Excited baryons in the extended SU(3) chiral quark-soliton model

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Physics for excited baryons

- Confinement & Chiral symmetry with its spontaneous breaking
- Relativistic Quantum field theory should be used for excited baryons ($q\bar{q}$ excitations).
- Vector, Axial-vector, and tensor mean fields for higher-lying excited states
- Question: How can one incorporate them to describe excited baryons?

Puzzles in excited baryon spectra

- Missing Resonances: Too many resonances were predicted. Additional symmetries?
- Mass orderings: N*(1440) & N*(1535), N*(1520)(3/2-) & N*(1535)(1/2-)
- Broad widths: Large coupling constants.
- Question: How can one resolve these puzzles?

Chiral quark-soliton model

Merits of the chiral quark-soliton model

- Fully relativistic field theoretic model.
- Related to QCD via the Instanton vacuum.
- Renormalisation scale is naturally given.
  $1/\rho \approx 600\,\mathrm{MeV}$
- All relevant parameters were fixed already.

$$\mathcal{Z}_{\chi\mathrm{QSM}} = \int \mathcal{D}U \exp(-S_{\mathrm{eff}})$$

$$S_{\mathrm{eff}} = -N_c \mathrm{Tr} \ln D(U)$$

HChK et al. Prog. Part. Nucl. Phys. Vol.37, 91 (1996)

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$$H(U) = -i\gamma_4\gamma_i\partial_i + \gamma_4 M U^{\gamma_5}$$

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$$D(U) = \partial_4 + H(U) + \hat{m}$$

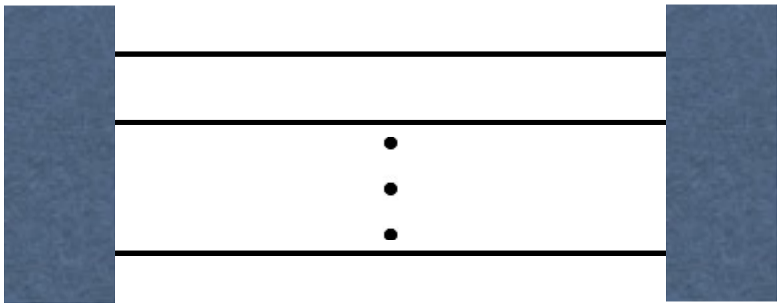
$$\hat{m} = \mathrm{diag}(m_u, m_d, m_s)\gamma_4$$

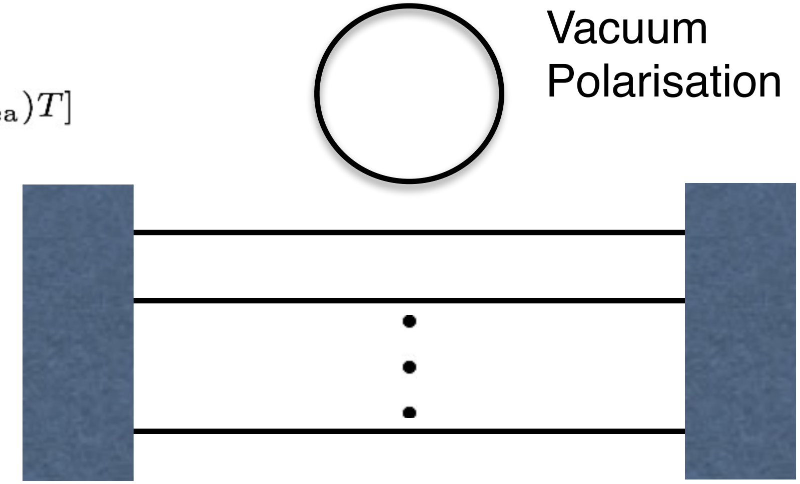
HChK et al. Prog. Part. Nucl. Phys. Vol.37, 91 (1996)

Chiral quark–soliton model

Classical solitons

$$\langle J_N(\vec{x},T)J_N^\dagger(\vec{y},-T)\rangle_0 \sim \Pi_N(T) \sim e^{-[(N_c E_{\rm val}+E_{\rm sea})T]}$$



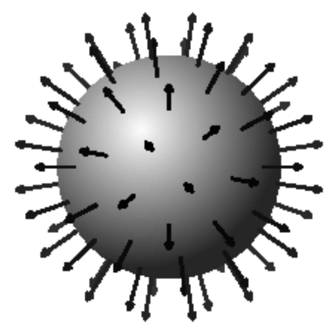


Vacuum Polarisation

$$\frac{\delta}{\delta U}(N_c E_{\rm val} + E_{\rm sea}) = 0 \;\rightarrow\; M_{\rm cl} = N_c E_{\rm val}(U_c) + E_{\rm sea}(U_c)$$

Hedgehog Ansatz:

$$U_{\rm SU(2)} \;=\; \exp\left[i\gamma_5 \mathbf{n}\cdot\boldsymbol{\tau} P(r)\right]$$



hedgehog

HChK et al. Prog. Part. Nucl. Phys. Vol.95, (1995)

Chiral quark-soliton model

Collective (Zero-mode) quantisation

$$U_0 = \begin{bmatrix} e^{i\vec{n}\cdot\vec{\tau}P(r)} & 0 \\ 0 & 1 \end{bmatrix}$$

Zero-mode quantisation

$$U(\boldsymbol{x},t) = R(t)U_c(\boldsymbol{x}-\boldsymbol{Z}(t))R^\dagger(t)$$

$$\int DU[\cdots] \to \int DADZ[\cdots]$$

$$\Rightarrow \quad \mathcal{L} = -M_{sol} + \frac{I_1}{2}\sum_{i=1}^{3}{\Omega_i}^2 + \frac{I_2}{2}\sum_{i=4}^{7}{\Omega_i}^2 + \frac{N_c}{2\sqrt{3}}\Omega_8$$

HChK et al. Prog. Part. Nucl. Phys. Vol.95, (1995)

Extended XQSM

Extended effective chiral action

- **How to incorporate quark confinement**

$$S_{\rm eff} = -N_c \mathrm{Trlog}\left[i\partial\!\!\!/ + i\hat{m} + iM(r)U^{\gamma_5}\right]$$

[D. Diakonov, V. Petrov, and A. Vladimirov, Phys. Rev. D 88, 074030 (2013)]

Extended effective chiral action

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$$S_{\rm eff} = -N_c \mathrm{Tr}\log\left[i\partial\!\!\!/ + i\hat{m} + iM(r)U^{\gamma_5}\right]$$

$$M(r)U^{\gamma_5}(r) = S(r)\left[\cos P(r) + i\gamma_5 \tau\cdot\mathbf{n}\sin P(r)\right]$$

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$S(r)$ Confining background (mean) field

$P(r)$ Pion background (mean) field

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$S(r)$ Confining background (mean) field

$P(r)$ Pion background (mean) field

The confining and pion fields are non-linearly coupled within **hedgehog Ansatz**.

