J. Nieves, R. Pavao and L. Tolos, Eur. Phys. J. C 78, 114 (2018)
J. Nieves, R. Pavao and L. Tolos, in preparation

Heavy (charm) excited baryons with heavy-quark spin symmetry

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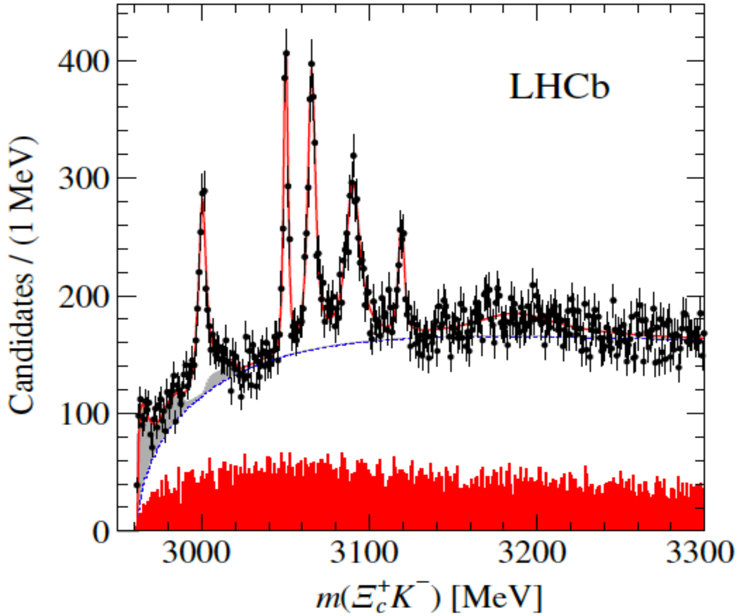
Experimental scenario and theoretical predictions

Ω_c:

- five Ω_c with masses between 3 and 3.1 GeV are detected by LHCb analyzing the $\Xi^+_c K^-$ spectrum in pp collisions   Aaij et al '17
- four of them are seen by Belle in $e^- e^+$ collisions   Yelton et al '18



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.
$\Omega_c(3188)^0$	$3188 \pm 5 \pm 13$	$60 \pm 15 \pm 11$
$\Omega_c(3066)^0_{fd}$		
$\Omega_c(3090)^0_{fd}$		
$\Omega_c(3119)^0_{fd}$		

Aaij et al '17

Ω_c Excited State	3000	3050	3066	3090	3119	3188
Yield	37.7 ± 11.0	28.2 ± 7.7	81.7 ± 13.9	86.6 ± 17.4	3.6 ± 6.9	135.2 ± 43.0
Significance	3.9σ	4.6σ	7.2σ	5.7σ	0.4σ	2.4σ
LHCb Mass	$3000.4 \pm 0.2 \pm 0.1$	$3050.2 \pm 0.1 \pm 0.1$	$3065.5 \pm 0.1 \pm 0.3$	$3090.2 \pm 0.3 \pm 0.5$	$3119 \pm 0.3 \pm 0.9$	$3188 \pm 5 \pm 13$
Belle Mass (with fixed Γ)	$3000.7 \pm 1.0 \pm 0.2$	$3050.2 \pm 0.4 \pm 0.2$	$3064.9 \pm 0.6 \pm 0.2$	$3089.3 \pm 1.2 \pm 0.2$	-	$3199 \pm 9 \pm 4$

Yelton et al '18

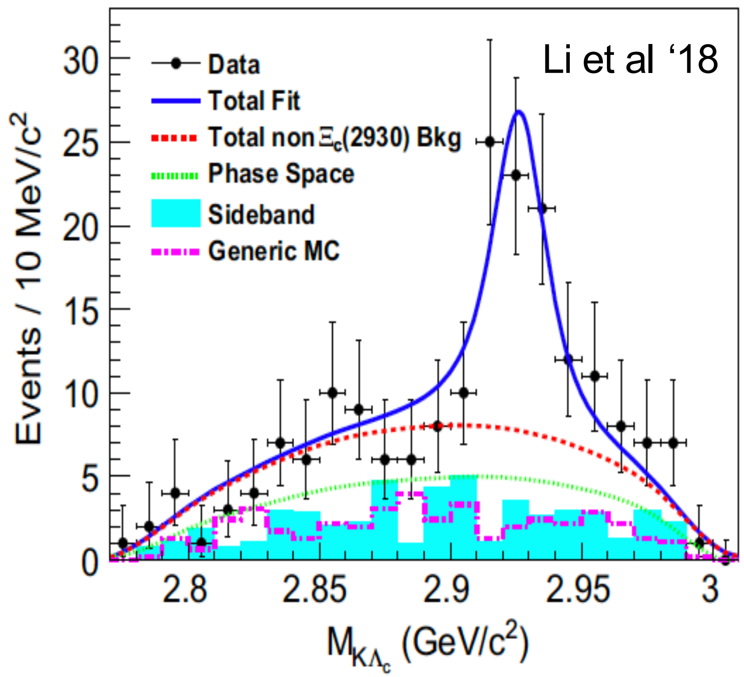
Ξ_c:

four Ξ_c states below 3 GeV

PDG

Baryon	J^P	M (MeV)	Γ (MeV)	Decay channels
$\Xi_c(2790)^+/\Xi_c(2790)^0$	$1/2^-$	2792.4 ± 0.5 / 2794.1 ± 0.5	8.9 ± 1 / 10 ± 1.1	$\Xi_c'\pi$
$\Xi_c(2815)^+/\Xi_c(2815)^0$	$3/2^-$	2816.73 ± 0.21 / 2820.26 ± 0.27	2.43 ± 0.26 / 2.54 ± 0.25	$\Xi_c'\pi$, $\Xi_c^*\pi$
$\Xi_c(2930)^+/\Xi_c(2930)^0$	?	2942 ± 5 / $2929.7^{+2.8}_{-5}$	15 ± 9 / 26 ± 8	$\Lambda_c^+ K^-$, $\Lambda_c^+ K_S^0$
$\Xi_c(2970)^+/\Xi_c(2970)^0$	?	2969.4 ± 0.8 / $2967.8^{+0.9}_{-0.7}$	$20.9^{+2.4}_{-3.5}$ / $28.1^{+3.4}_{-4}$	$\Lambda_c^+ \bar{K}\pi$, $\Sigma_c \bar{K}$, $\Xi_c 2\pi$, $\Xi_c'\pi$, $\Xi_c^*\pi$

