Molecular Ω_{cc}, Ω_{bc} and Ω_{bb} states.

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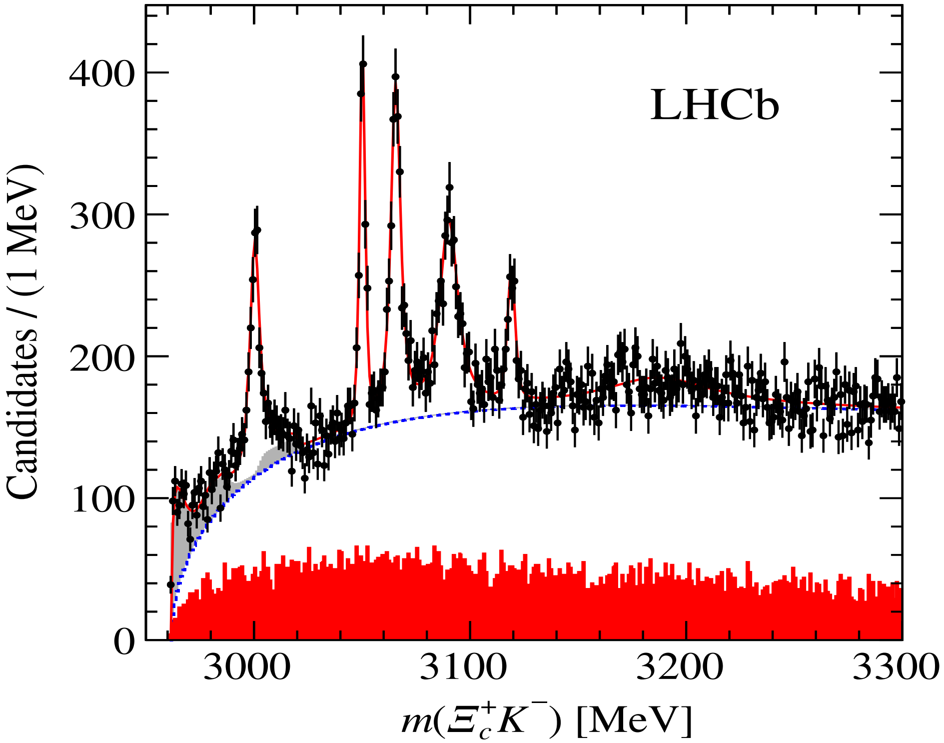
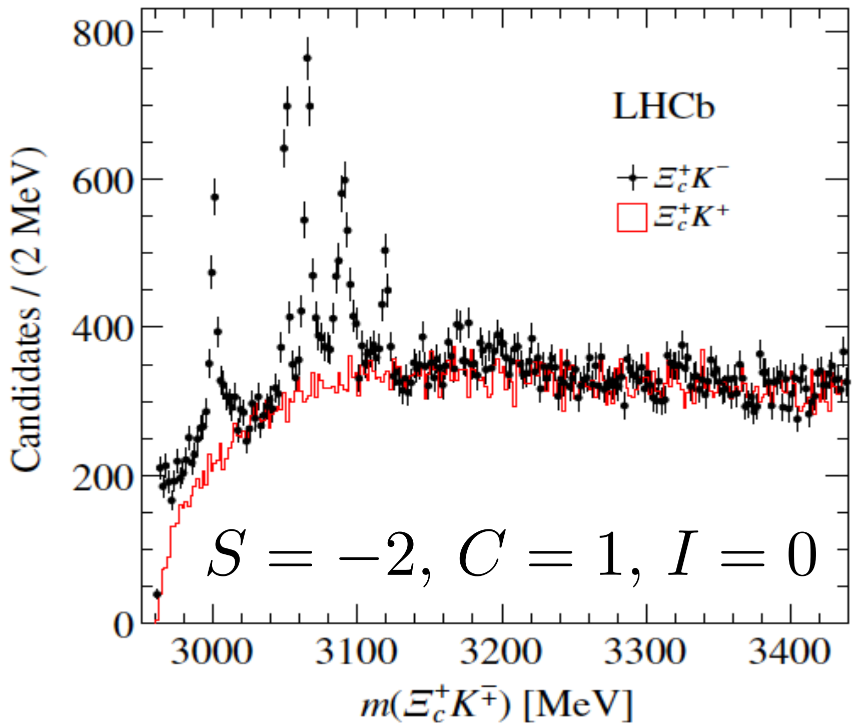
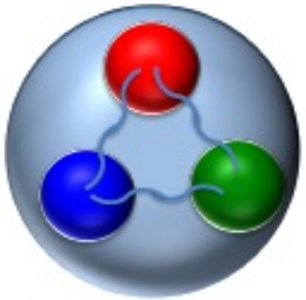
The new Ω_c's observed at LHCb:

