2}{\sqrt{6}}|D^0\Xi^0\rangle + \frac{2}{\sqrt{6}}|D^+\Xi^-\rangle + |D_s^+\Omega^-\rangle - \frac{2}{\sqrt{6}}|\eta_c\Omega_c^0\rangle . \quad (2)$$

As in [7], we can rewrite eq.(2) in an isospin basis. Taking into account that the phase convention for the mesons is $|D^0\rangle = -|\frac{1}{2},-\frac{1}{2}\rangle$, $|D^+\rangle = |\frac{1}{2},\frac{1}{2}\rangle$, and for the baryons is $|\Xi^0\rangle = |\frac{1}{2},\frac{1}{2}\rangle$, $|\Xi^-\rangle = -|\frac{1}{2},-\frac{1}{2}\rangle$, $|H\rangle$ is rewritten as a combination of states with $I = 0$ as it should be for $css-$type states:

$$|H\rangle = -\frac{2}{\sqrt{6}}|D\Xi\rangle_{I=0} + |\bar{D}_s\Omega_{cc}\rangle_{I=0} - \frac{2}{\sqrt{6}}|\eta_c\Omega_c\rangle_{I=0} . \quad (3)$$

We observe that there is no direct production of $\Xi_c^+ K^-$, however, this channel can be generated through the intermediate loops in the final-state interaction, as diagrammatically represented in Fig.3. Moreover, the intermediate $D_s^+\Omega^-$ state will be neglected as well as the $\eta_c\Omega_c^0$ state since their energy is much larger than that of the other channels and they will have a small effect. Hence, effectively, we will only consider the $D\Xi$ channel.

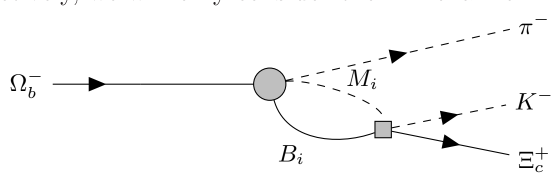

FIG. 3: Diagrammatic representation of the hadronic model for the $\Omega_b^- \to \pi^-\Xi_c^+K^-$ decay. The circle denotes the production mechanism of the $\pi^- M_i B_i$, which contains the hadronization factors of the reaction, whereas the square represents the meson-baryon scattering matrix t_{ij}.

After the meson-baryon pair is produced, the final-state interaction takes place, which is parametrized by the scattering matrix t_{ij}. As in [6], we absorb all the kinematic and hadronization prefactors in an overall factor V_p, which is unknown and taken as a constant, and calculate the amplitude $\mathcal{M}$ for the transition $\Omega_b^- \to \pi^-\Xi_c^+K^-$ as a function of the invariant mass of the meson-baryon pair in the final state, in our case, $\Xi_c^+K^-$:

$$\mathcal{M}(\sqrt{s}) = V_p\left[h_{\bar{K}\Xi_c} + h_{D\Xi}G_{D\Xi}t_{(D\Xi)(\bar{K}\Xi_c)}\right] , \quad (4)$$

where h_{MB} corresponds to the relative weights of the different possible meson-baryon pairs as provided by eq.(3)

$$h_{D\Xi} = -\frac{2}{\sqrt{6}}, \quad h_{\bar{K}\Xi_c} = 0,$$

$G_{D\Xi}$ denotes the one-meson-one-baryon loop function, and $t_{(D\Xi)(\bar{K}\Xi_c)}$ describes the $s-$wave contribution to the scattering matrix. Consequently, the invariant mass distribution for the $\Omega_b^- \to \pi^-\Xi_c^+K^-$ process reads as follows [4]

$$\frac{d\Gamma}{d(\sqrt{s})} = \frac{1}{(2\pi)^3}\frac{M_{\Xi_c^+}}{M_{\Omega_b^-}}|\mathbf{p}|_{\pi^-}|\mathbf{p}|_{cm}\left|\mathcal{M}(\sqrt{s})\right|^2 , \quad (5)$$

where $\mathbf{p}_{\pi^-}$ is the momentum of the π^- meson in the rest frame of Ω_b^- and $\mathbf{p}_{cm}$ is the centre-of-mass momentum in the $\Xi_c^+K^-$ system of reference.