[D. Diakonov, V. Petrov, and A. Vladimirov, Phys. Rev. D 88, 074030 (2013)]

Hedgehog symmetry and mean field

Collective (Zero-mode) quantisation

$$U_0 = \begin{bmatrix} e^{i\vec{n}\cdot\vec{\tau}\,P(r)} & 0 \\ 0 & 1 \end{bmatrix} \quad \mathrm{SU(3)_f} \otimes \mathrm{O(3)_{space}} \to \mathrm{SU(2)_{iso+space}}$$

- Breaking of this higher symmetry will reduce the number of baryon states!
- We keep the zero-mode quantization for the moment.
- For excited states, meson loops should come into play. (**beyond the zero modes. Future works**)
- Vector and axial-vector, and tensor mean fields should be considered! **(Future works)**

Confining background field

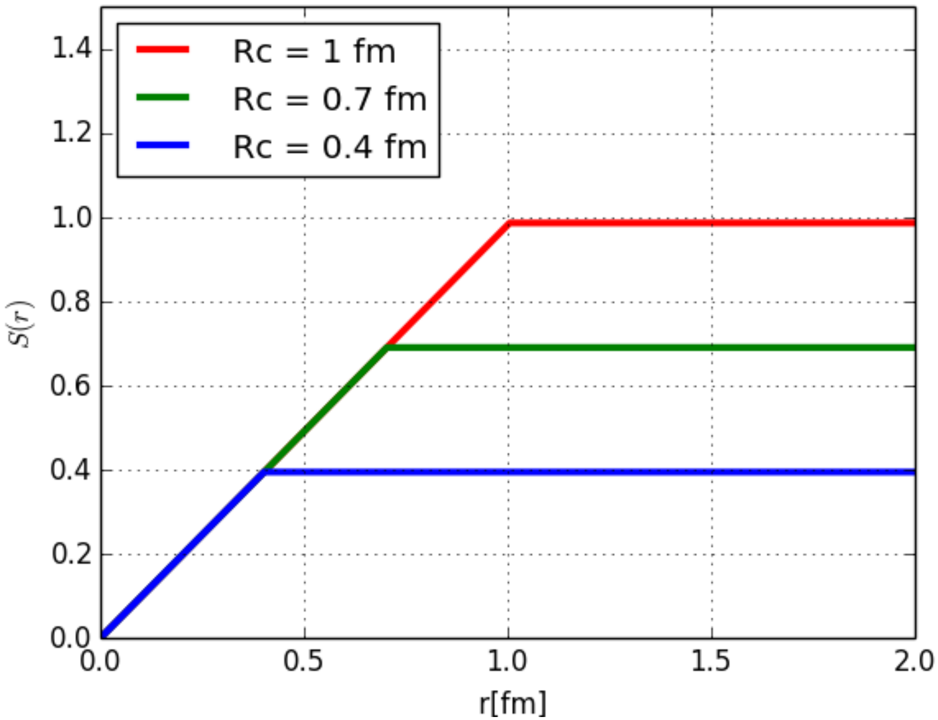
Critical distance

$$\sigma R_c \approx M, \quad \lim_{r\to\infty} S(r) = M$$

σ = (0.44 GeV)^2

We need to saturate S(r) to avoid a divergence

$$S(r) = \sigma r\, \theta(R_c - r) + \sigma R_c\, \theta(r - R_c)$$



This is plausible, since the string should be broken into creating mesons.

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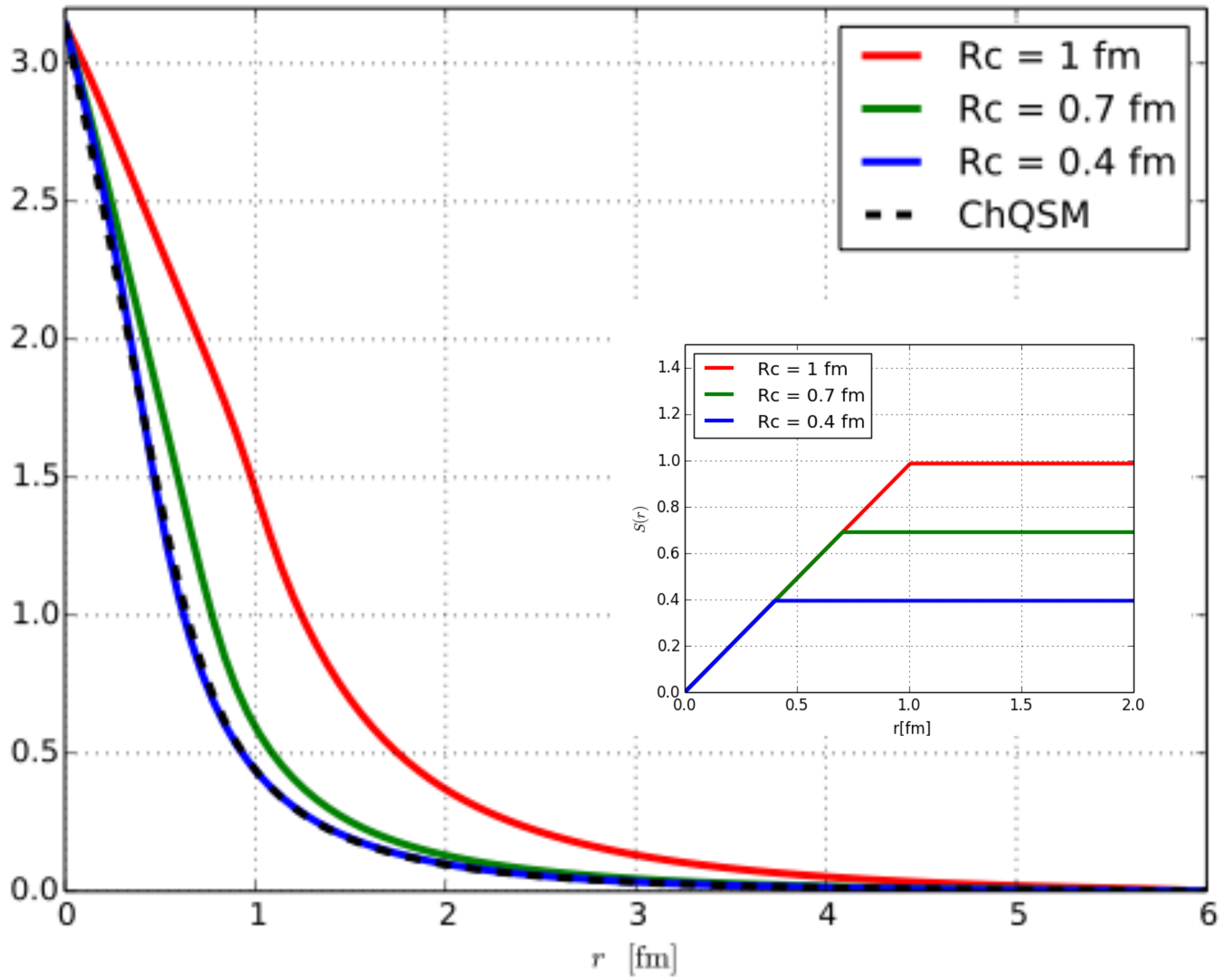
Self-consistent pion background field



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Classical Nucleon mass

[MeV]	Valence	Sea	Total
ChQSM M = 420 MeV	589	707	1296
Rc = 0.4 fm	701	557	1258
Rc = 0.7 fm	269	916	1185
Rc = 1.0 fm	x	916	916