R. Aaij et al. (LHCb Collaboration), Phys. Rev. Lett. 118, 182001 (2017).





Constituent Quark Models (CQMs) interpretation:



- Bound states consisting of 1 heavy quark (c) and a P-wave (ss) diquark. (System that gives 5 possible combinations)

$$S_c = \frac{1}{2}, S_{ss} = 1 + L_{ss} = 1 \rightarrow J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$$

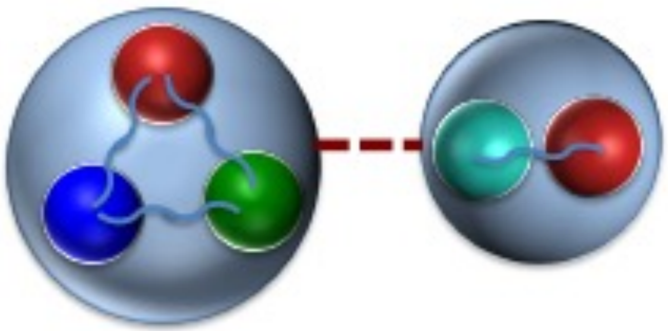
M. Karliner and J. L. Rosner, Phys. Rev. D 95, no.11, 114012 (2017).
W. Wang and R. L. Zhu, Phys. Rev. D 96, no.1, 014024 (2017).
Z. G. Wang, Eur. Phys. J. C 77, no.5, 325 (2017).
B. Chen and X. Liu, Phys. Rev. D 96, no.9, 094015 (2017).

- Alternative interpretation: some states (the 3 lightest ones) remain with (ss) diquark with 1P orbital excitation and the others with 2S radial excitations.

$$J^P = \frac{3}{2}^-, \frac{5}{2}^-, \frac{1}{2}^+, \frac{3}{2}^+$$

S. S. Agaev, K. Azizi and H. Sundu, EPL 118, no.6, 61001 (2017).
S. S. Agaev, K. Azizi and H. Sundu, Eur. Phys. J. C 77, no.6, 395 (2017).
H. Y. Cheng and C. W. Chiang, Phys. Rev. D 95, no.9, 094018 (2017).
K. L. Wang, L. Y. Xiao, X. H. Zhong and Q. Zhao, Phys. Rev. D 95, no.11, 116010 (2017).

What about a molecular interpretation of these states?



R. Aaij et al. (LHCb Collaboration), Phys. Rev. Lett. 118, 182001 (2017).

Resonance	Mass (MeV)	Γ (MeV)
$\Omega_c(3000)^0$	$3000.4 \pm 0.2 \pm 0.1^{+0.3}_{-0.5}$	$4.5 \pm 0.6 \pm 0.3$
$\Omega_c(3050)^0$	$3050.2 \pm 0.1 \pm 0.1^{+0.3}_{-0.5}$	$0.8 \pm 0.2 \pm 0.1$
		<1.2 MeV, 95% C.L.
$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$
$\Omega_c(3090)^0$	$3090.2 \pm 0.3 \pm 0.5^{+0.3}_{-0.5}$	$8.7 \pm 1.0 \pm 0.8$
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$
		<2.6 MeV, 95% C.L.

- The $\bar{K}\Xi_c$ (2964 MeV) and $\bar{K}\Xi_c'$ (3070 MeV) thresholds are within the energy range where the physical Ω_c states pop up!!!

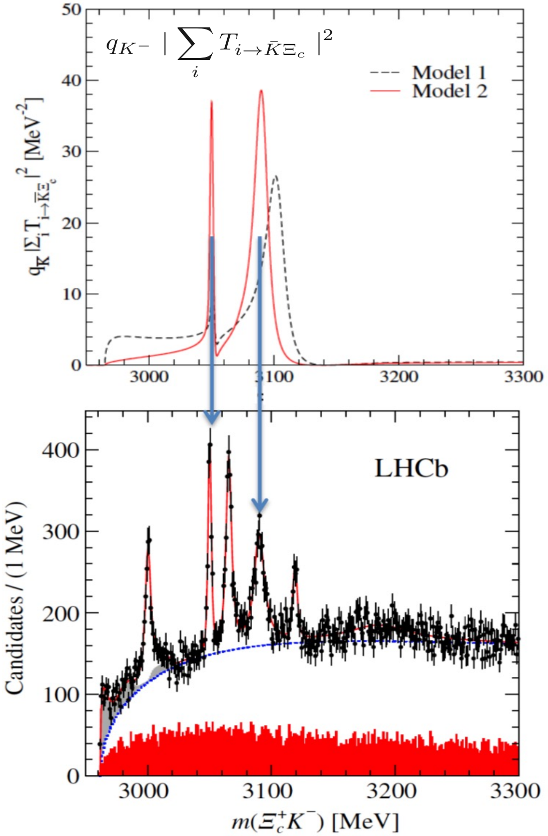
- Prior to the experimental measurement, some theoretical works predicted some states in this sector :

1. SU(8) spin-flavor sym. Model → 5 states much more bound than the LHCb ones. O. Romanets et al., Physical. Rev. D85,114032 (2012)
2. SU(4) finite range Model
   J. Hofmann and M.F.M. Lutz, Nucl. Phys. A 763, 90-139 (2005) → 3 states below 2953 MeV
   C. E. Jimenez-Tejero, A. Ramos and I. Vidaña, Phys. Rev. C 80, 055206 (2009) → 3 states, one at 3117 MeV ($\Gamma = 16$ MeV)!!!

