Molecular Ω_c states within the local hidden gauge approach

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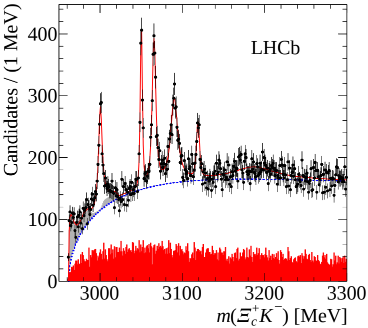
Introduction

The discovery of five narrow Ω_c states by the LHCb Collaboration [1] has trigged a wave of theoretical works with different interpretations.

In our work [2] we have investigated meson-baryon molecular states with $C = +1$, $S = -2$ and found that three of the five observed structures can be obtained in remarkable agreement with the experiment.

Another recent work [3] with similar approach also found the first two states in agreement with our results.

And a third study of these meson-baryon states, based on Ref. [4], is being developed [5].



[1] R. Aaij *et al.* [LHCb Collaboration], Phys. Rev. Lett. **118**, no. 18, 182001 (2017).

[2] V. R. Debastiani, J. M. Dias, W. H. Liang and E. Oset, arXiv:1710.04231 [hep-ph].

[3] G. Montaña, A. Feijoo and A. Ramos, arXiv:1709.08737 [hep-ph].

[4] O. Romanets, L. Tolos, C. Garcia-Recio, J. Nieves, L. L. Salcedo and R. G. E. Timmermans, Phys. Rev. D **85**, 114032 (2012).

[5] R. Pavao, R.L. Tolos and J. Nieves.

The meson-baryon interaction in the $\mathrm{SU}(3)$ sector is given by the chiral Lagrangian

$$\mathcal{L}^B = \frac{1}{4f_\pi^2} \left\langle \bar{B} i\gamma^\mu \left[(\Phi\, \partial_\mu \Phi - \partial_\mu \Phi\, \Phi\,) B - B(\Phi\, \partial_\mu \Phi - \partial_\mu \Phi\, \Phi\,) \right] \right\rangle ,$$

$$\Phi = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta & \pi^+ & K^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta & K^0 \\ K^- & \bar{K}^0 & -\frac{2}{\sqrt{6}}\eta \end{pmatrix} ,$$

$$B = \begin{pmatrix} \frac{1}{\sqrt{2}}\Sigma^0 + \frac{1}{\sqrt{6}}\Lambda & \Sigma^+ & p \\ \Sigma^- & -\frac{1}{\sqrt{2}}\Sigma^0 + \frac{1}{\sqrt{6}}\Lambda & n \\ \Xi^- & \Xi^0 & -\frac{2}{\sqrt{6}}\Lambda \end{pmatrix} .$$

The extension of Eq. (1) to the charm sector is complicated particularly in the baryon sector.

At energies close to threshold one can consider only the dominant contribution coming from ∂_0 and γ^0, such that the interaction is given by

$$V_{ij} = -C_{ij} \frac{1}{4f^2} (k^0 + k'^0) ,$$

where k^0, k'^0 are the energies of the incoming and outgoing mesons, respectively.

In the LHGA the meson-baryon interaction in $\mathrm{SU}(3)$ is obtained exchanging vector mesons

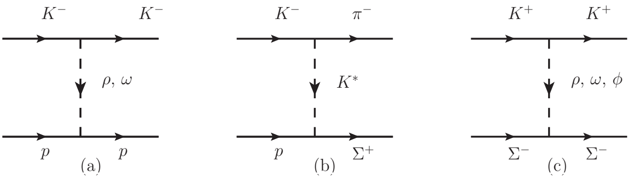


Figure: Vector exchange in the meson-baryon interaction.