B. Interaction model

In this subsection we summarize the meson-baryon interaction model presented in [2]. This model employs chiral effective Lagrangians to describe the coupling of the vector meson to pseudoscalar mesons (VPP) and baryons (VBB) using the hidden gauge formalism and assuming $SU(4)$ symmetry:

$$\mathcal{L}_{VPP} = ig\ \mathrm{tr}\left([\partial_\mu\phi,\phi]V^\mu\right) ,$$
$$\mathcal{L}_{VBB} = \frac{g}{2}\sum_{i,j,k,l=1}^{4}\bar{B}_{ijk}\gamma^\mu\left(V_{\mu,l}^{k}B^{ijl} + 2V_{\mu,l}^{j}B^{ilk}\right) , \quad (6)$$

where the trace is taken over the $SU(4)$ matrices in flavor space, the indices identify with the (u,d,s,c) quarks, the factor g is the universal coupling constant, ϕ is the 16$-$plet matrix of pseudoscalar mesons, B is the tensor of baryons that belong to the 20$-$plet of the proton and V_μ represents the vector fields of the 16$-$plet of the ρ. Working with these Lagrangians as in [2], one obtains the expression for the $t-$channel vector-meson-exchange potential:

$$V_{ij}(\sqrt{s}) = -C_{ij}\frac{1}{8f^2}(2\sqrt{s}-M_i-M_j)\sqrt{\frac{(E_i+M_i)(E_j+M_j)}{M_iM_j}} , \quad (7)$$

where M_i, E_i, M_j, E_j are the masses and energies of the baryons in the i and j channels, respectively, and C_{ij} are the transition coefficients.

For isospin $I = 0$, strangeness $S = -2$ and charm $C = 1$, the available pseudoscalar meson-baryon channels considered here are given in Table I.

	$\bar{K}\Xi_c$	$\bar{K}\Xi_c'$	$D\Xi$	$\eta\Omega_c$	$\eta'\Omega_c$
Threshold [MeV]	2964	3070	3189	3246	3656

TABLE I: Meson-baryon channels for the $I = 0$, $S = -2$, $C = 1$ sector and their corresponding threshold masses.

The matrix of C_{ij} coefficients for the meson-baryon channels is given in Table II, where κ_c is a correcting factor. The slight change in the coefficients with respect to [2] stems from the use of the η, η' physical mesons.

The resonance states are identified as poles of the scattering amplitude, T_{ij}, unitarized via the coupled-channel Bethe-Salpeter equation, which implements the resummation of loop diagrams to infinite order:

$$T_{ij} = V_{ij} + V_{il}G_lV_{lj} + V_{il}G_lV_{lk}G_kV_{kj} + \ldots$$
$$= V_{ij} + V_{il}G_lT_{lj} , \quad (8)$$

with the loop function G_l given by

$$G_l = i\int\frac{d^4q}{(2\pi)^4}\frac{2M_l}{(P-q)^2 - M_l^2 + i\varepsilon}\frac{1}{q^2 - m_l^2 + i\varepsilon} , \quad (9)$$

	$\bar{K}\Xi_c$	$\bar{K}\Xi'_c$	$D\Xi$	$\eta\Omega_c$	$\eta'\Omega_c$
$\bar{K}\Xi_c$	1	0	$\sqrt{\frac{3}{2}}\kappa_c$	0	0
$\bar{K}\Xi'_c$		1	$\frac{1}{\sqrt{2}}\kappa_c$	$-\frac{4}{\sqrt{3}}$	$\sqrt{\frac{2}{3}}$
$D\Xi$			2	$-\sqrt{\frac{2}{3}}\kappa_c$	$-\frac{1}{\sqrt{3}}\kappa_c$
$\eta\Omega_c$				0	0
$\eta'\Omega_c$					0

TABLE II: Coefficients C_{ij} for the interaction of pseudoscalar mesons and baryons in the $I=0$, $S=-2$, $C=1$ sector.

where M_l and m_l are the baryon and meson masses of the l channel, $P = p+k = (\sqrt{s}, \vec{0})$ is the four-momentum in the centre-of-mass frame and q is the four-momentum of the meson propagating in the intermediate loop.