Molecular-Picture Models revisited

G. Montaña, A. F. and A. Ramos, Eur. Phys. J. A 54, no.4, 64 (2018)

Ω_c states dynamically generated by the s-wave interaction between a pseudoscalar meson and a ground state baryon:



$0^- \oplus \frac{1}{2}^+$ interaction in the $(I,S,C) = (0,-2,1)$ sector

	Model 1			
M [MeV]	3051.6		3103.3	
Γ [MeV]	0.45		17	
	$\lvert g_i\rvert$	$-g_i^2 dG/dE$	$\lvert g_i\rvert$	$-g_i^2 dG/dE$
$\bar{K}\Xi_c(2964)$	0.11	$0.00 + i\,0.00$	0.58	$0.01 + i\,0.03$
$\bar{K}\Xi_c'(3070)$	1.67	$0.54 + i\,0.01$	0.30	$0.01 - i\,0.01$
$D\Xi(3189)$	1.10	$0.05 - i\,0.01$	4.08	$0.90 - i\,0.05$
$\eta\Omega_c(3246)$	2.08	$0.23 + i\,0.00$	0.44	$0.01 + i\,0.01$
$\eta'\Omega_c(3656)$	0.04	$0.00 + i\,0.00$	0.28	$0.00 + i\,0.00$

The state at 3051 MeV mainly composed by $K\Xi_c'$ and $\eta\Omega_c$

The state at 3103 MeV is basically a $D\Xi$ bound state

➔10 MeV too heavy and too wide…

Experimental states

$$\Omega_c(3050)^0: \quad M = 3050.2 \pm 0.1 \pm 0.1^{+0.3}_{-0.5}\ \text{MeV}, \quad \Gamma = 0.8 \pm 0.2 \pm 0.1\ \text{MeV},$$

$$\Omega_c(3090)^0: \quad M = 3090.2 \pm 0.3 \pm 0.5^{+0.3}_{-0.5}\ \text{MeV}, \quad \Gamma = 8.7 \pm 1.0 \pm 0.8\ \text{MeV}$$

Assuming this scheme, spin-parity can only be 1/2-!

Molecular-Picture Models revisited

V. R. Debastiani, J. M. Dias, W. H. Liang and E. Oset, Phys. Rev. D 97, no.9, 094035 (2018)

- Extension of the local hidden gauge approach with heavy-baryon states as a spectator c quark + sym. wave funtions of the remaining light quarks
- Inclusion of pseudoscalar-decuplet baryon channels

➔ Same 2 states with $J^P = \frac{1}{2}^-$ and a new $J^P = \frac{3}{2}^-$ Ω_c resonance which could be identified with the LHCb $\Omega_c(3119)$

J. Nieves, R. Pavao and L. Tolos, Eur. Phys. J. C 78, no.2, 114 (2018)

- $SU(6)_{lsf}$ xHQSS-extended WT meson-baryon interaction
- The symmetries automatically account for the additional presence of additional vector mesons and $3/2^+$ baryons

➔ 2 states with $J^P = \frac{1}{2}^-$ and 1 $J^P = \frac{3}{2}^-$ state consistent with the experimental $\Omega_c(3000)$, $\Omega_c(3050)$ and $\Omega_c(3119)$

Introduction: Historical Background (Ω_b states)

R. Aaij et al. [LHCb], Phys. Rev. Lett. 124, no.8, 082002 (2020)

	δM_{peak} [MeV]	Mass [MeV]	Width [MeV]
$\Omega_b(6316)^-$	$523.74 \pm 0.31 \pm 0.07$	$6315.64 \pm 0.31 \pm 0.07 \pm 0.50$	< 2.8 (4.2)
$\Omega_b(6330)^-$	$538.40 \pm 0.28 \pm 0.07$	$6330.30 \pm 0.28 \pm 0.07 \pm 0.50$	< 3.1 (4.7)
$\Omega_b(6340)^-$	$547.81 \pm 0.26 \pm 0.05$	$6339.71 \pm 0.26 \pm 0.05 \pm 0.50$	< 1.5 (1.8)
$\Omega_b(6350)^-$	$557.98 \pm 0.35 \pm 0.05$	$6349.88 \pm 0.35 \pm 0.05 \pm 0.50$	< 2.8 (3.2) $1.4^{+1.0}_{-0.8} \pm 0.1$