$\Xi_c(2930)$ recently discovered in its decay to $K^-\Lambda_c^+$ in B- -> $K^- \Lambda_c^+ \bar{\Lambda}_c^-$ by Belle



Earlier predictions were reported within different approaches, but this discovery has triggered a large activity revisiting conventional quark models, QCD sum-rule schemes, quark-soliton models, lattice QCD and **molecular models**. Some recent examples of molecular models are:

Ω_c

Montana, Feijoo and Ramos '18

two states with $J=1/2^-$ identified with $\Omega_c(3050)$ and $\Omega_c(3090)$

Debastiani, Dias, Liang and Oset '18

two states with $J=1/2^-$ identified with $\Omega_c(3050)$ and $\Omega_c(3090)$, and one state $J=3/2^-$ identified with $\Omega_c(3119)$

Wang, Liu, Kang and Guo '18

identification of $1/2^-$ $\Omega_c(3118)$ as superposition of two $D\Xi$ states

Chen, Liu, Hosaka '18

prediction of $3/2^-$ $\Omega_c(3140)$ loosely bound state with large $\Xi^*_c\bar{K}$ component

Ξ_c

Yu, Pavao, Debastiani and Oset '18

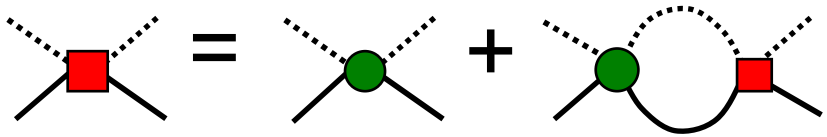
five Ξ_c states with masses around 3 GeV, that can be identified with the experimental $\Xi_c(2790)$, $\Xi_c(2930)$, $\Xi_c(2970)$, $\Xi_c(3055)$ and $\Xi_c(3080)$

Romanets, LT, Garcia-Recio, Nieves, Salcedo, Timmermans '12

Our molecular model

unitarized coupled-channel model with a $SU(6)_{lsf}$ x HQSS - extended WT meson-baryon interaction

$$V = \frac{K(s)}{4f^2} H_{\rm WT}$$



$$T_{ij} = V_{ij} + V_{il}\, G_l\, T_{lj}$$

coupling constant

$$T_{ij}(s) \simeq \frac{g_i g_j}{\sqrt{s} - \sqrt{s_R}}$$

mass and width

G_{ij} regularized with one subtraction at certain scale

Ω_c : C=1, S=-2, I=0

M_R	Γ_R	Couplings to main channels	J
2810.9	0.0	$g_{\Xi D} = 3.3$, $g_{\Xi D^*} = 1.7$, $g_{\Xi_c \bar{K}^*} = 0.9$, $g_{\Xi^* D^*} = 4.8$, $g_{\Omega_c \eta'} = 0.9$, $g_{\Omega D_s^*} = 4.2$	1/2
2814.3	0.0	$g_{\Xi D^*} = 3.7$, $g_{\Xi^* D} = 3.1$, $g_{\Xi^* D^*} = 3.8$, $g_{\Omega D_s} = 2.7$, $g_{\Omega_c^* \eta'} = 0.9$, $g_{\Omega D_s^*} = 3.4$	3/2
2884.5	0.0	$g_{\Xi_c \bar{K}} = 2.1$, $g_{\Xi D^*} = 1.7$, $g_{\Xi_c' \bar{K}^*} = 1.5$, $g_{\Xi_c^* \bar{K}^*} = 1.8$, $g_{\Omega_c \phi} = 0.9$, $g_{\Omega_c^* \phi} = 1.1$	1/2
2941.6	0.0	$g_{\Xi_c' \bar{K}} = 1.9$, $g_{\Xi D} = 1.5$, $g_{\Omega_c \eta} = 1.7$, $g_{\Xi_c \bar{K}^*} = 1.4$, $g_{\Xi_c' \bar{K}^*} = 1.1$, $g_{\Omega_c \phi} = 1.0$, $g_{\Omega D_s^*} = 0.9$	1/2
2980.0	0.0	$g_{\Xi_c^* \bar{K}} = 1.9$, $g_{\Omega_c^* \eta} = 1.6$, $g_{\Xi D^*} = 1.4$, $g_{\Xi_c \bar{K}^*} = 1.6$, $g_{\Xi_c^* \bar{K}^*} = 1.3$, $g_{\Omega_c^* \phi} = 1.2$	3/2