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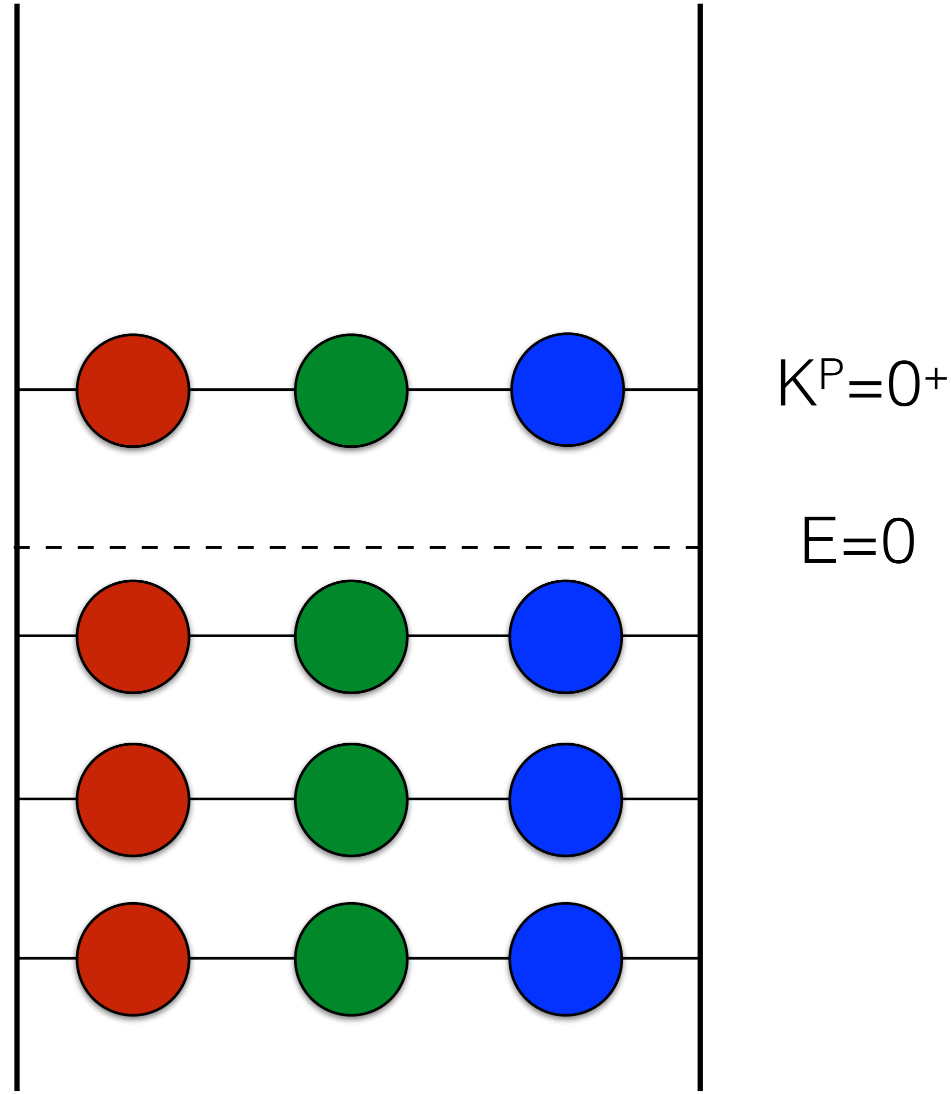
Ground baryons

$$\boldsymbol{K} = \boldsymbol{J} + \boldsymbol{T} = \boldsymbol{0}, \quad T_8 = \frac{N_c}{2\sqrt{3}}$$

Right hypercharge

$$Y' = \frac{N_c}{3}$$

- Nc quark gives the baryon number in the XQSM.



Ground state

Collective Hamiltonian for ground baryons

$$H = H_{\rm cl} + H_{\rm rot} + H_{\rm sb}$$

$$H_{\rm rot} = \frac{1}{2I_1}\sum_{i=1}^{3} J_i^2 + \frac{1}{2I_2}\sum_{a=4}^{7} J_a^2$$

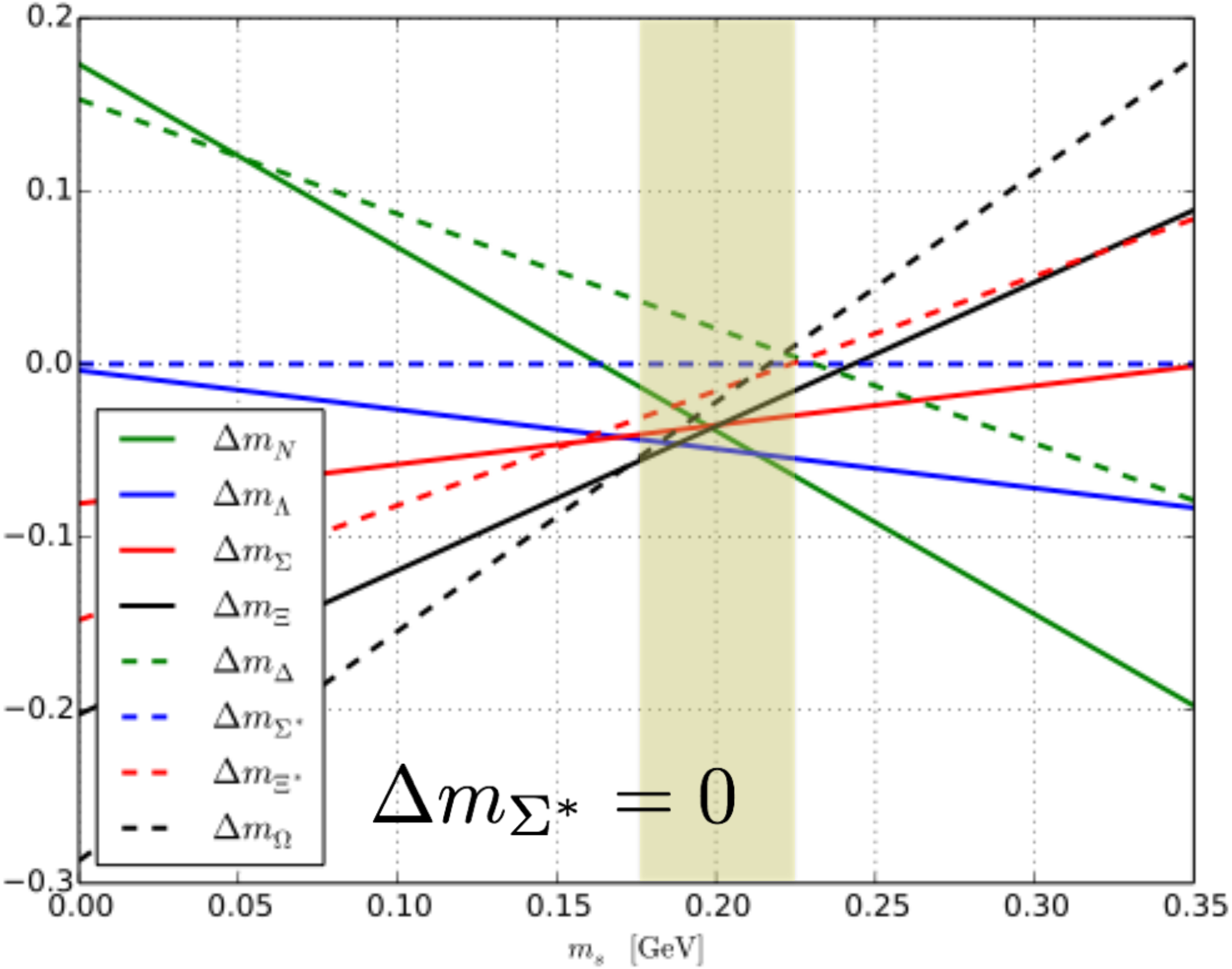
$$H_{\rm sb} = \alpha D_{88}^{(8)}(R) + \beta Y + \frac{1}{\sqrt{3}}\gamma \sum_{i=1}^{3} D_{8i}^{(8)} J_i$$

$$\alpha = -\left(\frac{2}{3}\frac{\Sigma_{\pi N}}{m_{\rm u}+m_{\rm d}} - \frac{K_2}{I_2}\right), \quad \beta = -\frac{K_2}{I_2}, \quad \gamma = 2\left(\frac{K_1}{I_1} - \frac{K_2}{I_2}\right)$$

Baryon wave functions

$$|B\rangle = \sqrt{\dim(\mathcal{R})}(-1)^{J_3+Y'/2} D^{(\mathcal{R})*}_{(Y,T,T_3)(-Y',J,-J_3)}$$