Predictions by Molecular-Picture Models:

- W. H. Liang, J. M. Dias, V. R. Debastiani and E. Oset, Nucl. Phys. B 930, 524 (2018)

7 Ω_b^- states were generated dinamically with 1/2- and 3/2- (lowest mass 50MeV above Ω_b^-(6350))

- W. H. Liang and E. Oset, Phys. Rev. D 101, no.5, 054033 (2020)

Arguments against the molecular nature of these states, instead structures at higher energies should be analysed

- J. Nieves, R. Pavao and L. Tolos, Eur. Phys. J. C 80, 22 (2020)

Prediction of a 1/2- state Ω_b^-(6360) as member of a sextet jointly with $\Xi_b(6227)$ and $\Sigma_b(6227)$

- G. Montaña, A. F. and A. Ramos, Eur. Phys. J. A 54, no.4, 64 (2018)

2 Ω_b^- states were generated dinamically with 1/2- (lowest mass 70MeV above Ω_b^-(6350))

Ω_{QQ} *states*

→ **The plans of LHCb to measure Ω_{cc}, Ω_{bc} and Ω_{bb} states has motivated the present study.**

Theoretical studies dedicated to this topic from different approaches:

- Quark Models

Mod. Phys. Lett. A 14, 135 (1999), Phys. Rev. D 66, 014008 (2002), Int. J. Mod. Phys. A 23, 2817 (2008)
Phys. Lett. B 683, 21 (2010), Phys. Rev. D 98, 094021 (2018), Chin. Phys. C 44, 013102 (2020)
…

- Lattice QCD

Phys. Rev. D 64, 094509 (2001), Phys. Rev. D 90, 094507 (2014)
Phys. Rev. D 94, 074003 (2016), Phys. Rev. D 98, 114505 (2018)
…

- QCD sum rules

Eur. Phys. J. A 45, 267 (2010), Chin. Phys. C 42, 123102 (2018)
Eur. Phys. J. C 78, 826 (2018)
…

- Other approaches

Phys. Rev. D 83, 056006 (2011), Phys. Rev. Lett. 115, 122001 (2015),
Phys. Rev. D 102, 014013 (2020), [Erratum: Phys.Rev.D 104, 059901 (2021),
Phys. Rev. D 104, 074027 (2021)

Ω_{QQ} *states: Sectors with their corresponding meson-baryon basis*

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]

TABLE I: Threshold masses (in MeV) of different channels for Ω_{cc}.

$PB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-$	$\Xi_{cc}\bar{K}$ 4115	$\Omega_{cc}\eta$ 4263	$\Xi_c D$ 4338	$\Xi'_c D$ 4448
$PB(\frac{3}{2}^+)$, $J^P = \frac{3}{2}^-$	$\Xi^*_{cc}\bar{K}$ 4168	$\Omega^*_{cc}\eta$ 4320	$\Xi^*_c D$ 4516	
$VB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$	$\Xi_{cc}\bar{K}^*$ 4512	$\Omega_{cc}\omega$ 4495	$\Xi_c D^*$ 4478	$\Xi'_c D^*$ 4588
$VB(\frac{3}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$	$\Xi^*_{cc}\bar{K}^*$ 4565	$\Omega^*_{cc}\omega$ 4552	$\Xi^*_c D^*$ 4656	

TABLE II: Threshold masses (in MeV) of different channels for Ω_{bb}.

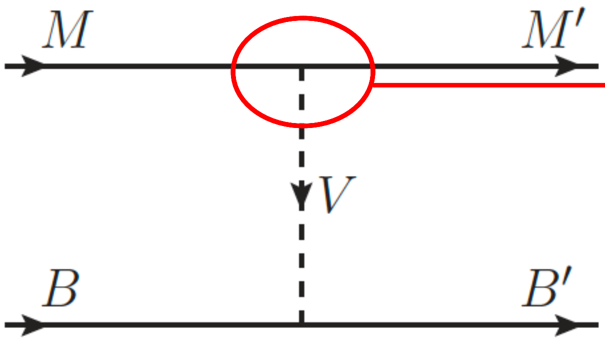
$PB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-$	$\Xi_{bb}\bar{K}$ 10833	$\Omega_{bb}\eta$ 10778	$\Xi_b \bar{B}$ 11076	$\Xi'_b \bar{B}$ 11214
$PB(\frac{3}{2}^+)$, $J^P = \frac{3}{2}^-$	$\Xi^*_{bb}\bar{K}$ 10863	$\Omega^*_{bb}\eta$ 10806	$\Xi^*_b \bar{B}$ 11231	
$VB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$	$\Xi_{bb}\bar{K}^*$ 11230	$\Omega_{bb}\omega$ 11010	$\Xi_b \bar{B}^*$ 11122	$\Xi'_b \bar{B}^*$ 11260
$VB(\frac{3}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$	$\Xi^*_{bb}\bar{K}^*$ 11260	$\Omega^*_{bb}\omega$ 11038	$\Xi^*_b \bar{B}^*$ 11277	

TABLE III: Threshold masses (in MeV) of different channels for Ω_{bc}.