The ingredients needed are the *VPP* Lagrangian

$$\mathcal{L}_{VPP} = -ig \, \langle \, [\, \Phi, \, \partial_\mu \Phi \,] \, V^\mu \, \rangle \, ,$$

with

$$V_\mu = \begin{pmatrix} \frac{\rho^0}{\sqrt{2}} + \frac{\omega}{\sqrt{2}} & \rho^+ & K^{*+} \\ \rho^- & -\frac{\rho^0}{\sqrt{2}} + \frac{\omega}{\sqrt{2}} & K^{*0} \\ K^{*-} & \bar{K}^{*0} & \phi \end{pmatrix}_\mu ,$$

and the *VBB* Lagrangian

$$\mathcal{L}_{VBB} = g \left(\langle \bar{B} \gamma_\mu [V^\mu, B] \, \rangle + \langle \bar{B} \gamma_\mu B \rangle \langle V^\mu \rangle \right) ,$$

with $g = m_V/2f$ and m_V the mass of the vector mesons.

Taking $q^2/m_V^2 \to 0$ in the propagator of the exchanged vector gives rise to the same interaction of the Chiral Lagrangian.

We have chosen the following channels. We neglect channels whose threshold is already too high to generate the experimental states.

We separate spin 1/2 and spin 3/2.

Table: $J = 1/2$ states chosen and threshold mass in MeV. From pseudoscalar-baryon(1/2) and vector-baryon(1/2) interactions.

States	$\Xi_c \bar{K}$	$\Xi_c' \bar{K}$	ΞD	$\Omega_c \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi_c' \bar{K}^*$
Threshold	2965	3072	3185	3245	3326	3363	3470

Table: $J = 3/2$ states chosen and threshold mass in MeV. From pseudoscalar-baryon(3/2) and vector-baryon(1/2) interactions.

States	$\Xi_c^* \bar{K}$	$\Omega_c^* \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi^* D$	$\Xi_c' \bar{K}^*$
Threshold	3142	3316	3326	3363	3400	3470

Extending VPP Lagrangian to the charm sector is easy. We take the same structure with

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

where we include the mixing between η and η', and

$$V = \begin{pmatrix} \frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & \rho^+ & K^{*+} & \bar{D}^{*0} \\ \rho^- & -\frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & K^{*0} & \bar{D}^{*-} \\ K^{*-} & \bar{K}^{*0} & \phi & D_s^{*-} \\ D^{*0} & D^{*+} & D_s^{*+} & J/\psi \end{pmatrix}.$$

- Heavy quark as a spectator $\rightarrow \mathrm{SU}(3)$ content of $\mathrm{SU}(4)$.
- Respects heavy quark spin symmetry,
- Except for non diagonal transitions like $\Xi_c\bar{K} \rightarrow \Xi D$
  - Exchange a $D_s^* \rightarrow \mathrm{SU}(4)$ is used,
  - Suppressed: heavy quark propagator $\sim (1/m_{D_s^*})^2$.

Extending the VBB Lagrangian to charm sector is not so easy.

- We look at the quark structure of the ρ^0, ω and ϕ (which can be extended to K^*, $\rho^\pm$, ...)

$$\begin{aligned} \rho^0 &= \frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d}), \\ \omega &= \frac{1}{\sqrt{2}}(u\bar{u} + d\bar{d}), \\ \phi &= s\bar{s}. \end{aligned}$$

- $\gamma_\mu \rightarrow \gamma^0$ approximation $\Rightarrow$ No spin dependence.

- We consider an operator at the quark level, for instance, for $\rho^0 pp$ vertex

$$\langle p|\, \rho^0 \,|p\rangle \equiv \frac{1}{\sqrt{2}}\frac{1}{\sqrt{2}}\langle \phi_{MS}\,\chi_{MS} + \phi_{MA}\,\chi_{MA}|g\,\frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})|\phi_{MS}\,\chi_{MS} + \phi_{MA}\,\chi_{MA}\rangle\,,$$

  where ϕ_{MS}, ϕ_{MA}, χ_{MS}, χ_{MA} are the flavor and spin mixed symmetric and mixed antisymmetric wave functions for the proton.

- Same result as using $\mathcal{L}_{VBB}$.