Ξ_c : C=1, S=-1, I=1/2

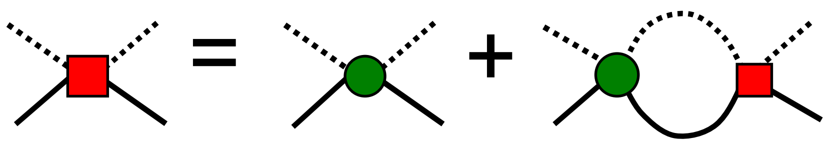
M_R	Γ_R	Couplings to main channels	Status PDG	J
2702.8	177.8	$g_{\Xi_c \pi} = \mathbf{2.4}$, $g_{\Lambda D} = 1.2$, $g_{\Sigma D} = 1.1$, $g_{\Lambda D^*} = 2.1$, $g_{\Sigma D^*} = 1.7$, $g_{\Xi D_s^*} = 1.1$		1/2
2699.4	12.6	$g_{\Xi_c \pi} = \mathbf{0.8}$, $g_{\Lambda D} = 1.2$, $g_{\Sigma D} = 3.4$, $g_{\Lambda D^*} = 2.2$, $g_{\Sigma D^*} = 5.4$, $g_{\Xi D_s} = 1.9$, $g_{\Xi_c \eta'} = 1.0$, $g_{\Xi D_s^*} = 3.3$		1/2
2733.0	2.2	$g_{\Xi_c' \pi} = \mathbf{0.5}$, $g_{\Lambda D} = 1.9$, $g_{\Sigma D} = 1.8$, $g_{\Lambda D^*} = 0.9$, $g_{\Sigma D^*} = 1.2$, $g_{\Xi D_s} = 1.2$, $g_{\Sigma^* D^*} = 5.8$, $g_{\Xi_c' \eta'} = 0.9$, $g_{\Xi^* D_s^*} = 3.3$		1/2
2734.3	0.0	$g_{\Lambda D^*} = 2.2$, $g_{\Sigma D^*} = 2.1$, $g_{\Sigma^* D} = 3.6$, $g_{\Sigma^* D^*} = 4.6$, $g_{\Xi D_s^*} = 1.3$, $g_{\Xi^* D_s} = 2.1$, $g_{\Xi^* D_s^*} = 2.6$		3/2
2775.4	0.6	$g_{\Xi_c \pi} = \mathbf{0.1}$, $g_{\Xi_c' \pi} = \mathbf{0.1}$, $g_{\Lambda_c \bar{K}} = 1.4$, $g_{\Xi_c \eta} = 0.9$, $g_{\Lambda D^*} = 1.0$, $g_{\Sigma D^*} = 1.4$, $g_{\Sigma_c \bar{K}^*} = 1.0$, $g_{\Sigma_c^* \bar{K}^*} = 1.3$		1/2
2772.9	83.7	$g_{\Xi_c \pi} = \mathbf{0.1}$, $g_{\Xi_c' \pi} = \mathbf{2.3}$, $g_{\Sigma_c \bar{K}} = 1.2$, $g_{\Lambda D} = 2.1$, $g_{\Lambda D^*} = 1.5$, $g_{\Omega_c K} = 0.9$, $g_{\Sigma D^*} = 0.9$, $g_{\Xi_c \rho} = 1.0$, $g_{\Sigma_c \bar{K}^*} = 0.9$, $g_{\Xi_c' \rho} = 1.0$, $g_{\Sigma^* D^*} = 1.4$, $g_{\Xi^* D_s^*} = 1.1$		1/2
2819.7	32.4	$g_{\Xi_c^* \pi} = \mathbf{1.9}$, $g_{\Sigma_c^* \bar{K}} = 2.3$, $g_{\Lambda D^*} = 2.0$, $g_{\Lambda_c \bar{K}^*} = 1.0$, $g_{\Xi_c^* \eta} = 1.1$, $g_{\Sigma D^*} = 1.2$, $g_{\Xi_c \rho} = 1.1$, $g_{\Sigma_c \bar{K}^*} = 1.0$, $g_{\Sigma_c^* \bar{K}^*} = 2.0$		3/2
2804.8	20.7	$g_{\Xi_c' \pi} = \mathbf{1.1}$, $g_{\Sigma_c \bar{K}} = 2.4$, $g_{\Lambda D} = 1.5$, $g_{\Sigma D} = 1.2$, $g_{\Xi_c' \eta} = 1.3$, $g_{\Lambda_c \bar{K}^*} = 1.2$, $g_{\Sigma D^*} = 0.9$, $g_{\Sigma_c \bar{K}^*} = 1.8$, $g_{\Sigma^* D^*} = 1.1$, $g_{\Sigma_c^* \bar{K}^*} = 1.0$, $g_{\Xi^* D_s^*} = 1.2$	$\Xi_c(2790)$ ***	1/2
2845.2	44.0	$g_{\Xi_c^* \pi} = \mathbf{1.9}$, $g_{\Sigma_c^* \bar{K}} = 2.1$, $g_{\Lambda D^*} = 2.6$, $g_{\Lambda_c \bar{K}^*} = 1.4$, $g_{\Xi_c^* \eta} = 1.2$, $g_{\Sigma D^*} = 1.2$, $g_{\Xi_c \rho} = 0.9$, $g_{\Sigma_c \bar{K}^*} = 0.9$, $g_{\Sigma_c^* \bar{K}^*} = 1.7$, $g_{\Xi^* D_s} = 0.9$, $g_{\Xi^* D_s^*} = 1.1$	$\Xi_c(2815)$ ***	3/2