$PB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-$	$\Xi_{bc}\bar{K}$ 7415	$\Omega_{bc}\eta$ 7559	$\Xi_b D$ 7667	$\Xi_c \bar{B}$ 7747
$PB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-$	$\Xi'_{bc}\bar{K}$ 7441	$\Omega'_{bc}\eta$ 7595	$\Xi'_b D$ 7805	$\Xi'_c \bar{B}$ 7857
$PB(\frac{3}{2}^+)$, $J^P = \frac{3}{2}^-$	$\Xi^*_{bc}\bar{K}$ 7466	$\Omega^*_{bc}\eta$ 7614	$\Xi^*_b D$ 7822	$\Xi^*_c \bar{B}$ 7925
$VB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$	$\Xi_{bc}\bar{K}^*$ 7812	$\Omega_{bc}\omega$ 7791	$\Xi_b D^*$ 7807	$\Xi_c \bar{B}^*$ 7793
$VB(\frac{1}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$	$\Xi'_{bc}\bar{K}^*$ 7838	$\Omega'_{bc}\omega$ 7827	$\Xi'_b D^*$ 7945	$\Xi'_c \bar{B}^*$ 7903
$VB(\frac{3}{2}^+)$, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$	$\Xi^*_{bc}\bar{K}^*$ 7863	$\Omega^*_{bc}\omega$ 7846	$\Xi^*_b D^*$ 7962	$\Xi^*_c \bar{B}^*$ 7971

Ω_{QQ} states: Formalism

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]



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

$$\mathcal{L}_{\rm VVV} = ig\,\langle (V^\mu \partial_\nu V_\mu - \partial_\nu V^\mu V_\mu)\, V^\nu \rangle$$

Charm sector

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

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

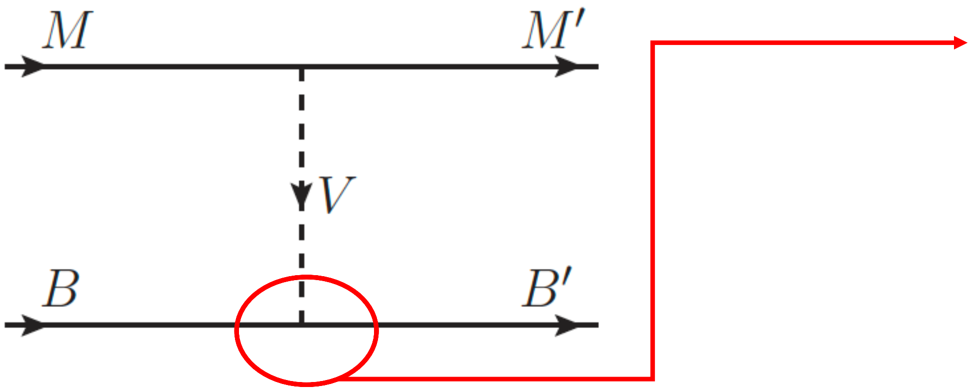
Bottom sector

$$P = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta + \frac{1}{\sqrt{6}}\eta' & \pi^+ & K^+ & B^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta + \frac{1}{\sqrt{6}}\eta' & K^0 & B^0 \\ K^- & \bar{K}^0 & -\frac{1}{\sqrt{3}}\eta + \sqrt{\frac{2}{3}}\eta' & B_s^0 \\ B^- & \bar{B}^0 & \bar{B}_s^0 & \eta_b \end{pmatrix}$$

$$V = \begin{pmatrix} \frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & \rho^+ & K^{*+} & B^{*+} \\ \rho^- & -\frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & K^{*0} & B^{*0} \\ K^{*-} & \bar{K}^{*0} & \phi & B_s^{*0} \\ B^{*-} & \bar{B}^{*0} & \bar{B}_s^{*0} & \Upsilon \end{pmatrix}$$

Ω_{QQ} *states: Formalism*

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]



$$\langle \phi^{B'}_{flavor} \chi^{B'}_{spin} | g q\bar{q} | \phi^{B}_{flavor} \chi^{B}_{spin} \rangle$$

$$\widetilde{\mathcal{L}}_{\mathrm{VBB}} \equiv g q\bar{q}(V) = g \begin{Bmatrix} \frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d}), & \rho^0 \\ \frac{1}{\sqrt{2}}(u\bar{u} + d\bar{d}), & \omega \\ s\bar{s}, & \phi \end{Bmatrix}$$

Symmetric spin-flavor wave function $\phi_{flavor} \cdot \chi_{spin}$

TABLE IV: Wave functions of baryon states.