$SU(3)$ symmetry in light quarks, inspired in Ref. [1]. Heavy quark as spectator.

$$\Xi^0 \equiv \frac{1}{\sqrt{2}}(\phi_{MS}\,\chi_{MS} + \phi_{MA}\,\chi_{MA}),$$

with the Mixed-Symmetric and Mixed-Antisymmetric flavor and spin wavefunctions:

$$\phi_{MS} = \frac{1}{\sqrt{6}}[s(us+su) - 2uss]\,, \quad \phi_{MA} = -\frac{1}{\sqrt{2}}[s(us-su)]\,,$$

$$\chi_{MS} = \frac{1}{\sqrt{6}}(\uparrow\uparrow\downarrow + \uparrow\downarrow\uparrow -2\downarrow\uparrow\uparrow), \quad \chi_{MA} = \frac{1}{\sqrt{2}}\uparrow(\uparrow\downarrow - \downarrow\uparrow),$$

- Ξ^{*0}: $\frac{1}{\sqrt{3}}(sus+ssu+uss)\uparrow\uparrow\uparrow$, (Symmetric for the three light quarks, ϕ_S and χ_S).
- Ξ_c^+: $\frac{1}{\sqrt{2}}\,c\,(us-su)\uparrow\frac{1}{\sqrt{2}}(\uparrow\downarrow - \downarrow\uparrow)$, (Antisymmetric for the two light quarks, and χ_{MA}).
- $\Xi_c'^+$: $\frac{1}{\sqrt{2}}c(us+su)\frac{1}{\sqrt{6}}(\uparrow\uparrow\downarrow + \uparrow\downarrow\uparrow -2\downarrow\uparrow\uparrow)$, (Symmetric for the two light quarks, and χ_{MS}).
- Ξ_c^{*+}: $\frac{1}{\sqrt{2}}c(us+su)\uparrow\uparrow\uparrow$, (Symmetric for the two light quarks, and χ_S).

[1] F. E. Close, *"An Introduction to Quarks and Partons,"* Academic Press/London 1979.

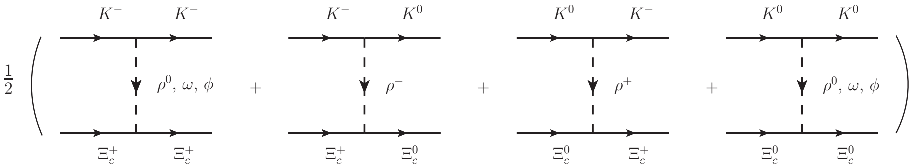


Figure: Diagrams in the $\bar{K}\Xi_c \to \bar{K}\Xi_c$ transition.

We reach the same structure for the meson-baryon interaction

$$V_{ij} = D_{ij} \frac{1}{4f^2} (p^0 + p'^0) \,,$$

and the matrix D_{ij} is constructed from VPP and VBB vertex.

Alternatively, we can use another expression which includes relativistic correction in S-wave

$$V_{ij} = D_{ij} \frac{2\sqrt{s} - M_{B_i} - M_{B_j}}{4f^2} \sqrt{\frac{M_{B_i} + E_{B_i}}{2M_{B_i}}} \sqrt{\frac{M_{B_j} + E_{B_j}}{2M_{B_j}}} \,,$$

where M_{B_i,B_j} and E_{B_i,B_j} stand for the mass and the center-of-mass energy of the baryons.

We have also evaluated the diagrams connecting the $VP \to VB$ transitions, like pseudoescalar(0^-)-baryon($1/2^+$) $\to$ vector(1^-)-baryon($1/2^+$), as in $\Xi D \to \Xi D^*$.

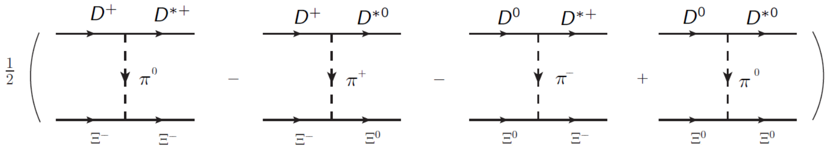


Figure: Example of pion exchange in $VP \to VB$ transition.