Hyperon mass splitting to the first order of m_s



Original XQSM

— octet

- - decuplet

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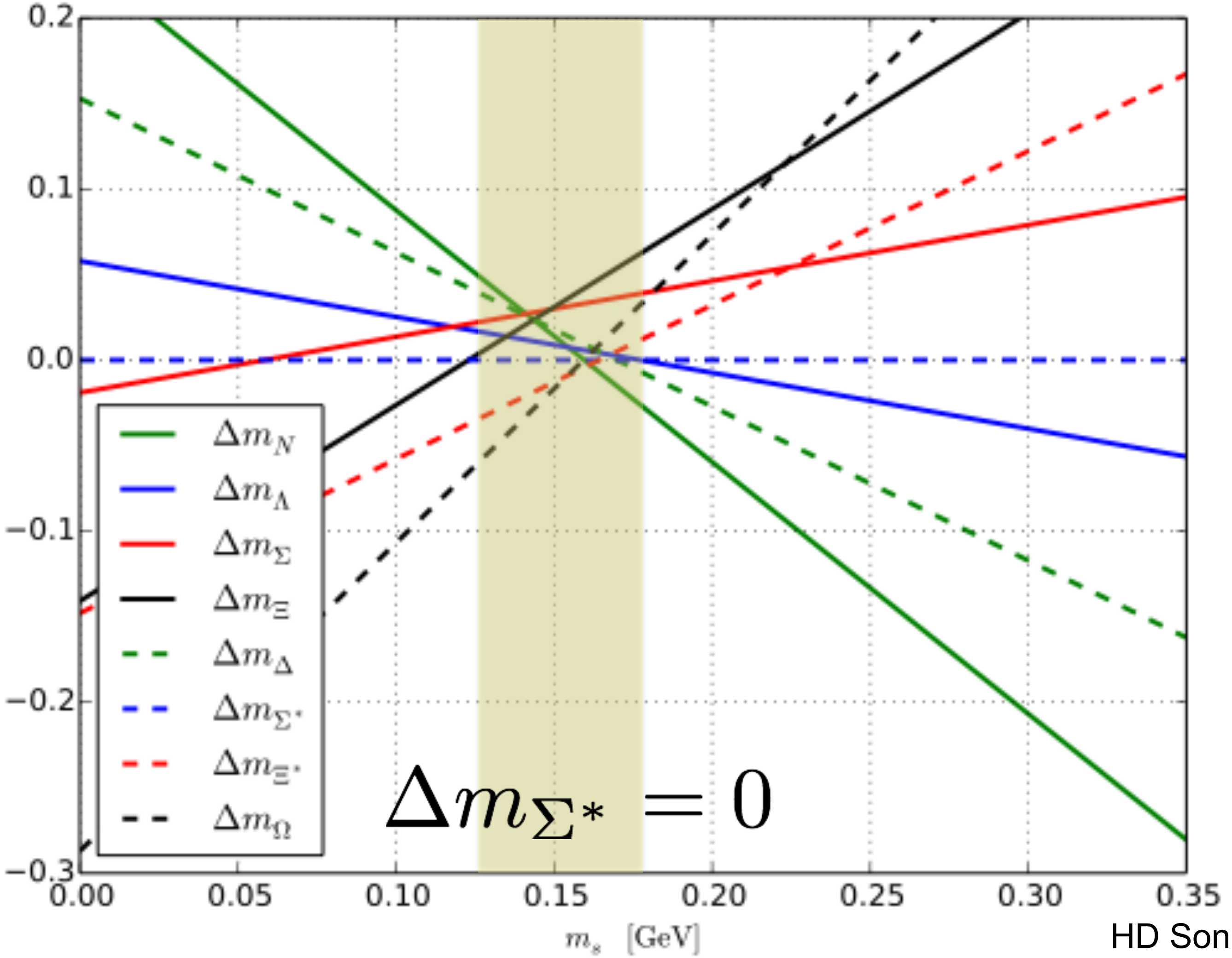
Hyperon mass splitting to the first order of m_s

Rc = 0.42 fm: — octet - - decuplet

Large σ-term → smaller strange quark mass



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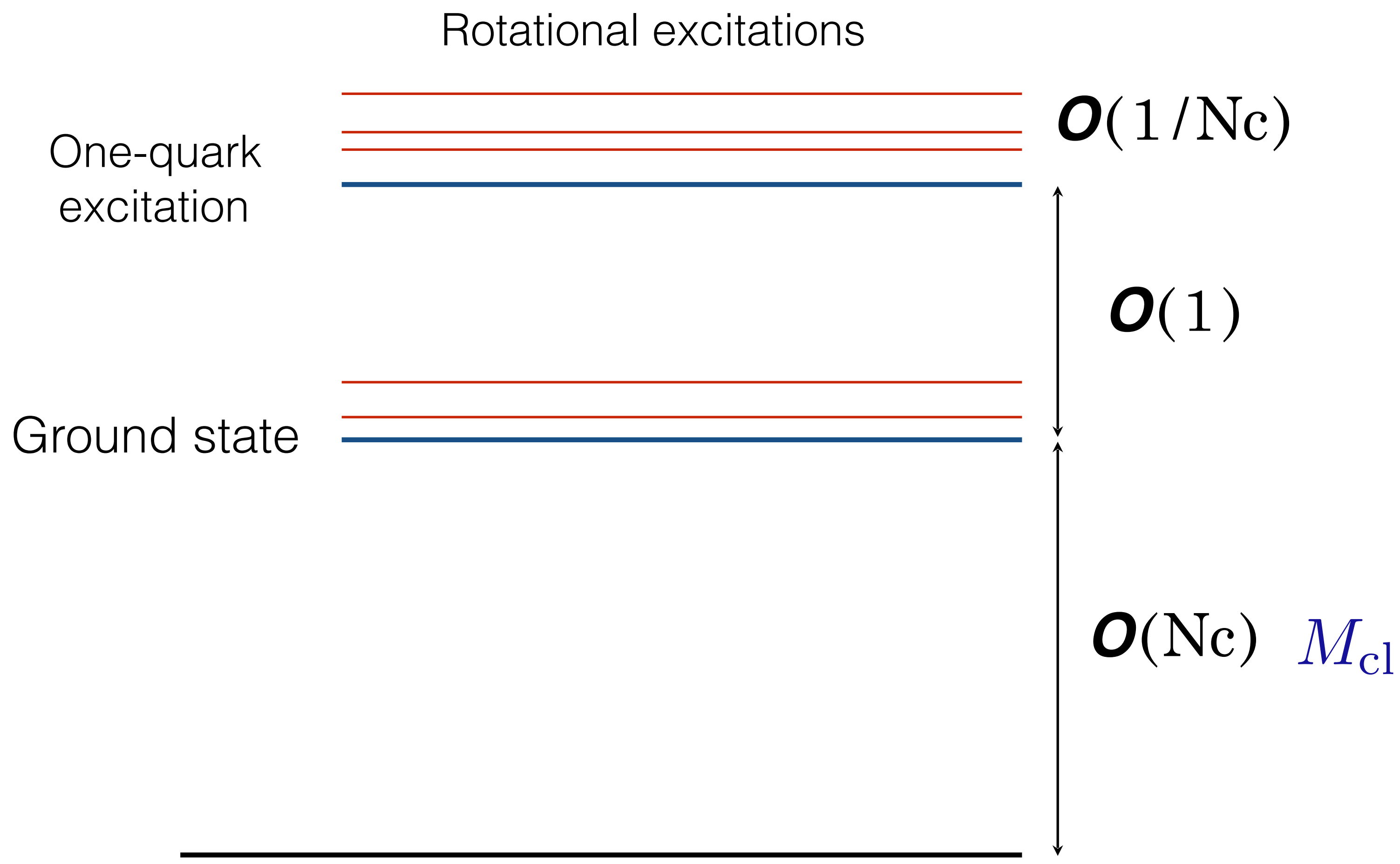
Excited valence quark