State	I, J	flavor	spin
Ξ_{cc}^{++}	$1/2, 1/2$	ccu	$\chi_{MS}(12)$
Ξ_{cc}^{+}	$1/2, 1/2$	ccd	$\chi_{MS}(12)$
Ω_{cc}^{+}	$0, 1/2$	ccs	$\chi_{MS}(12)$
Ξ_{c}^{+}	$1/2, 1/2$	$\frac{1}{\sqrt{2}}c(us - su)$	$\chi_{MA}(23)$
Ξ_{c}^{0}	$1/2, 1/2$	$\frac{1}{\sqrt{2}}c(ds - sd)$	$\chi_{MA}(23)$
$\Xi_{c}^{\prime +}$	$1/2, 1/2$	$\frac{1}{\sqrt{2}}c(us + su)$	$\chi_{MS}(23)$
$\Xi_{c}^{\prime 0}$	$1/2, 1/2$	$\frac{1}{\sqrt{2}}c(ds + sd)$	$\chi_{MS}(23)$
Ω_{c}^{0}	$0, 1/2$	css	$\chi_{MS}(23)$

W. Roberts and M. Pervin, Int. J. Mod. Phys. A 23, 2817 (2008)

$$\chi_{MS}(12) = \frac{1}{\sqrt{6}}(\uparrow\downarrow\uparrow + \downarrow\uparrow\uparrow - 2\uparrow\uparrow\downarrow)$$

$$\chi_{MS}(23) = \frac{1}{\sqrt{6}}(\uparrow\downarrow\uparrow + \uparrow\uparrow\downarrow - 2\downarrow\uparrow\uparrow)$$

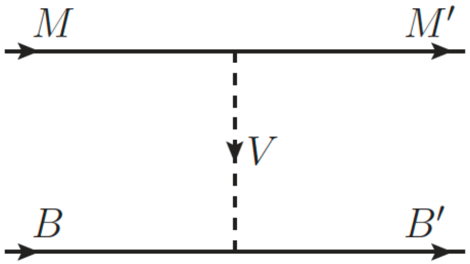
$$\chi_{MA}(23) = \frac{1}{\sqrt{2}}(\uparrow\uparrow\downarrow - \uparrow\downarrow\uparrow)$$

$$\langle \chi_{MS}(12) | \chi_{MS}(23) \rangle = -\frac{1}{2}$$

$$\langle \chi_{MS}(12) | \chi_{MA}(23) \rangle = -\frac{\sqrt{3}}{2}$$

Ω_{QQ} *states: Formalism*

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]



$$V_{ij} = -C_{ij}\,\frac{1}{4f_\pi^2}(p_1^0 + p_3^0)$$

$$\frac{1}{(q^0)^2 - |\vec{q}|^2 - m_{D^*}^2} \approx \frac{1}{(m_D - m_\eta)^2 - m_{D^*}^2}$$

TABLE V: Coefficients C_{ij} for the PB sector with $J^P = \frac{1}{2}^-$.

	$\Xi_{cc}\bar{K}$	$\Omega_{cc}\eta$	$\Xi_c D$	$\Xi_c' D$
$\Xi_{cc}\bar{K}$	2	$\frac{2\sqrt{2}}{\sqrt{3}}$	$\frac{-\sqrt{3}}{2\sqrt{2}}\lambda$	$\frac{1}{2\sqrt{2}}\lambda$
$\Omega_{cc}\eta$		0	$-\frac{1}{2}\lambda$	$\frac{-1}{2\sqrt{3}}\lambda$
$\Xi_c D$			2	0
$\Xi_c' D$				2

$$\lambda \equiv \frac{-m_V^2}{(m_D - m_\eta)^2 - m_{D^*}^2} \approx 0.25$$

TABLE IX: Coefficients C_{ij} for the PB sector with $J^P = \frac{1}{2}^-$.

	$\Omega_{bb}\eta$	$\Xi_{bb}\bar{K}$	$\Xi_b\bar{B}$	$\Xi_b'\bar{B}$
$\Omega_{bb}\eta$	0	$\frac{2\sqrt{2}}{\sqrt{3}}$	0	0
$\Xi_{bb}\bar{K}$		2	0	0
$\Xi_b\bar{B}$			2	0
$\Xi_b'\bar{B}$				2

$$\lambda = 0$$

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]

Unitarized T-matrix from coupled-channel Bethe-Salpeter equation solved through On-shell factorization:

$$T_{ij} = (1 - V_{il} G_l)^{-1} V_{lj}$$

Meson-baryon loop function

$$G_l^{\rm cut} = \int_0^{\Lambda} \frac{d^3 q}{(2\pi)^3} \frac{1}{2\omega_l(\vec{q})} \frac{M_l}{E_l(\vec{q})} \frac{1}{\sqrt{s} - \omega_l(\vec{q}) - E_l(\vec{q}) + i\epsilon}$$

Cut-off regularization method $\Lambda = 650 MeV$

Ω_{QQ} *states: Results*

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]

TABLE XVIII: The poles for Ω_{cc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-$ sector from $PB(\frac{1}{2}^+)$.