However, they are small in comparison to the diagonal channels like $\Xi D \to \Xi D$, $\Xi^* D \to \Xi^* D$ and $\Xi D^* \to \Xi D^*$, and we can safely neglect them.

Coefficients - Spin 1/2

Results

Two blocks: pseudoescalar(0^-)-baryon($1/2^+$) decouples from vector(1^-)-baryon($1/2^+$).

Table: D_{ij} coefficients of Eq. (1) for the meson-baryon states coupling to $J^P = 1/2^-$ in s-wave.

$J=1/2$	$\Xi_c\bar{K}$	$\Xi'_c\bar{K}$	ΞD	$\Omega_c\eta$	ΞD^*	$\Xi_c\bar{K}^*$	$\Xi'_c\bar{K}^*$
$\Xi_c\bar{K}$	-1	0	$-\frac{1}{\sqrt{2}}\lambda$	0	0	0	0
$\Xi'_c\bar{K}$		-1	$\frac{1}{\sqrt{6}}\lambda$	$\frac{4}{\sqrt{3}}$	0	0	0
ΞD			-2	$-\frac{\sqrt{2}}{3}\lambda$	0	0	0
$\Omega_c\eta$				0	0	0	0
ΞD^*					-2	$-\frac{1}{\sqrt{2}}\lambda$	$\frac{1}{\sqrt{6}}\lambda$
$\Xi_c\bar{K}^*$						-1	0
$\Xi'_c\bar{K}^*$							-1

In some non diagonal transitions like $\bar{K} \to D$, the propagator of the exchanged vector

$$\frac{1}{q^0 - |\mathbf{q}|^2 - m_{D_s^*}^2} \approx \frac{1}{(m_D - m_K)^2 - m_{D_s^*}^2},$$

and the ratio to the propagator of the light vectors is

$$\lambda \equiv \frac{-m_V^2}{(m_D - m_K)^2 - m_{D_s^*}^2} \approx 0.25\,.$$

Pseudoescalar(0^-)-baryon($3/2^+$) decouples from vector(1^-)-baryon($1/2^+$).

Table: D_{ij} coefficients of Eq. (1) for the meson-baryon states coupling to $J^P = 3/2^-$.

$J = 3/2$	$\Xi_c^* \bar{K}$	$\Omega_c^* \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi^* D$	$\Xi_c' \bar{K}^*$
$\Xi_c^* \bar{K}$	-1	$\frac{4}{\sqrt{3}}$	0	0	$\frac{2}{\sqrt{6}}\lambda$	0
$\Omega_c^* \eta$		0	0	0	$\frac{\sqrt{2}}{3}\lambda$	0
ΞD^*			-2	$-\frac{1}{\sqrt{2}}\lambda$	0	$\frac{1}{\sqrt{6}}\lambda$
$\Xi_c \bar{K}^*$				-1	0	0
$\Xi^* D$					-2	0
$\Xi_c' \bar{K}^*$						-1

- Same diagonals matrix elements of Ref. [1], non diagonal not the same.
- Heavy baryons wave functions are not eigenstates of $\mathrm{SU}(4) \rightarrow$ Different spin-flavor dependence from Ref. [1].
- Both our coefficients and the ones from Ref. [1] differ from Ref. [2] in some diagonal and non diagonal.

[1] G. Montaña, A. Feijoo and A. Ramos, arXiv:1709.08737 [hep-ph].

[2] O. Romanets, L. Tolos, C. Garcia-Recio, J. Nieves, L. L. Salcedo and R. G. E. Timmermans, Phys. Rev. D **85**, 114032 (2012).