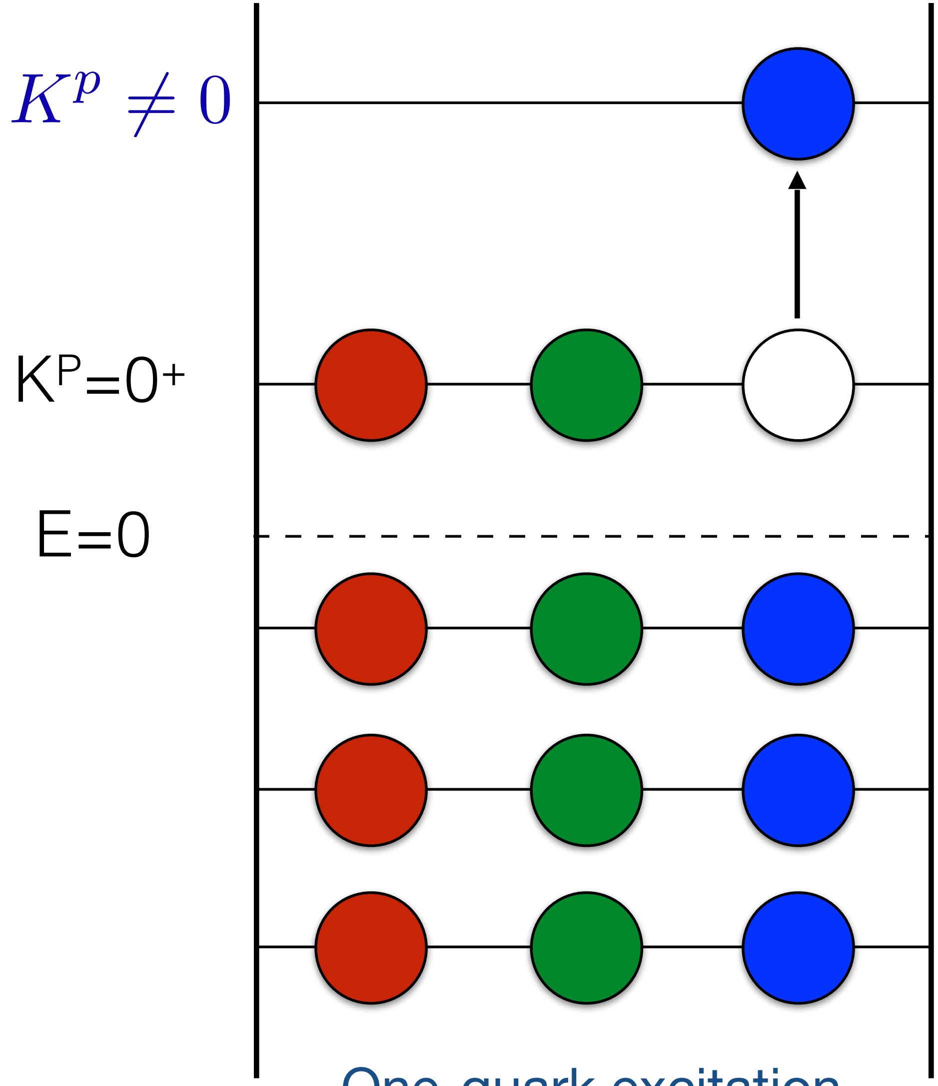
Schematic picture at large N_c



Excited valence quark for 8(J^P=1/2$^+$)

$$\boldsymbol{K} = \boldsymbol{J} + \boldsymbol{T},$$

$$Y' = \frac{N_c}{3} = \frac{2}{\sqrt{3}} T_8$$

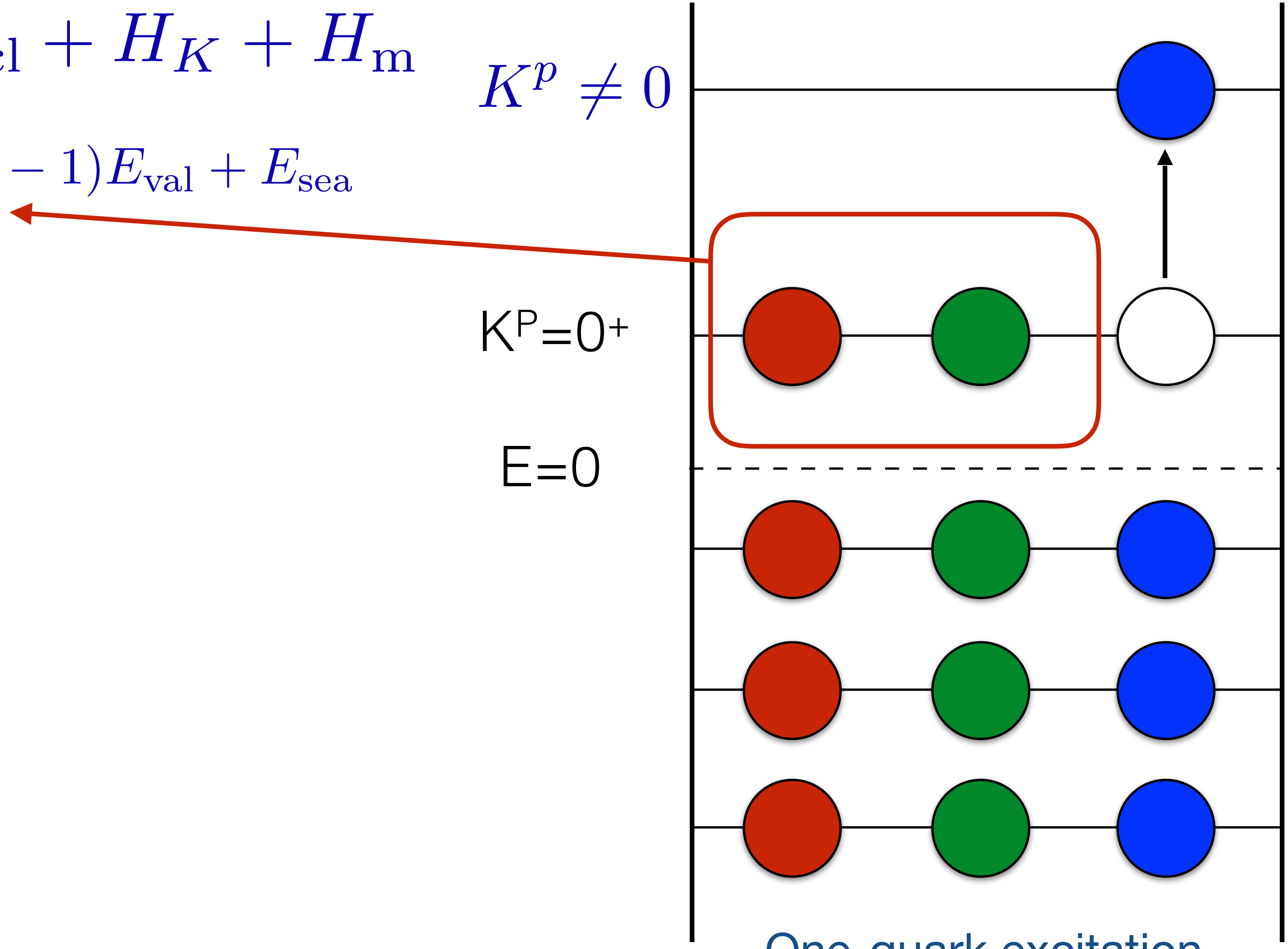


One-quark excitation from the valence level

Collective Hamiltonian for excited baryons

$$H = H_{\rm cl} + H_K + H_{\rm m}$$

$$M_{\rm cl} = (N_c - 1)E_{\rm val} + E_{\rm sea}$$



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$$H_m = \alpha D_{88}^{(8)}(R) + \beta Y + \frac{1}{\sqrt{3}}\gamma \sum_{i=1}^{3} D_{8i}^{(8)}(R) T_i + \frac{1}{\sqrt{3}}\delta_K \sum_{i=1}^{3} D_{8i}^{(8)}(R) K_i$$

$$\delta_K = \frac{2m_s}{3}\left(d_K - \frac{K_1}{I_1} a_K\right)$$

Wave functions for excited baryons

$$\Psi_K(R, S, \chi) = \sqrt{\frac{\dim(R)(2J+1)}{2K+1}} \sum_{TT_3J_3} C_{TT_3JJ_3}^{KK_3} D_{Y'T'T'_3, YTT_3}(R^\dagger) D_{J'_3J_3}(S^\dagger) \chi_{K_3}$$