Poles		$\Xi_{cc}\bar{K}$	$\Omega_{cc}\eta$	$\Xi_c D$	$\Xi'_c D$
4069.86	g_i	**2.63**	1.55	-1.10	0.26
	$g_i G_i^{II}$	$\mathbf{-40.42}$	-13.26	3.59	-0.65
$4205.22 + i0.94$	g_i	$0.10 + i0.20$	$0.04 + i0.09$	$\mathbf{6.25 - i0.04}$	$0.09 + i0.01$
	$g_i G_i^{II}$	$-5.86 - i1.84$	$-0.57 - i1.32$	$\mathbf{-31.79 + i0.06}$	$-0.30 - i0.05$
$4310.76 + i0.28$	g_i	$0.02 + i0.01$	$-0.13 - i0.04$	$-0.02 + i0.00$	$\mathbf{6.35 + i0.00}$
	$g_i G_i^{II}$	$-0.45 + i0.64$	$3.47 - i0.96$	$0.23 - i0.01$	$\mathbf{-31.95 - i0.05}$

TABLE XXI: The poles for Ω_{cc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$ sector from $VB(\frac{3}{2}^+)$.

Poles		$\Omega^*_{cc}\omega$	$\Xi^*_{cc}\bar{K}^*$	$\Xi^*_c D^*$
4446.59	g_i	1.59	**3.93**	2.64
	$g_i G_i^{II}$	-16.03	$\mathbf{-35.31}$	-9.69
4520.38	g_i	-0.18	-0.94	**6.10**
	$g_i G_i^{II}$	2.78	12.44	$\mathbf{-29.41}$

TABLE XIX: The poles for Ω_{cc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-, \frac{3}{2}^-$ sector from $VB(\frac{1}{2}^+)$.

Poles		$\Xi_c D^*$	$\Omega_{cc}\omega$	$\Xi_{cc}\bar{K}^*$	$\Xi'_c D^*$
4332.86	g_i	**6.51**	-0.70	-1.35	-0.07
	$g_i G_i^{II}$	$\mathbf{-29.78}$	5.66	9.74	0.23
4405.47	g_i	1.27	1.41	**3.81**	0.83
	$g_i G_i^{II}$	-8.44	-15.17	$\mathbf{-35.89}$	-3.33
4446.29	g_i	-0.08	-0.32	-0.24	**6.58**
	$g_i G_i^{II}$	0.73	4.34	2.81	$\mathbf{-30.80}$

TABLE XXII: The poles for Ω_{bb} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-$ sector from $PB(\frac{1}{2}^+)$.

Poles		$\Omega_{bb}\eta$	$\Xi_{bb}\bar{K}$	$\Xi_b\bar{B}$	$\Xi'_b\bar{B}$
10741.65	g_i	1.50	**2.72**	0	0
	$g_i G_i^{II}$	-25.56	$\mathbf{-34.78}$	0	0
10864.15	g_i	0	0	**11.87**	0
	$g_i G_i^{II}$	0	0	$\mathbf{-20.43}$	0
11001.63	g_i	0	0	0	**11.87**
	$g_i G_i^{II}$	0	0	0	$\mathbf{-20.43}$

Ω_{QQ} states: Results

W. F. Wang, A. F., J. Song and E. Oset, arXiv:2208.14858 [hep-ph]

TABLE XXIII: The poles for Ω_{bb} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-, \frac{3}{2}^-$ sector from $VB(\frac{1}{2}^+)$.

Poles		$\Omega_{bb}\omega$	$\Xi_b\bar{B}^*$	$\Xi_{bb}\bar{K}^*$	$\Xi_b'\bar{B}^*$
10909.88	g_i	0	$\mathbf{11.92}$	0	0
	$g_iG_i^{II}$	0	$\mathbf{-20.35}$	0	0
11047.36	g_i	0	0	0	$\mathbf{11.92}$
	$g_iG_i^{II}$	0	0	0	$\mathbf{-20.34}$

TABLE XXVI: The poles for Ω_{bc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-$ sector from $PB(\frac{1}{2}^+)$.