We use the potential of Eq. (1) and the on-shell factorized Bethe-Salpeter equation

$$T = [1 - VG]^{-1}\, V\,,$$

with G the meson-baryon loop function which we regularize with a cutoff.

$$\begin{aligned} G_l &= i \int \frac{d^4 q}{(2\pi)^4} \frac{M_l}{E_l(\mathbf{q})} \frac{1}{k^0 + p^0 - q^0 - E_l(\mathbf{q}) + i\epsilon} \frac{1}{\mathbf{q}^2 - m_l^2 + i\epsilon} \\ &= \int_{|\mathbf{q}|<q_{max}} \frac{1}{2\omega_l(\mathbf{q})} \frac{M_l}{E_l(\mathbf{q})} \frac{1}{k^0 + p^0 - \omega_l(\mathbf{q}) - E_l(\mathbf{q}) + i\epsilon}\,, \end{aligned}$$

where $k^0 + p^0 = \sqrt{s}$ and E_l, ω_l, m_l, M_l are the energies and masses of the meson and baryon.

- Poles in the second Riemann sheet. We define G_l^{II} for $\mathrm{Re}(\sqrt{s}) >$ threshold of the l channel

$$G_l^{II} = G_l^{I} + i\frac{2M_l\, q}{4\pi\sqrt{s}}\,, \qquad q = \frac{\lambda^{1/2}(s, m_l^2, M_l^2)}{2\sqrt{s}}\,, \text{ and } \mathrm{Im}(\mathrm{q}) > 0\,.$$

- $T_{ij} = \dfrac{g_i g_j}{\sqrt{s} - M_R}$: Couplings close to the pole (M_R)

- $g_i G_i^{II}$: Strength of the wave function at the origin (S-wave).

Table: The coupling constants to various channels for the poles in the $J^P = 1/2^-$ sector, with $q_{max} = 650$ MeV.

3054.05 + i0.44	$\Xi_c \bar{K}$	$\Xi'_c \bar{K}$	ΞD	$\Omega_c \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi'_c \bar{K}^*$
g_i	$-0.06 + i0.14$	$1.94 + i0.01$	$-2.14 + i0.26$	$-1.98 + i0.01$	0	0	0
$g_i\, G_i^{II}$	$-1.40 - i3.85$	$-34.41 - i0.30$	$9.33 - i1.10$	$16.81 + i0.11$	0	0	0
3091.28 + i5.12	$\Xi_c \bar{K}$	$\Xi'_c \bar{K}$	ΞD	$\Omega_c \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi'_c \bar{K}^*$
g_i	$0.18 - i0.37$	$0.31 + i0.25$	$5.83 - i0.20$	$-0.38 - i0.23$	0	0	0
$g_i\, G_i^{II}$	$5.05 + 10.19$	$-9.97 - i3.67$	$-29.82 + i0.31$	$3.59 + i2.23$	0	0	0

Resonance	Mass (MeV)	Γ (MeV)
$\Omega_c(3050)^0$	$3050.2 \pm 0.1 \pm 0.1^{+0.3}_{-0.5}$	$0.8 \pm 0.2 \pm 0.1$
		< 1.2 MeV, 95% CL
	3054.05	**0.88**
$\Omega_c(3090)^0$	$3090.2 \pm 0.3 \pm 0.5^{+0.3}_{-0.5}$	$8.7 \pm 1.0 \pm 0.8$
	3091.28	**10.24**

- No coupling to vector(1^-)-baryon($1/2^+$)
- $\Rightarrow$ **pseudoescalar(0^-)-baryon($1/2^+$) nature with** $J^P = 1/2^-$
- $\Omega_c(3050)^0$ mostly $\Xi'_c \bar{K}$.
- $\Omega_c(3090)^0$ mostly ΞD.

Table: The coupling constants to various channels for the poles in the $J^P = 3/2^-$ sector, with $q_{max} = 650$ MeV.