Romanets, LT, Garcia-Recio, Nieves, Salcedo, Timmermans '12

Our molecular model

unitarized coupled-channel model with a $SU(6)_{lsf}$ x HQSS - extended WT meson-baryon interaction

$$V = \frac{K(s)}{4f^2} H_{\mathrm{WT}}$$



$T_{ij} = V_{ij} + V_{il}\, G_l\, T_{lj}$

coupling constant

$$T_{ij}(s) \simeq \frac{g_i g_j}{\sqrt{s} - \sqrt{s_R}}$$

mass and width

G_{ij} regularized with one subtraction at certain scale

Ω_c : C=1, S=-2, I=0

M_R	Γ_R	Couplings to main channels	J
2810.9	0.0	[illegible] = 3.3, [illegible] = 1.7, [illegible] = 0.9, [illegible] = 4.8,	1/2
2814.3	0.0	[illegible] 2.7,	3/2
2884.5	0.0	[illegible] 1.8,	1/2
2941.6	0.0	[illegible] 1.4,	1/2
2980.0	0.0	[illegible] 1.6,	3/2

too low in mass to be identified experimentally

Ξ_c : C=1, S=-1, I=1/2

M_R	Γ_R	Couplings to main channels	Status PDG	J
2702.8	177.8	$g_{\Xi_c\pi} = \mathbf{2.4}$, $g_{\Lambda D} = 1.2$, $g_{\Sigma D} = 1.1$, $g_{\Lambda D^*} = 2.1$, $g_{\Sigma D^*} = 1.7$, $g_{\Xi D_s^*} = 1.1$		1/2
2699.4	12.6	$g_{\Xi_c\pi} = \mathbf{0.8}$, $g_{\Lambda D} = 1.2$, $g_{\Sigma D} = 3.4$, $g_{\Lambda D^*} = 2.2$, $g_{\Sigma D^*} = 5.4$, $g_{\Xi D_s} = 1.9$, $g_{\Xi_c\eta'} = 1.0$, $g_{\Xi D_s^*} = 3.3$		1/2
2733.0	[illegible]2.2			1/2
2734.3	[illegible].0			3/2
2775.4	[illegible]6			1/2
2772.9	8[illegible].7			1/2
2819.7	3[illegible].4	[illegible], $g_{\Lambda_c\bar{K}^*} = 1.0$, $g_{\Xi_c^*\eta} = 1.1$, $g_{\Sigma D^*} = 1.2$, $g_{\Xi_c\rho} = 1.1$, $g_{\Sigma_c\bar{K}^*} = 1.0$, $g_{\Sigma_c^*\bar{K}^*} = 2.0$		3/2
2804.8	[illegible]0.7	$g_{\Xi_c'\pi} = \mathbf{1.1}$, $g_{\Sigma_c\bar{K}} = 2.4$, $g_{\Lambda D} = 1.5$, $g_{\Sigma D} = 1.2$, $g_{\Xi_c'\eta} = 1.3$, $g_{\Lambda_c\bar{K}^*} = 1.2$, $g_{\Sigma D^*} = 0.9$, $g_{\Sigma_c\bar{K}^*} = 1.8$, $g_{\Sigma^* D^*} = 1.1$, $g_{\Sigma_c^*\bar{K}^*} = 1.0$, $g_{\Xi^* D_s^*} = 1.2$	$\Xi_c(2790)$ ***	1/2
2845.2	44.0	$g_{\Xi_c^*\pi} = \mathbf{1.9}$, $g_{\Sigma_c^*\bar{K}} = 2.1$, $g_{\Lambda D^*} = 2.6$, $g_{\Lambda_c\bar{K}^*} = 1.4$, $g_{\Xi_c^*\eta} = 1.2$, $g_{\Sigma D^*} = 1.2$, $g_{\Xi_c\rho} = 0.9$, $g_{\Sigma_c\bar{K}^*} = 0.9$, $g_{\Sigma_c^*\bar{K}^*} = 1.7$, $g_{\Xi^* D_s} = 0.9$, $g_{\Xi^* D_s^*} = 1.1$	$\Xi_c(2815)$ ***	3/2

too low in mass, only two might be identifed experimentally

Regularization schemes (RS) of the loop function

$$G_i(s) = i2M_i \int \frac{d^4q}{(2\pi)^4} \frac{1}{q^2 - m_i^2 + i\epsilon} \frac{1}{(P-q)^2 - M_i^2 + i\epsilon}$$

$$G_i(s) = \overline{G}_i(s) + G_i(s_{i+}) \quad \text{with} \quad s_{i+} = (m_i + M_i)^2$$

One-subtraction regularization
(one subtraction at certain scale)

$$G_i(\sqrt{s} = \mu) = 0$$

$$G_i^{\mu}(s) = \overline{G}_i(s) - \overline{G}_i(\mu^2)$$

Common cutoff regularization
(use of a common UV cutoff)

$$G_i^{\Lambda}(s) = \overline{G}_i(s) + G_i^{\Lambda}(s_{i+})$$

Note that using channel-dependent cutoffs, the one-subtraction regularization scheme is recovered by choosing Λ_i in each cannel such that

$$G_i^{\Lambda_i}(s_{i+}) = -\overline{G}_i(\mu^2)$$

We need to explore the impact of different RS in a control manner: **employ common UV cutoff within reasonable limits**

first we determine how masses (and widths) of the states change as we adiabatically vary the subtraction constants

$$G_i(s) = \overline{G}_i(s) - (1-x)\overline{G}_i(\mu^2) + x G_i^{\Lambda}(s_{i+})$$

$$x \text{ changes from } 0 \text{ to } 1$$

- two J=1/2⁻ and one J=3/2⁻ can be identified with three experimental states due to closeness in energy and also because of the important contribution of the experimental channels $\Xi'_c\overline{K}$, $\Xi_c\overline{K}$ to their dynamical generation