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Excited valence quark for 8($J^P=1/2^+$)

K=0+ → K=0+ : No contribution from χ_K

	Y	Mass	Candidates	Status	I(J^P)	Δ_{calc}	Δ_{exp}
N	1	1458	1440	****	1/2($1/2^+$)	190	220
Λ	0	1648	1660	***	0($1/2^+$)	102	
Σ	0	1750	1660	****	1($1/2^+$)	139	
Ξ	-1	1889	1690	*	1/2($?^?$)		

HD Son & HChK, in preparation

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HD Son & HChK, in preparation

Excited valence quark for 8($J^P=3/2^+$)

K=0+ → K=0+ : No contribution from χ_K

	Y	Mass	Candidates	Status	$I(J^P)$	Δ_{calc}	Δ_{exp}
Δ	1	**1826**	1600	****	$3/2(3/2^+)$	**151**	
Σ	0	**1977**	1660	*	$1(3/2^+)$	**151**	
Ξ	-1	**2128**	1950	***	$1/2(?^?)$	**151**	
Ω	-2	**2280**	2250	***	$0(?^?)$		

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Parameters for the baryons with negative parity

c_K, a_K, and d_K

	$\Delta E(0+\rightarrow 1-)$ [MeV]	c_K	a_K	d_K
ChQSM (M=420MeV)	240	0.377	0.217	0.213
R_C=0.42 fm	163	0.391	0.207	0.201
R_C=0.44 fm	249	0.398	0.202	0.198
R_C=0.46 fm	337	0.407	0.195	0.193
Diakonov *et al*	468		0.336	

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Excited valence quark for $8(J^P=1/2^-)$

<u>K=0+ → K=1-</u>

	Y	Mass[MeV]	Candidates	Status	$I(J^P)$	Δ_{calc}	Δ_{exp}
N	1	**1408**	1535	****	$1/2(1/2^-)$	**145**	**135**
Λ	0	**1553**	1670	****	$0(1/2^-)$	**92**	
Σ	0	**1645**				**99**	
Ξ	-1	**1744**	?	?	?		

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Σ	0	1645				99	
Ξ	-1	1744	?	?	?		

HD Son & HChK, in preparation

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K=0+ → K=1-

	Y	Mass[MeV]	Candidates	Status	$I(J^P)$	Δ_{calc}	Δ_{exp}
N	1	**1432**	1520	****	$1/2(3/2^-)$	**170**	**170**
Λ	0	**1602**	1690	****	$0(3/2^-)$	**103**	**-20**
Σ	0	**1705**	1670	****	$1(3/2^-)$	**119**	**150**
Ξ	-1	**1824**	1820	***	$1/2(3/2^-)$		

HD Son & HChK, in preparation

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Ξ	-1	1824	1820	***	1/2(3/2-)		

HD Son & HChK, in preparation

Excited valence quark for 10($J^P=1/2^-$)

$K=0+ \rightarrow K=1-$

	Y	Mass[MeV]	Candidates	Status	I(J^P)	Δ_{calc}	Δ_{exp}
Δ	1	**1669**	1620	****	3/2($1/2^-$)	139	130
Σ*	0	**1808**	1750	***	1($1/2^-$)	139	
Ξ*	-1	**1947**	1900	?	?	139	
Ω	-2	**2085**	2050	?	?		

Predictions by V. Petrov

HD Son & HChK, in preparation

Excited valence quark for 10($J^P=3/2^-$)

K=0+ → K=1-

	Y	Mass[MeV]	Candidates	Status	I(J^P)	Δ_{calc}	Δ_{exp}
Δ	1	1726	1700	****	3/2(3/2⁻)		
						136	
Σ*	0	1862	1850	?	?		
						136	
Ξ*	-1	1999	2000	?	?		
						136	
Ω	-2	2135	2150	?	?		

Predictions by V. Petrov

HD Son & HChK, in preparation

What is missing in this approach?

- Meson-loop corrections (1/Nc): So far, the approach is just like a mean-field approach. We need to do more: RPA-like meson-loop contributions.

- qqbar excitations more than pions: vector, Axial-vector, and tensor mean fields and meson loops for higher-lying excited states

Summary and Outlook

Summary & Outlook

- We constructed the extended chiral quark-soliton model, deriving the pion mean field self-consistently in the presence of the confining field.
- The mass ordering problems are not solved but the mass differences are better than the other quark models.
- Meson-loop corrections (RPA-like contributions) to the excited baryons
- Contribution of the vector, axial-vector, and tensor mean fields to the excited baryons
- Radiative and strong decays of the excited baryons
- Transition form factors of the excited baryons

Summary & Outlook

- Application to Heavy baryon systems (We already did recently.)
- Model-independent analysis

(We can describe the correct mass ordering.)

- Long way to go for a complete generalization of the chiral quark-soliton model.

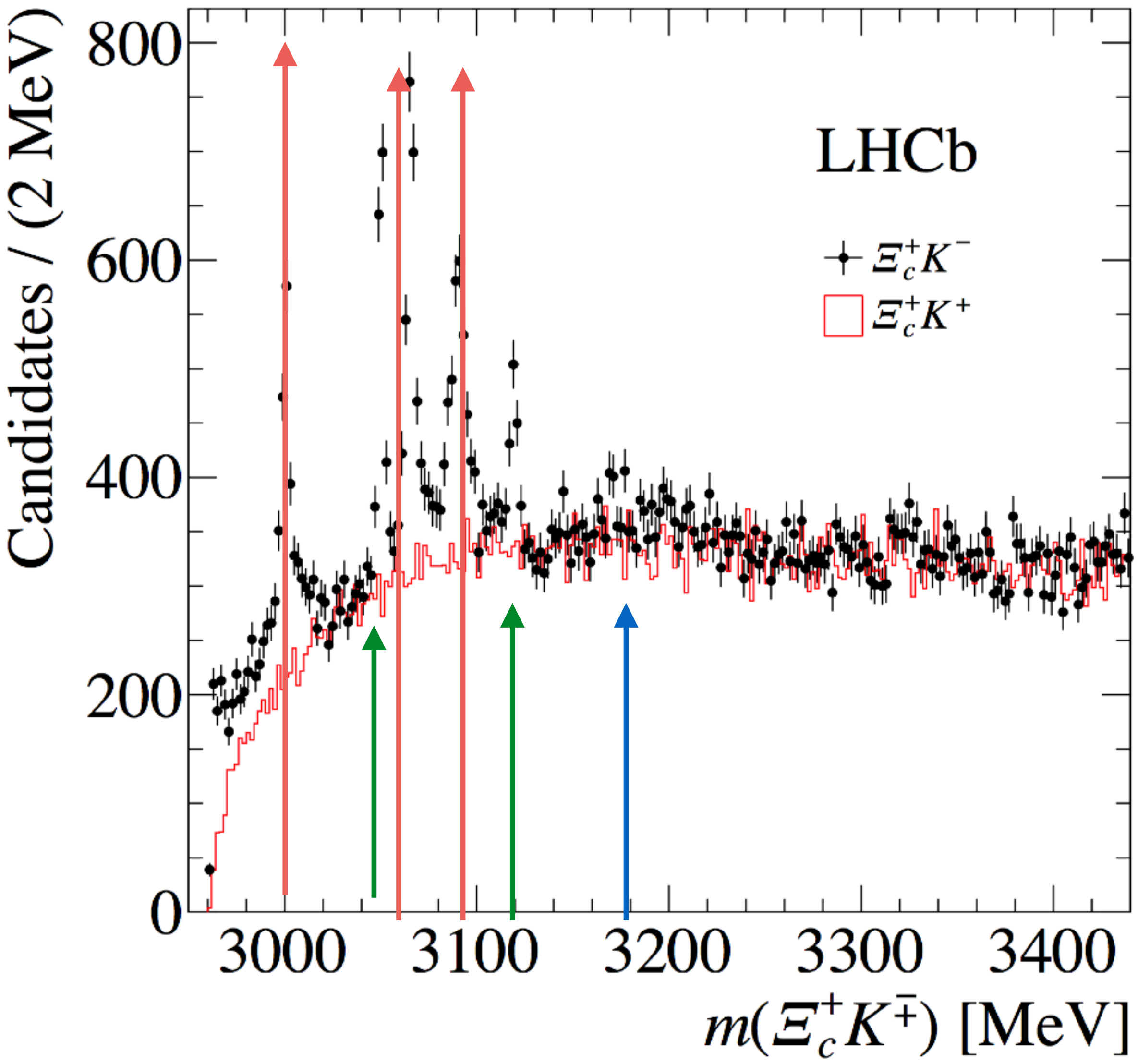
Though this be madness,
yet there is method in it.