The logarithm of the loop function shows a divergence when $q \to \infty$ which here is solved employing the dimensional regularization approach. This method introduces, for each channel l, a subtraction constant $a_l(\mu)$ that depends on the regularization scale, μ, taken here as 1 GeV. The final equations for the loop function and the subtraction constants can be found in [2]. Table III provides the values for a_l used in this work.

	$\bar{K}\Xi_c$	$\bar{K}\Xi'_c$	$D\Xi$	$\eta\Omega_c$	$\eta'\Omega_c$
Model 1	-1.69	-2.09	-1.93	-2.46	-2.42
Model 2	-1.69	-2.12	-1.94	-2.46	-2.42

TABLE III: Subtraction constants for Model 1 and Model 2.

Factorizing the V and T matrices, eq.(8) has the following solution

$$T = (1 - VG)^{-1} V \,. \tag{10}$$

Therefore, the resonances correspond to the poles, z_p, of eq.(10) which appear when $G = \frac{1}{V}$ and are found in the complex plane using the steepest ascent method. In the neighbourhood of a pole, one may approximate the scattering amplitude as

$$T_{ij} \sim \frac{g_i g_j}{z - z_p} \,, \tag{11}$$

and the coupling constants for all the channels are obtained as the corresponding residues

$$g_i g_j = \left[\frac{\partial}{\partial z} \left(\frac{1}{T_{ij}(z)} \right) \Big|_{z_p} \right]^{-1} . \tag{12}$$

In addition, we calculate the compositeness which measures the amount of each meson-baryon component within a given resonance

$$\chi_i = -g_i^2 \left(\frac{\partial G}{\partial(\sqrt{s})} \right) \Big|_{z_p} . \tag{13}$$

III. RESULTS

In this section we present the results of our approach. Figure 4 shows the sum of amplitudes to final $\Xi_c^+ K^-$ states squared multiplied by a phase-space factor for the pseudoscalar meson-baryon interaction obtained in [2], to which we shall refer as Ref.[2], and for the model obtained by exchanging the η mesons by their physical expressions and maintaining the same subtraction constants, which we shall name Model 1.

We observe two peaks in both models, with small differences, which signal the presence of two poles with mass and width values shown in Table IV. These states have energies very similar to the second and fourth Ω_c^0 resonances discovered in [3].

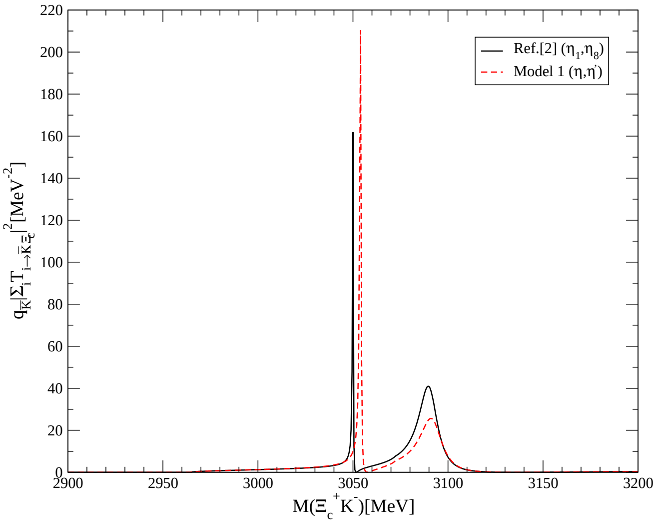

FIG. 4: Sum of amplitudes squared times a phase space factor for Ref.[2] and Model 1.