- need to assess the cutoff dependence of our results

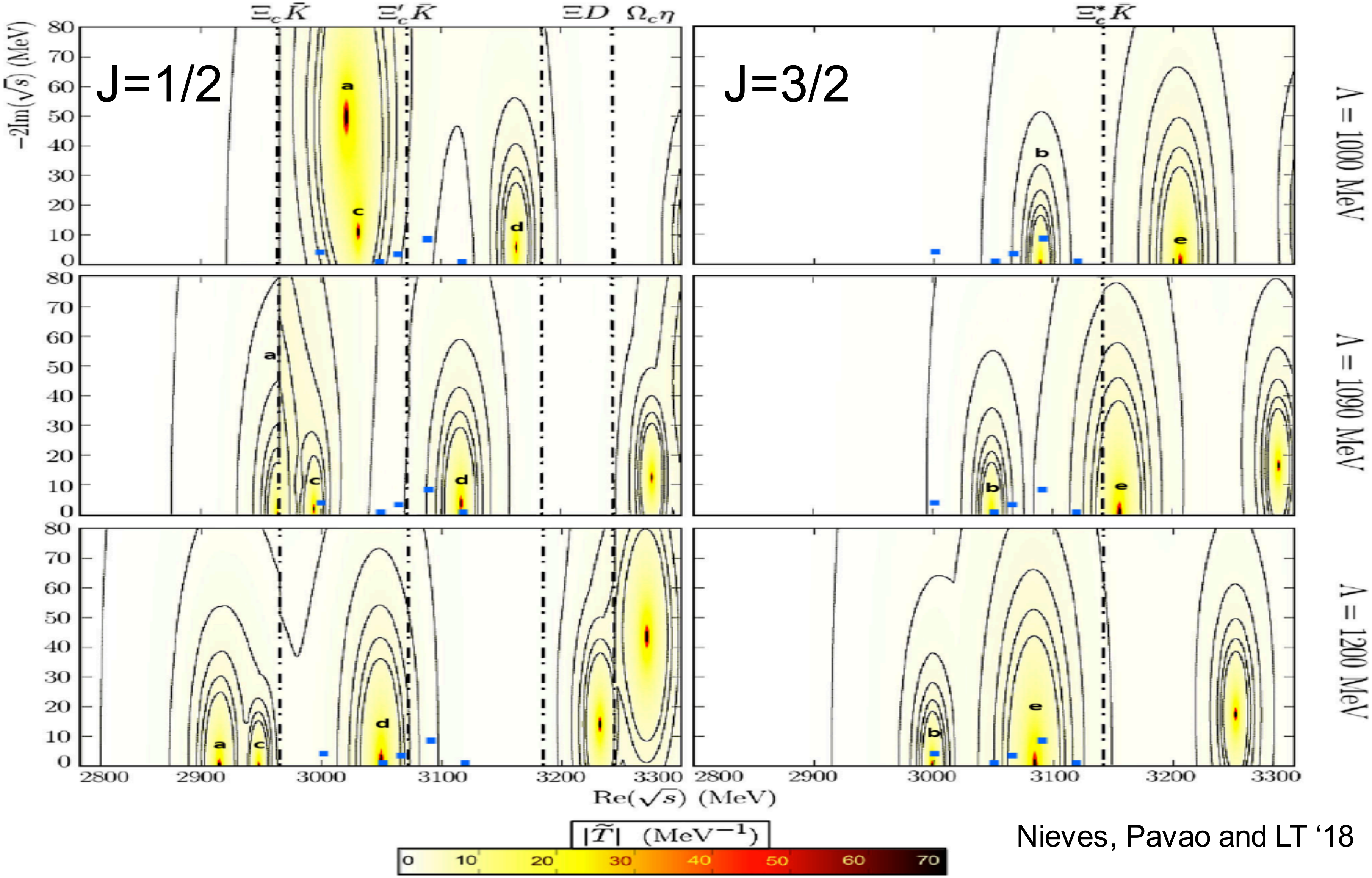
Ω_c : C=1, S=-2, I=0

$\Lambda = 1090$ 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/ 3090.2	1.1/ 8.7
e	3155.37	0.17	3/2	–	–

Nieves, Pavao and LT ‘18

Ω_c : C=1, S=-2, I=0



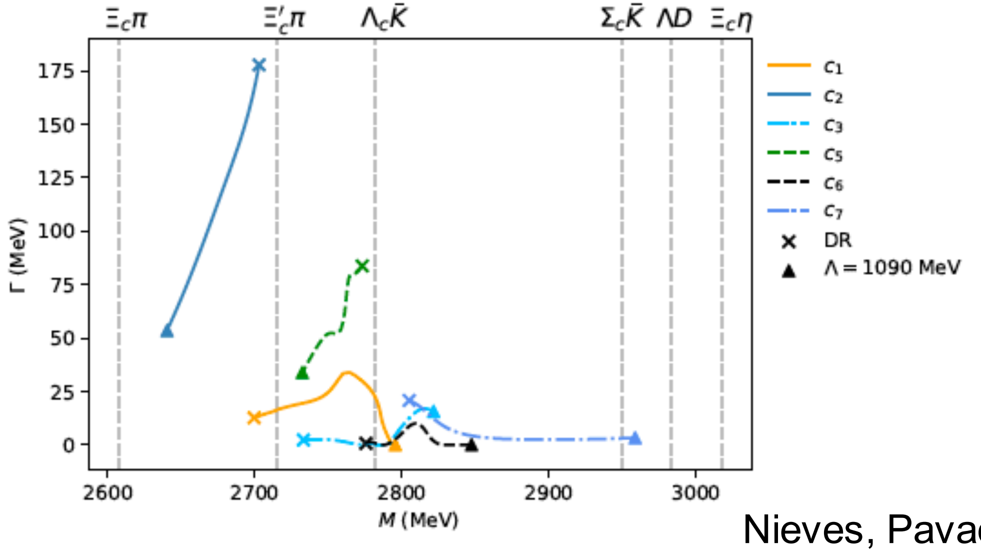
Nieves, Pavao and LT '18

- for Λ<1000 MeV or Λ>1300 MeV no identification is possible
- a maximum number of three states can be identified