Hamlet Act 2, Scene 2

Thank you very much!

$$\Omega_c$$

LHCb Findings: New five Omega_cs

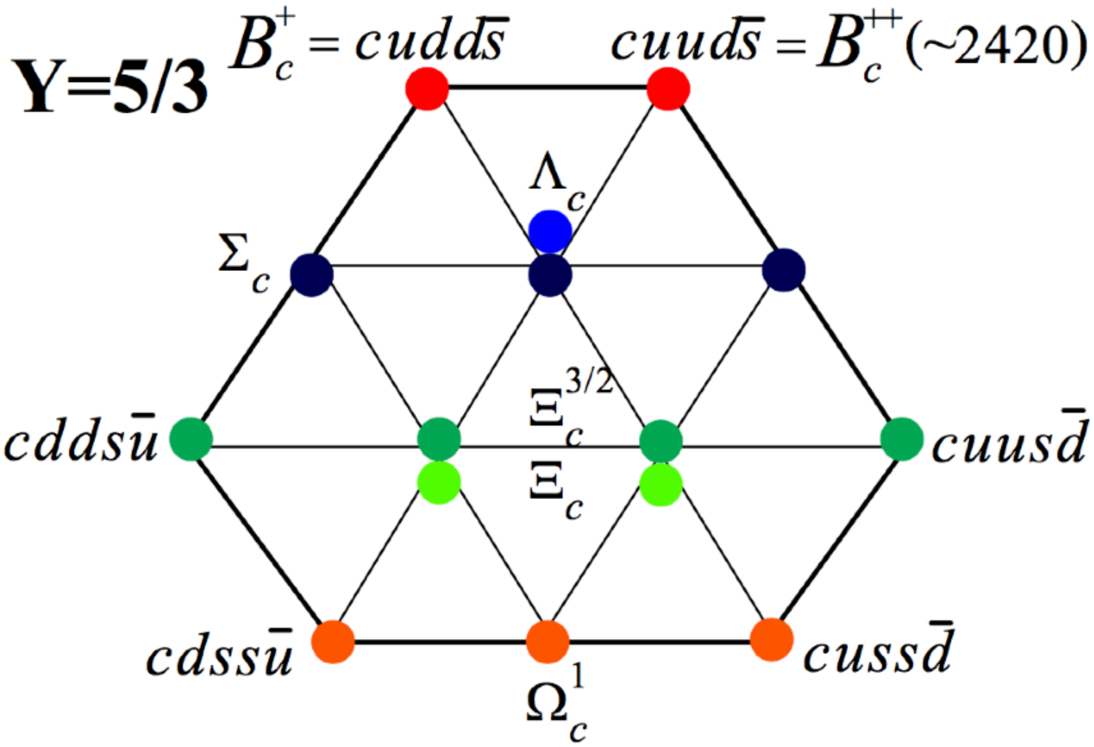


LHCb Findings: New five Omega_cs

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
		$< 1.2\,\text{MeV}, 95\%\ \text{CL}$		
$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$	$1740 \pm 100 \pm 50$	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
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$	$480 \pm 70 \pm 30$	10.4
		$< 2.6\,\text{MeV}, 95\%\ \text{CL}$		
$\Omega_c(3188)^0$	$3188 \pm 5 \pm 13$	$60 \pm 15 \pm 11$	$1670 \pm 450 \pm 360$	
$\Omega_c(3066)^0_{\text{fd}}$			$700 \pm 40 \pm 140$	
$\Omega_c(3090)^0_{\text{fd}}$			$220 \pm 60 \pm 90$	
$\Omega_c(3119)^0_{\text{fd}}$			$190 \pm 70 \pm 20$	

Anti-15plet

Exotic anti-15plet naturally arises from the XQSM.



Anti-15plet

- Mass splitting due to the mean fields

$$\mathcal{M}_{\overline{\mathbf{15}},J=0} = M_{\rm sol} + \frac{5}{2}\frac{1}{\rho I_2},$$

$$\mathcal{M}_{\overline{\mathbf{15}},J=1} = M_{\rm sol} + \frac{3}{2}\frac{1}{\rho I_2} + \frac{1}{\rho I_1}$$

- Mass splitting is positive!

$$\Delta_{\overline{\mathbf{15}}} = \mathcal{M}_{\overline{\mathbf{15}},J=0} - \mathcal{M}_{\overline{\mathbf{15}},J=1} = \frac{1}{\rho}\left(\frac{1}{I_2} - \frac{1}{I_1}\right) > 0\,!$$

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Anti-15plet

- SU(3) symmetry-breaking splitting

$$\Delta_s M_{\overline{\mathbf{15}}} = Y\left(\beta + \frac{17}{144}(\alpha - 2\gamma)\right) + \left(-\frac{2}{27} + \frac{1}{24}\left(T(T+1) - \frac{1}{4}Y^2\right)\right)(\alpha - 2\gamma).$$

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Excited anti-3plet and 6plet

$$K = 1$$

$$\mathcal{M}'_{\overline{\mathbf{3}}} = M'_{\rm sol} + \frac{1}{2I_2} + \frac{1}{I_1}(1 - a_1^2).$$

$$\mathcal{M}'_{\mathbf{6}\,J} = \mathcal{M}'_{\overline{\mathbf{3}}} + \frac{1 - a_1}{I_1} + \frac{a_1}{I_1} \times \begin{cases} -1 & \text{for} \quad J = 0 \\ 0 & \text{for} \quad J = 1 \\ 2 & \text{for} \quad J = 2 \end{cases} .$$

$$\delta'_{\overline{\mathbf{3}}} = \frac{3}{8}\bar{\alpha} + \beta = \delta_{\overline{\mathbf{3}}}$$

$$\delta'_{\mathbf{6}\,J} = \delta_{\mathbf{6}} - \frac{3}{20}\delta \times \begin{cases} 2 & \text{for} \quad J = 0 \\ 1 & \text{for} \quad J = 1 \\ -1 & \text{for} \quad J = 2 \end{cases}$$

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Hyperfine splittings

$$\Delta^{\rm hf}_{\overline{\mathbf{3}}} = \Delta^{\rm hf}_{\mathbf{6}\,J=1} = \frac{\kappa'}{m_c}, \quad \Delta^{\rm hf}_{\mathbf{6}\,J=2} = \frac{5}{3}\frac{\kappa'}{m_c}$$