3124.84	$\Xi_c^* \bar{K}$	$\Omega_c^* \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi^* D$	$\Xi_c' \bar{K}^*$
g_i	1.95	-1.98	0	0	-0.65	0
$g_i\, G_i^{II}$	-35.65	16.83	0	0	1.93	0
$3290.31 + i0.03$	$\Xi_c^* \bar{K}$	$\Omega_c^* \eta$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi^* D$	$\Xi_c' \bar{K}^*$
g_i	$0.01 + i0.02$	$-0.31 - i0.01$	0	0	$6.22 - i0.04$	0
$g_i\, G_i^{II}$	$-0.62 - i0.18$	$5.25 + i0.18$	0	0	$-31.08 + i0.20$	0

Resonance	Mass (MeV)	Γ (MeV)
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$
		< 2.6 MeV, 95% CL
	3124.84	**0.0**

- No coupling to vector(1^-)-baryon($1/2^+$)
- $\Rightarrow$ **pseudoescalar(0^-)-baryon($3/2^+$) nature with** $J^P = 3/2^-$
- $\Omega_c(3119)^0$ mostly $\Xi_c^* \bar{K}$.
- New " $\Omega_c(3290)^0$ " mostly $\Xi^* D$.
- "Spin-Partners" of $\Omega_c(3050)^0$ and $\Omega_c(3090)^0$.

Poles and Couplings - Degenerated Spin $J^P = 1/2^-, 3/2^-$

We isolate the vector(1^-)-baryon($1/2^+$) channels and find two more poles.

Table: The coupling constants to various channels for the poles in $J^P = 1/2^-, 3/2^-$ stemming from vector-baryon interaction with $q_{max} = 650$ MeV.

3221.98	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi_c' \bar{K}^*$
g_i	6.37	0.59	-0.28
$g_i\, G_i^{II}$	-29.29	-4.66	1.62
$3465.17 + i0.09$	ΞD^*	$\Xi_c \bar{K}^*$	$\Xi_c' \bar{K}^*$
g_i	$-0.01 + i0.06$	$0.01 - i0.01$	$1.75 + i0.01$
$g_i\, G_i^{II}$	$-0.84 - i0.23$	$0.17 + i0.24$	$-32.29 - i0.08$

- **Degenerated Spin of vector(1^-)-baryon($1/2^+$) nature with $J^P = 1/2^-, 3/2^-$.**
- New " $\Omega_c(3222)^0$ " mostly ΞD^*.
- New " $\Omega_c(3465)^0$ " mostly $\Xi_c' \bar{K}^*$.
- Same pattern in opposite order (due to thresholds mass in opposite order).

Table: Results of the fit to $m(\Xi_c^+ K^-)$ for the mass, width, yield and significance for each resonance. For each fitted parameter, the first uncertainty is statistical and the second systematic. Upper limits are also given for the resonances $\Omega_c(3050)^0$ and $\Omega_c(3119)^0$ for which the width is not significant.
AND COMPARISON WITH OUR RESULTS.

Resonance	Mass (MeV)	Γ (MeV)	Yield	N_σ
$\Omega_c(3000)^0$	$3000.4 \pm 0.2 \pm 0.1^{+0.3}_{-0.5}$	$4.5 \pm 0.6 \pm 0.3$	$1300 \pm 100 \pm 80$	20.4
$\Omega_c(3050)^0$	$3050.2 \pm 0.1 \pm 0.1^{+0.3}_{-0.5}$	$0.8 \pm 0.2 \pm 0.1$	$970 \pm 60 \pm 20$	20.4
		$< 1.2\mathrm{MeV}$, 95% CL		
$J^P = 1/2^-$	**3054.05**	**0.88**		
$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$	$1740 \pm 100 \pm 50$	23.9
$\Omega_c(3090)^0$	$3090.2 \pm 0.3 \pm 0.5^{+0.3}_{-0.5}$	$8.7 \pm 1.0 \pm 0.8$	$2000 \pm 140 \pm 130$	21.1
$J^P = 1/2^-$	**3091.28**	**10.24**		
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$	$480 \pm 70 \pm 30$	10.4
		$< 2.6\mathrm{MeV}$, 95% CL		
$J^P = 3/2^-$	**3124.84**	**0.0**		
$\Omega_c(3188)^0$	$3188 \pm 5 \pm 13$	$60 \pm 15 \pm 11$	$1670 \pm 450 \pm 360$	