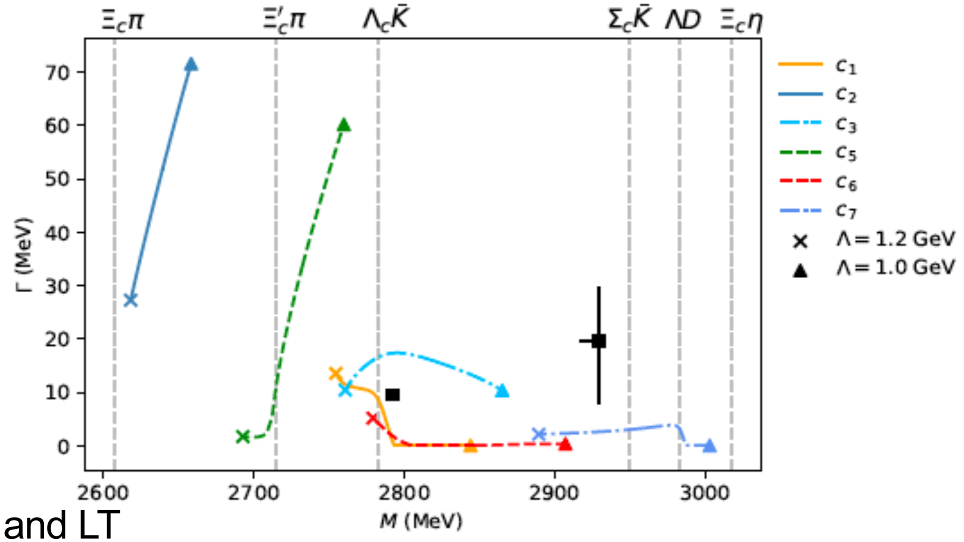
Ξ_c : C=1, S=-1, I=1/2

from one-subtraction regularization (DR) to common UV cutoff

assessing dependence on common UV cutoff

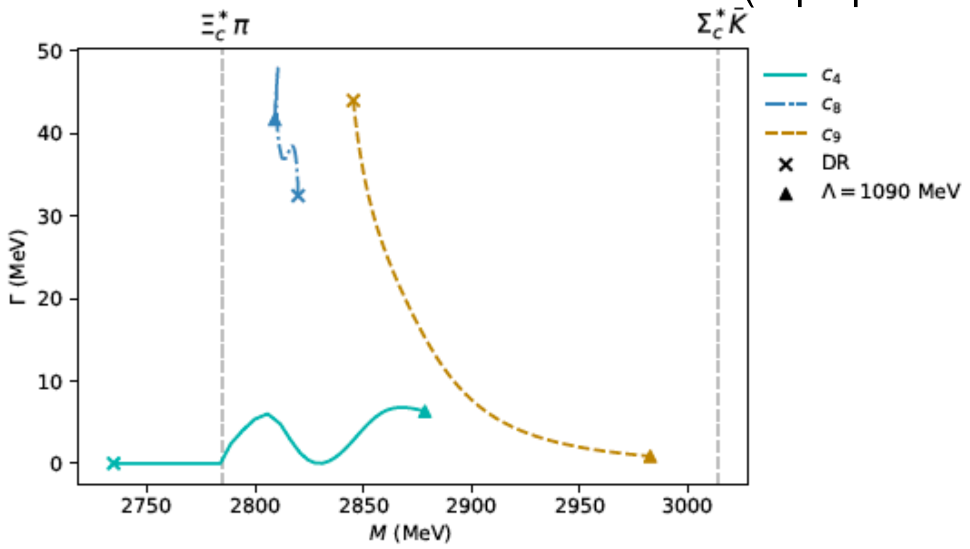


(a) $J = 1/2$

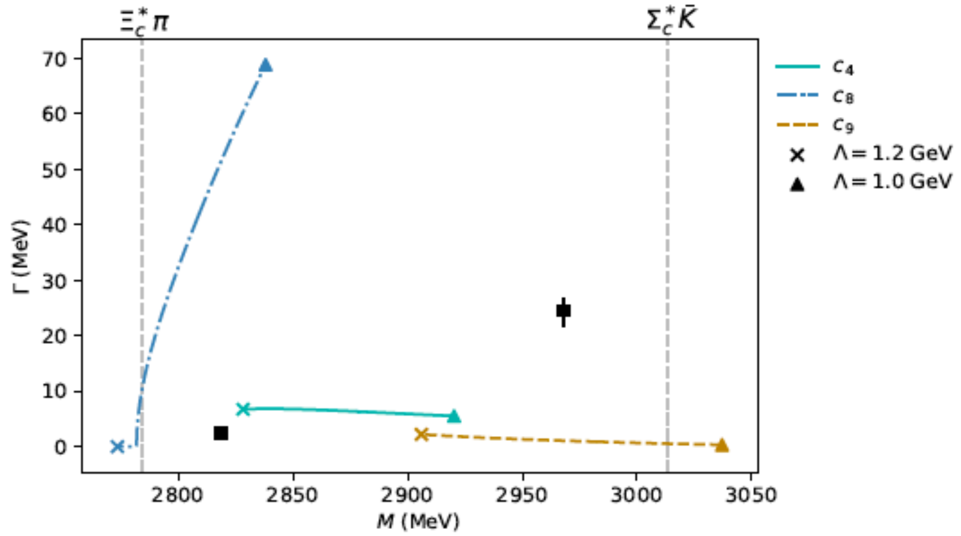


(a) $J = 1/2$

Nieves, Pavao and LT
(in preparation)