- Candidates for excited anti-3plet

$$\Lambda_c(2592), \quad \Xi_c(2790) \text{ for } J^p = 1/2^-$$

$$\Lambda_c(2628), \quad \Xi_c(2818) \quad \text{for } J^P = 3/2^-$$

- Determine the parameters

$$\frac{\kappa'}{m_c} = \frac{1}{3}\left(M_{\Lambda_c(2628)} + 2M_{\Xi_c(2818)}\right) - \frac{1}{3}\left(M_{\Lambda_c(2252)} + 2M_{\Xi_c(2790)}\right) = 30 \text{ MeV},$$

$$\mathcal{M}'_{\overline{\mathbf{3}}} = \frac{2}{9}\left(M_{\Lambda_c(2628)} + 2M_{\Xi_c(2818)}\right) + \frac{1}{9}\left(M_{\Lambda_c(2252)} + 2M_{\Xi_c(2790)}\right) = 2744 \text{ MeV}$$

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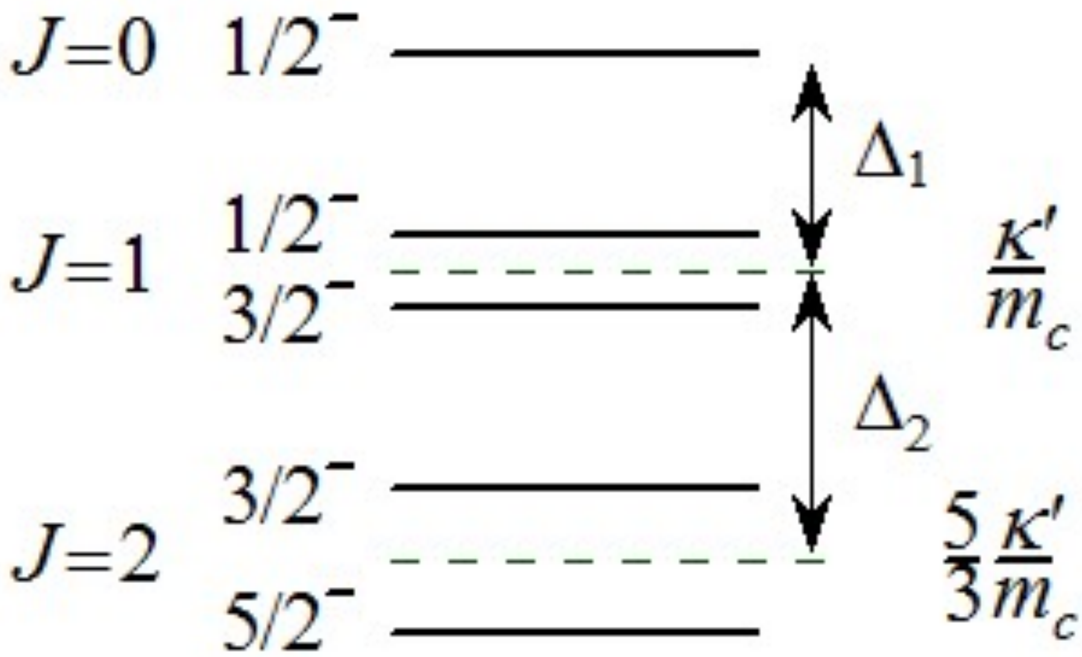
Hyperfine splittings



$$\Delta_1 = \frac{a_1}{I_1} + \frac{3}{20}\delta, \quad \Delta_2 = 2\Delta_1$$

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Scenario I

Assertion: Five Omega_cs belong to excited sextets.

J	S^P	M [MeV]	κ'/m_c [MeV]	Δ_J [MeV]
0	$\frac{1}{2}^-$	3000	–	–
1	$\frac{1}{2}^-$	3050	16	61
	$\frac{3}{2}^-$	3066		
2	$\frac{3}{2}^-$	3090	17	47
	$\frac{5}{2}^-$	3119		

$$\frac{\kappa'}{m_c} = 30\,\mathrm{MeV}$$

The HF splittings are very much deviated from what we have determined from the anti-3plet.

Scenario II

Assertion: Thee Omega_cs belong to excited sextets, whereas two Omega_cs with smaller widths belongs to the anti-15plet.

J	S^P	M [MeV]	κ'/m_c [MeV]	Δ_J [MeV]
0	$\frac{1}{2}^-$	3000	–	–
1	$\frac{1}{2}^-$	3066	24	82
	$\frac{3}{2}^-$	3090		
2	$\frac{3}{2}^-$	*3222*	input	input
	$\frac{5}{2}^-$	*3262*	24	164

$$\frac{\kappa}{m_c} \approx 70\,\mathrm{MeV}$$ Excellent agreement with the ground-state value!

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LHCb Findings: New five Omega_cs

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
		$< 1.2\,\text{MeV}, 95\%\ \text{CL}$		
$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$	$1740 \pm 100 \pm 50$	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
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$	$480 \pm 70 \pm 30$	10.4
		$< 2.6\,\text{MeV}, 95\%\ \text{CL}$		
$\Omega_c(3188)^0$	$3188 \pm 5 \pm 13$	$60 \pm 15 \pm 11$	$1670 \pm 450 \pm 360$	
$\Omega_c(3066)^0_{\text{fd}}$			$700 \pm 40 \pm 140$	
$\Omega_c(3090)^0_{\text{fd}}$			$220 \pm 60 \pm 90$	
$\Omega_c(3119)^0_{\text{fd}}$			$190 \pm 70 \pm 20$	

LHCb Findings: New five Omega_cs

$\Omega_c(3050)$ and $\Omega_c(3119)$ as a exotic anti-15plet

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
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$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$	$1740 \pm 100 \pm 50$	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
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$	$480 \pm 70 \pm 30$	10.4
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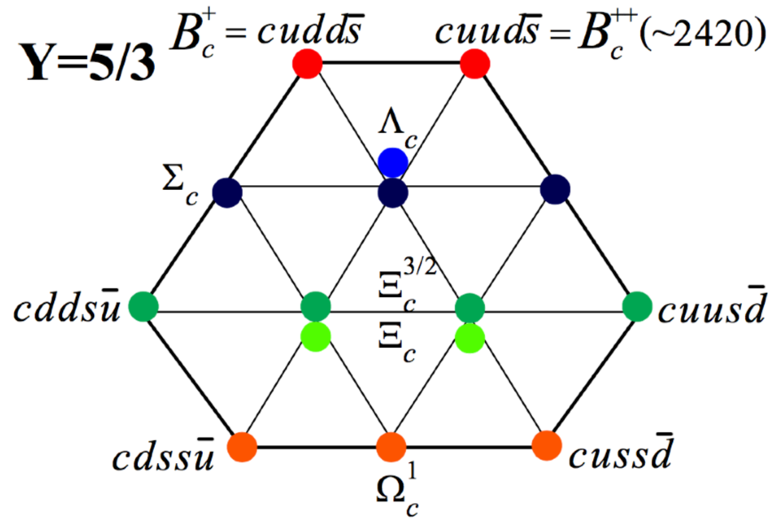
$\Omega_c(3090)^0_{\mathrm{fd}}$			$220 \pm 60 \pm 90$	
$\Omega_c(3119)^0_{\mathrm{fd}}$			$190 \pm 70 \pm 20$	

LHCb Findings: New five Omega_cs

	Y	T	$S^P = \frac{1}{2}^+$	$S^P = \frac{3}{2}^+$
B_c	$\frac{5}{3}$	$\frac{1}{2}$	2685	2754
Σ_c	$\frac{2}{3}$	1	2808	2877
Λ_c	$\frac{2}{3}$	0	2806	2875
Ξ_c	$-\frac{1}{3}$	$\frac{1}{2}$	2928	2997
$\Xi_c^{3/2}$	$-\frac{1}{3}$	$\frac{3}{2}$	2931	3000
Ω_c	$-\frac{4}{3}$	1	3050	3119



Bc baryons will decay weakly. So, they should be stable!