Table IV also displays the couplings of each resonance to the different meson-baryon channels, together with their compositeness, given by eq.(13). The lowest energy state at 3053.9 MeV couples appreciably to the channels $\bar{K}\Xi'_c$, $D\Xi$, and $\eta\Omega_c$. In Model 1, although the strongest coupling is to the $D\Xi$ channel, the compositeness is larger in the $\bar{K}\Xi'_c$ channel, to which the resonance also strongly couples. The higher energy resonance at 3092.1 MeV has the strongest coupling to the $D\Xi$ channel.

We now implement Model 2 modifying the values of the subtraction constants (as seen in Table III) in order to reproduce more accurately the lowest energy state. The resulting mass and width values of the poles found by Model 2 are listed at the bottom of Table IV. The couplings in Model 2 are qualitatively very similar to the ones obtained in Model 1.

Finally, in Fig.5, we compare the data of the LHCb collaboration [3] and their superimposed fitting with the predictions of Models 1 and 2. For both of them, we find, in the invariant $\Xi_c^+ K^-$ mass distribution, Ω_c^0 resonances which are clearly visible and located around

$0^- \oplus \frac{1}{2}^+$ interaction in the $(I,S,C) = (0,-2,1)$ sector				
Ref.[2]				
M [MeV]	3050.3		3090.8	
Γ [MeV]	0.44		12.0	
	$\lvert g_i \rvert$	χ_i	$\lvert g_i \rvert$	χ_i
$\bar{K}\Xi_c(2964)$	0.11	$0.00 + i\,0.00$	0.49	-0.02 $+ i\,0.01$
$\bar{K}\Xi_c'(3070)$	1.80	$0.61 + i\,0.01$	0.35	$0.02 - i\,0.02$
$D\Xi(3189)$	1.36	$0.07 - i\,0.01$	4.28	$0.91 - i\,0.01$
$\eta\Omega_c(3246)$	1.63	$0.14 + i\,0.00$	0.39	$0.01 + i\,0.01$
$\eta'\Omega_c(3656)$	0.06	$0.00 + i\,0.00$	0.28	$0.00 + i\,0.00$
Model 1				
M [MeV]	3053.9		3092.1	
Γ [MeV]	0.42		14.3	
	$\lvert g_i \rvert$	χ_i	$\lvert g_i \rvert$	χ_i
$\bar{K}\Xi_c(2964)$	0.15	$0.00 + i\,0.00$	0.49	-0.02 $+ i\,0.01$
$\bar{K}\Xi_c'(3070)$	1.67	$0.58 + i\,0.02$	0.48	$0.04 - i\,0.03$
$D\Xi(3189)$	1.78	$0.12 - i\,0.02$	4.19	$0.88 - i\,0.01$
$\eta\Omega_c(3246)$	1.56	$0.13 + i\,0.00$	0.50	$0.01 + i\,0.01$
$\eta'\Omega_c(3656)$	0.46	$0.01 + i\,0.00$	0.47	$0.01 + i\,0.00$
Model 2				
M [MeV]	3050.8		3090.0	
Γ [MeV]	0.43		14.1	
	$\lvert g_i \rvert$	χ_i	$\lvert g_i \rvert$	χ_i
$\bar{K}\Xi_c(2964)$	0.16	$0.00 + i\,0.00$	0.49	-0.02 $+ i\,0.01$
$\bar{K}\Xi_c'(3070)$	1.71	$0.55 + i\,0.02$	0.47	$0.04 - i\,0.03$
$D\Xi(3189)$	1.82	$0.13 - i\,0.02$	4.22	$0.88 - i\,0.01$
$\eta\Omega_c(3246)$	1.61	$0.14 + i\,0.00$	0.51	$0.01 + i\,0.01$
$\eta'\Omega_c(3656)$	0.48	$0.01 + i\,0.00$	0.47	$0.01 + i\,0.00$

TABLE IV: Energy, width, couplings and compositeness of the Ω_c^0 states generated in the model of Ref.[2], Model 1 and Model 2.

the $\Omega_c(3050)^0$ and the $\Omega_c(3090)^0$ experimentally found states. The states obtained by Model 2 reproduce better the experimental ones.