Poles		$\Xi_{bc}\bar{K}$	$\Xi'_{bc}\bar{K}$	$\Omega_{bc}\eta$	$\Omega'_{bc}\eta$	Ξ_bD	$\Xi_c\bar{B}$	Ξ'_bD	$\Xi'_c\bar{B}$
7362.26	g_i	$\mathbf{2.64}$	0	1.57	0	1.70	0	0	0
	$g_iG_i^{II}$	$\mathbf{-40.41}$	0	-13.52	0	-5.35	0	0	0
7392.60	g_i	0	$\mathbf{2.61}$	0	1.51	0	0	-0.73	0
	$g_iG_i^{II}$	0	$\mathbf{-41.08}$	0	-12.83	0	0	1.81	0
$7514.32 + i2.21$	g_i	$-0.14 - i0.27$	0	$-0.05 - i0.13$	0	$\mathbf{6.19 - i0.08}$	0	0	0
	$g_iG_i^{II}$	$9.18 + i2.42$	0	$0.83 + i2.04$	0	$\mathbf{-32.11 + i0.12}$	0	0	0
7566.65	g_i	0	0	0	0	0	$\mathbf{11.50}$	0	0
	$g_iG_i^{II}$	0	0	0	0	0	$\mathbf{-20.01}$	0	0
$7641.20 + i2.26$	g_i	0	$-0.06 - i0.03$	0	$0.34 + i0.11$	0	0	$\mathbf{6.50 + i0.02}$	0
	$g_iG_i^{II}$	0	$1.60 - i1.76$	0	$-10.29 + i2.74$	0	0	$\mathbf{-32.20 - i0.41}$	0
7674.29	g_i	0	0	0	0	0	0	0	$\mathbf{11.53}$
	$g_iG_i^{II}$	0	0	0	0	0	0	0	$\mathbf{-20.05}$

TABLE XXVIII: The poles for Ω_{bc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{3}{2}^-$ sector from $PB(\frac{3}{2}^+)$.

Poles		$\Xi^*_{bc}\bar{K}$	$\Omega^*_{bc}\eta$	Ξ^*_bD	$\Xi^*_c\bar{B}$
7415.55	g_i	$\mathbf{2.63}$	1.56	1.21	0
	$g_iG_i^{II}$	$\mathbf{-40.83}$	-13.37	-3.05	0
$7667.65 + i1.40$	g_i	$-0.02 - i0.20$	$0.02 - i0.06$	$\mathbf{6.25 - i0.05}$	0
	$g_iG_i^{II}$	$6.82 + i0.98$	$0.53 + i1.88$	$\mathbf{-32.26 + i0.09}$	0
7740.93	g_i	0	0	0	$\mathbf{11.52}$
	$g_iG_i^{II}$	0	0	0	$\mathbf{-20.08}$

TABLE XXIX: The poles for Ω_{bc} along with their coupling constants (in units of MeV) to various channels in the $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$ sector from $VB(\frac{3}{2}^+)$.

Poles		$\Omega^*_{bc}\omega$	$\Xi^*_{bc}\bar{K}^*$	$\Xi^*_bD^*$	$\Xi^*_c\bar{B}^*$
7729.11	g_i	1.60	$\mathbf{3.82}$	3.54	0
	$g_iG_i^{II}$	-15.96	$\mathbf{-33.56}$	-12.92	0
7786.71	g_i	0	0	0	$\mathbf{11.61}$
	$g_iG_i^{II}$	0	0	0	$\mathbf{-19.99}$
7811.82	g_i	-0.23	-1.24	$\mathbf{5.71}$	0
	$g_iG_i^{II}$	3.72	16.77	$\mathbf{-28.48}$	0

Ω_{QQ} states: Summary

We have studied Ω_{cc}, Ω_{bc} and Ω_{bb} molecular states arising from the meson-baryon interaction with different J^P within an extension of the hidden gauge approach.

- $(C = 2, S = -1, I = 0)$ **sector**

PB($\frac{1}{2}^+$): 3 states, $J^P = \frac{1}{2}^-$
VB($\frac{1}{2}^+$): 3 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$
PB($\frac{3}{2}^+$): 2 states, $J^P = \frac{3}{2}^-$
VB($\frac{3}{2}^+$): 2 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$

- $(B = -2, S = -1, I = 0)$ **sector**

PB($\frac{1}{2}^+$): 3 states, $J^P = \frac{1}{2}^-$
VB($\frac{1}{2}^+$): 2 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$
PB($\frac{3}{2}^+$): 2 states , $J^P = \frac{3}{2}^-$
VB($\frac{3}{2}^+$): 1 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$

- $(C = 1, B = -1, S = -1, I = 0)$ **sector**

PB($\frac{1}{2}^+$): 6 states, $J^P = \frac{1}{2}^-$
VB($\frac{1}{2}^+$): 6 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-$
PB($\frac{3}{2}^+$): 3 states, $J^P = \frac{3}{2}^-$
VB($\frac{3}{2}^+$): 3 states, $J^P = \frac{1}{2}^-, \frac{3}{2}^-, \frac{5}{2}^-$

Experimental outputs for these sectors are expected to be provided by LHCb in 2y approx.

Thank you for your attention!