(b) $J = 3/2$



(b) $J = 3/2$

Ξ_c : C=1, S=-1, I=1/2

$\Lambda = 1150$ MeV

Irreps	State	M_R (MeV)	Γ_R (MeV)	J	Couplings
$(\mathbf{168}, \mathbf{21}_{2,1}, \mathbf{3}^*_2)$	c_1	2773.59	10.52	1/2	$g_{\Xi_c\pi} = 0.53$, $g_{\Xi'_c\pi} = 0.32$, $g_{\Lambda_c K} = 1.3$, $g_{\Sigma_c K} = 0.92$, $g_{\Lambda D} = 1.6$, $g_{\Sigma D} = 1.5$, $g_{\Lambda D^*} = 2.9$, $g_{\Sigma D^*} = 1.0$, $g_{\Xi'_c\rho} = 1.$, $g_{\Lambda_c K^*} = 0.23$
$(\mathbf{168}, \mathbf{15}_{2,1}, \mathbf{6}_2)$	c_2	2627.5	38.84	1/2	$g_{\Xi_c\pi} = 1.8$, $g_{\Xi'_c\pi} = 0.04$, $g_{\Lambda_c K} = 1.2$, $g_{\Sigma_c K} = 0.09$, $g_{\Lambda_c K^*} = 0.04$, $g_{\Sigma D} = 1.2$, $g_{\Lambda D^*} = 1.$, $g_{\Sigma D^*} = 1.9$
$(\mathbf{168}, \mathbf{21}_{2,1}, \mathbf{6}_2)$	c_3^*	2791.24	17.31	1/2	$g_{\Xi_c\pi} = 0.37$, $g_{\Xi'_c\pi} = 0.8$, $g_{\Lambda_c K} = 0.26$, $g_{\Sigma_c K} = 1.6$, $g_{\Sigma D} = 2.6$, $g_{\Lambda D^*} = 2.7$, $g_{\Xi'_c\eta} = 1.$, $g_{\Lambda_c \bar{K}^*} = 1.1$, $g_{\Sigma D^*} = 2.5$, $g_{\Xi D_s^*} = 1.8$
$(\mathbf{168}, \mathbf{21}_{2,1}, \mathbf{6}_4)$	c_4	2850.89	6.76	3/2	$g_{\Xi_c^*\pi} = 0.57$, $g_{\Sigma_c^*\bar{K}} = 2.2$, $g_{\Lambda_c \bar{K}^*} = 1.5$, $g_{\Xi_c^*\eta} = 1.1$, $g_{\Sigma^* D} = 1.1$, $g_{\Sigma^* D^*} = 1.5$, $g_{\Sigma_c^* barK^*} = 1.8$
$(\mathbf{168}, \mathbf{15}_{2,1}, \mathbf{3}^*_2)$	c_5	2715.23	12.28	1/2	$g_{\Xi_c\pi} = 0.21$, $g_{\Xi'_c\pi} = 1.8$, $g_{\Lambda_c K} = 0.49$, $g_{\Sigma_c K} = 1.2$, $g_{\Lambda D} = 3.1$, $g_{\Lambda_c \bar{K}^*} = 0.07$, $g_{\Sigma D} = 1.5$
$(\mathbf{120}, \mathbf{21}_{2,1}, \mathbf{3}^*_2)$	c_6^*	2806.89	0	1/2	– **R.S. not connected** –
$(\mathbf{120}, \mathbf{21}_{2,1}, \mathbf{6}_2)$	c_7	2922.5	2.48	1/2	$g_{\Xi_c\pi} = 0.15$, $g_{\Xi'_c\pi} = 0.03$, $g_{\Lambda_c K} = 0.16$, $g_{\Sigma_c K} = 0.06$, $g_{\Lambda D} = 1.8$, $g_{\Sigma D} = 1.4$, $g_{\Lambda D^*} = 1.7$, $g_{\Lambda_c K^*} = 1.2$, $g_{\Sigma D^*} = 1.5$, $g_{\Xi_c\rho} = 1.2$, $g_{\Sigma^* D^*} = 3.7$, $g_{\Sigma_c K^*} = 1.1$, $g_{\Xi_c^*\rho} = 1.$, $g_{\Xi^* D_s^*} = 1.9$
$(\mathbf{168}, \mathbf{15}_{2,1}, \mathbf{3}^*_4)$	c_8	2792.06	22.79	3/2	$g_{\Xi_c^*\pi} = 1.7$, $g_{\Sigma_c^*\bar{K}} = 1.$, $g_{\Lambda D^*} = 2.4$, $g_{\Sigma D^*} = 1.2$, $g_{\Lambda_c \bar{K}^*} = 0.23$
$(\mathbf{120}, \mathbf{21}_{2,1}, \mathbf{6}_4)$	c_9	2942.05	1.46	3/2	$g_{\Xi_c^*\pi} = 0.2$, $g_{\Sigma_c^*\bar{K}} = 0.19$, $g_{\Lambda_c \bar{K}^*} = 0.4$, $g_{\Lambda D^*} = 2.7$, $g_{\Sigma D^*} = 2.2$, $g_{\Sigma^* D} = 2.8$, $g_{\Sigma^* D^*} = 3.4$, $g_{\Xi^* D_s} = 1.4$, $g_{\Xi^* D_s^*} = 1.8$

Nieves, Pavao and LT (in preparation)

Experimental identification based on energy position and couplings

$\Xi_c(2790)$: c_1, c_3 or c_6 (coupling to $\Xi'_c\pi$), different assignment using DR

$\Xi_c(2930)$: c_7 (assuming 1/2- and given coupling to $\Lambda_c\bar{K}$)

$\Xi_c(2815)$: c_4 or c_8 (coupling to $\Xi^*_c\pi$), different assignment using DR