Another work on Meson-Baryon Coming Soon

Teaser

Based on Ref. [1], an update considering the new experimental data is being developed [2]

Table: Ω_c and Ω_c^* resonances found using $\alpha = 1.16$

Name	M_R (MeV)	Γ_R (MeV)	J	M_R^{exp}	Γ_R^{exp}
a	2922.2	0	1/2	—	—
b	2928.1	0	3/2	—	—
c	2941.3	0	1/2	—	—
d	2999.9	0.06	1/2	3000.4	4.5
e	3036.3	0	3/2	3050.2	0.8

Table: Ω_c and Ω_c^* resonances found using the sharp cutoff $\Lambda = 1090$ MeV

Name	M_R (MeV)	Γ_R (MeV)	J	M_R^{exp}	Γ_R^{exp}
a	2963.95	0.0	1/2	—	—
c	2994.26	1.85	1/2	3000.4	4.5
b	3048.7	0.0	3/2	3050.2	0.8
d	3116.81	3.72	1/2	3119.1	1.1
e	3155.37	0.17	3/2	—	—

[1] O. Romanets, L. Tolos, C. Garcia-Recio, J. Nieves, L. L. Salcedo and R. G. E. Timmermans, Phys. Rev. D **85**, 114032 (2012).

[2] R. Pavao, R.L. Tolos and J. Nieves.

Different V_{ij} from the symmetries $SU(6)$ (spin-flavor in light sector) and $SU(2)$ (spin in heavy sector) and different renormalization of meson-baryon loops:

$$G_l(s) = \bar{G}_l(s) - \bar{G}_l(\mu^2), \qquad \mu = \alpha\sqrt{m_{th}^2 + M_{th}^2},$$

where m_{th} and M_{th} are the masses of the meson and baryon of the lightest channel.

In this framework, the transitions $VB \to VP$, vector(1^-)-baryon$(1/2^+)$ $\to$ pseudoescalar(0^-)-baryon$(3/2^+)$, like $\Xi D^* \to \Xi^* D$ are sizable due to the symmetry employed.

However, if one look at their couplings, there seem to exist a correspondence with our results.

The pattern is the same:

- One pole with $J = 1/2$ is mostly $\Xi_c' \bar{K}$. (Our $\Omega_c(3050)^0$, their $\Omega_c(3000)^0$)
- Another pole with $J = 1/2$ is mostly ΞD. (Our $\Omega_c(3090)^0$, their $\Omega_c(3119)^0$)
- And the pole with $J = 3/2$ is mostly $\Xi_c^* \bar{K}$. (Our $\Omega_c(3119)^0$, their $\Omega_c(3050)^0$)

But the agreement with the experimental values, specially the widths, is not so good.

On the other hand, we have a remarkable agreement with experiment and with Ref. [1] !

[1] G. Montaña, A. Feijoo and A. Ramos, arXiv:1709.08737 [hep-ph].

Conclusions

- We extend the Local Hidden Gauge Approach to the charm sector.
- We build baryon spin-flavor wavefunctions using $SU(3)$ in light quarks.
- Heavy quark as spectator $\rightarrow$ heavy quark spin symmetry respected (except when exchanging heavy vectors, which is suppressed).
- We can explain three of the recently measured new Ω_c states as meson-baryon molecular states with $C = +1$, $S = -2$, with remarkable agreement!
- $\Omega_c(3050)^0$ and $\Omega_c(3090)^0$ with $J^P = 1/2^-$, pseudoescalar(0^-)-baryon($1/2^+$) nature.
- $\Omega_c(3119)^0$ with $J^P = 3/2^-$, pseudoescalar(0^-)-baryon($3/2^+$) nature.
- Most important channels are $\Xi_c' \bar{K}$, and ΞD and $\Xi_c^* \bar{K}$, respectively.
- We also make predictions for higher mass molecular states.
- Similar to results of other works.
- **NEXT STEP: Measure the Spin-Parity of the Ω_c states.**