IV. CONCLUSIONS

In this work we have studied the $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decay process that has been reported by the LHCb collaboration in search of excited Ω_c^0 baryons. A previous LHCb measurement already established the existence of these Ω_c^0 baryons with strangeness and charm via pp collisions.

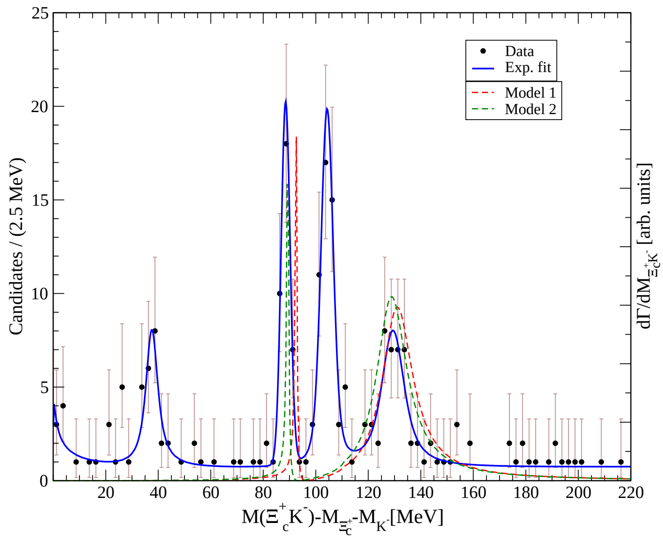

FIG. 5: Distribution of the reconstructed mass difference between the $\Xi_c^+ K^-$ invariant mass and the Ξ_c^+ and K^- masses, as seen in [3]. The blue line is the total fit over the data. The red dashed line corresponds to the results of Model 1, and the green dashed line to the results of Model 2.

Implementing the interaction of pseudoscalar mesons with the ground-state baryons in the $I = 0$, $S = -2$, $C = 1$ sector through a t-channel vector meson exchange model with effective Lagrangians as in [2], we have explored the possible molecular origin of some of the four Ω_c^0 states. Adjusting the subtraction constants, we have found two states that reproduce very satisfactorily the peaks of the $\Omega_c(3050)^0$ and the $\Omega_c(3090)^0$ resonances seen in the LHCb $\Xi_c^+ K^-$ spectrum from $\Omega_b^- \to \pi^- \Xi_c^+ K^-$ decays.

Our results support the view of these two resonances as meson-baryon molecular states. The excited state at 3050 MeV would qualify as a $\bar{K}\Xi_c'$ system, while the 3090 MeV state would mostly be a $D\Xi$ bound system with an strength of 88%.

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[1] R. Aaij *et al.* [LHCb], Phys. Rev. Lett. **118** (2017) no.18, 182001 [arXiv:1703.04639 [hep-ex]].
[2] G. Montaña A. Feijoo and À. Ramos, Eur. Phys. J. A **54** (2018) no.4, 64 [arXiv:1709.08737 [hep-ph]].
[3] R. Aaij *et al.* [LHCb], Phys. Rev. D **104** (2021) no.9, 9 [arXiv:2107.03419 [hep-ex]].
[4] P. A. Zyla *et al.* [Particle Data Group], PTEP **2020** (2020) no.8, 083C01
[5] V. Magas, À. Ramos, R. Somasundaram and J. Tena Vidal, Phys. Rev. D **102** (2020) no.5, 054027 [arXiv:2004.01541 [hep-ph]].
[6] L. Roca, M. Mai, E. Oset and U. G. Meißner, Eur. Phys. J. C **75** (2015) no.5, 218 [arXiv:1503.02936 [hep-ph]].
[7] R. P. Pavao, W. H. Liang, J. Nieves and E. Oset, Eur. Phys. J. C **77** (2017) no.4, 265 [arXiv:1701.06914 [hep-ph]].
[8] F.E. Close, *An Introduction to Quarks and Partons* (Academic Press, London, 1979).