$\Xi_c(2970)$: c_9 (assuming 3/2-) and given coupling to $\Lambda_c\bar{K}^* \rightarrow \Lambda_c\bar{K}\pi$ and $\Xi^*_c\pi \rightarrow \Xi_c\pi\pi$)

Experimental identification based on $SU(3)_{2J+1}$ classification of Λ_c and Ξ_c

$\Xi_c(2815)$

- Considering $\Lambda_c(2625)$* and c_8 SU(3) siblings with 1- ldof ($\Sigma^*_c \pi$/ $\Xi^*_c \pi$)
- Taking $\Xi_c(2815)$ as **c_8 state** with mixing of c_4 to obtain Γ=2-3 MeV,

then $\Xi_c(2815)$ and $\Lambda_c(2625)$* SU(3) siblings (same 3^*_4 multiplet)

$\Xi_c(2790)$

- Considering $\Lambda_c(2625)$* HQSS partner of $\Lambda_c(2595)$ (wide), then partner of c_5
- Assuming $\Xi_c(2815)$ is the HQSS partner of $\Xi_c(2790)$, then $\Xi_c(2790)$ is

c_5 state with mixing with c_3 and c_6 to reduce the decay width (3_2 multiplet)

$\Xi_c(2930)$ and $\Xi_c(2970)$

Taking $\Xi_c(2930)$ and $\Xi_c(2970)$ our **c_7 and c_9 states** (assuming 1/2- and 3/2-), then $\Xi_c(2930)$ and $\Xi_c(2970)$ HQSS partners (6_2 and 6_4 multiplets)

$\Xi_c(2790)$ 1/2- and $\Xi_c(2815)$ 3/2- HQSS partners
$\Xi_c(2930)$ (assuming 1/2-) and $\Xi_c(2970)$ (assuming 3/2-) HQSS partners

$\Xi_c(2930)$ and $\Omega_c(3090)$ SU(3) siblings (same 6_2 multiplet) with **$\Sigma_c(2800)$ (?)**
$\Xi_c(2970)$ and $\Omega_c(3119)$ (!!) SU(3) siblings (same 6_4 multiplet) with **$\Sigma_c(2800)$(?)**

* assuming $\Lambda_c(2625)$ is a molecular state

Comparison with recent molecular models

Ω_c : C=1, S=-2, I=0

Montana, Feijoo and Ramos '18

- t-channel vector meson exchange between $1/2^+$ baryons and $0^-,1^-$ mesons
- two states with $J=1/2^-$ identified with $\Omega_c(3050)$ and $\Omega_c(3090)$

Debastiani, Dias, Liang and Oset '18

- local hidden gauge model with $1/2^+,3/2^+$ baryons and $0^-,1^-$ vector mesons
- two states with $J=1/2^-$ identified with $\Omega_c(3050)$ and $\Omega_c(3090)$, and one state $J=3/2^-$ identified with $\Omega_c(3119)$

our model identifies $J=1/2^-$ $\Omega_c(3000)$, $\Omega_c(3119/3090)$ and $J=3/2^-$ $\Omega_c(3050)$ for Λ=1090 MeV due to a different regularization scheme and different interaction matrices (in particular for D, D* and light vector mesons)

Wang, Liu, Kang and Guo '18

identification of $1/2^-$ $\Omega_c(3118)$ as superposition of two Ξ D states

Chen, Liu, Hosaka '18

prediction of $3/2^-$ $\Omega_c(3140)$ loosely bound state with large $\Xi^*_c\bar{K}$ component

no identification is possible in our model: $\Omega_c(3118)$ comes from less attractive representation and $\Omega_c(3140)$ is not seen as we incorporate $\Xi^{(*)}$ $D^{(*)}$

Comparison with recent molecular models

Ξ_c : C=1, S=-1, I=1/2

Yu, Pavao, Debastiani and Oset '18

- local hidden gauge model with $1/2^+$,$3/2^+$ baryons and 0^-,1^- vector mesons
- five Ξ_c states with masses around 3 GeV, that can be identified with the experimental Ξ_c(2790), Ξ_c(2930), Ξ_c(2970), Ξ_c(3055) and Ξ_c(3080)
- whereas Ξ_c(2790) is obtained with 1/2-, Ξ_c(2930), Ξ_c(2970), Ξ_c(3055) and Ξ_c(3080) can be either 1/2- or 3/2- states

our model identifies
(Ξ_c(2790) 1/2- , Ξ_c(2815) 3/2-) and
(Ξ_c(2930) 1/2- , Ξ_c(2970) 3/2-) as HQSS partners

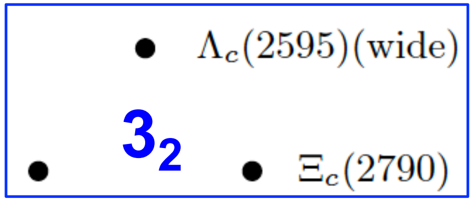
the differences are due to a different regularization scheme and different interaction matrices (in particular for D, D* and light vector mesons)

Summary

We study charm excited baryons (Ω_c and Ξ_c), where several excited states with masses around 3 GeV have been observed.

We use a unitarized coupled-channel approach with a $SU(6)_{lsf}$ x HQSS - extended WT meson-baryon interaction and analyze the dependence on the regularization scheme, and in particular on the common UV cutoff

We find that a maximum number of three Ω_c states can be identified experimentally, whereas the experimental ($\Xi_c(2790)$ 1/2-, $\Xi_c(2815)$ 3/2-) and ($\Xi_c(2930)$ 1/2- , $\Xi_c(2970)$ 3/2-) are found to be HQSS partners



SU(3) classification