Light-Cone Wave Functions of Heavy Baryons

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based on the paper (in preparation)
with Ahmed Ali and Christian Hambrock

Outline

Introduction

Heavy baryons H_Q – three-quark states with $Q = c, b$

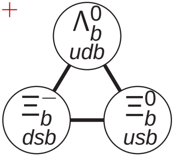
Within Heavy Quark Effective Theory (HQET):

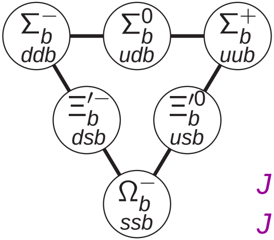
- spin of heavy quark S_Q is decoupled when $m_Q \to \infty$
- classified by the angular momentum ℓ and parity p of the light quark pair

Ground-state $\ell = 0$ bottom baryons

$J^P = 1/2^+$

$j^p = 0^+$





$j^p = 1^+$

$J^P = 1/2^+$

$J^P = 3/2^+$

QCD sum rules

Experimental measurements and theoretical predictions (based on HQET and Lattice QCD for the masses of the ground-state bottom baryons (in units of MeV).

Baryon	J^P	Experiment	HQET	Lattice QCD	$\bar{\Lambda}$	s_0
Λ_b	$1/2^+$	5620.0 ± 1.6	5637^{+68}_{-56}	$5641 \pm 21^{+15}_{-33}$	0.8	1.2
Σ_b^+	$1/2^+$	5807.8 ± 2.7	5809^{+82}_{-76}	$5795 \pm 16^{+17}_{-26}$	1.0	1.3
Σ_b^+	$1/2^+$	5815.2 ± 2.0				
Σ_b^{*+}	$3/2^+$	5829.0 ± 3.4	5835^{+82}_{-77}	$5842 \pm 26^{+20}_{-18}$	1.0	1.3
Σ_b^{*-}	$3/2^+$	5836.4 ± 2.8				
Ξ_b^0	$1/2^+$	5792.4 ± 3.0	5780^{+73}_{-68}	$5781 \pm 17^{+17}_{-16}$	1.0	1.3
Ξ_b'	$1/2^+$		5903^{+81}_{-79}	$5903 \pm 12^{+18}_{-19}$	1.1	1.4
$\Xi_b'^*$	$3/2^+$		5903^{+81}_{-79}	$5950 \pm 21^{+19}_{-21}$	1.1	1.4
Ω_b^-	$1/2^+$	6165 ± 16	6036 ± 81	$6006 \pm 10^{+20}_{-19}$	1.3	1.5
Ω_b^*	$3/2^+$		6063^{+83}_{-82}	$6044 \pm 18^{+20}_{-21}$	1.3	1.5

Introduction

- Heavy bottom baryons will be copiously produced at the LHC
- Their weak decays may give important information on physics beyond the SM through the FCNC processes
- LCDAs are the primary non-perturbative objects required for calculating decays into light particles based on the heavy quark expansion or within the methos of Light-Cone Sum Rules (LCSRs)
- For a long time existing models for heavy baryons were motivated by the quark model
- Complete classification of the three-quark LCDAs of the Λ_b-baryon in QCD and their main features were have been considered by Braun, Ball and Gardi (2008)
- We extent their analysis for all graund-state bottom baryons

Light-Cone Distribution Amplitudes (LCDAs)

Heavy baryon light-cone distribution amplitudes –
matrix elements of non-local light-ray operators
build off an effective heavy quark and two light quarks

- Similar in construction to B-meson LCDAs
- QCD description of nucleon LCDAs

Heavy Quark Symmetry $\Longrightarrow$ switch off the spin of heavy quark

LCDAs

$SU(3)_F$ antitriplet $J^P = j^p = 0^+$ scalar state

Non-local light-ray operators

$$\epsilon^{abc}\langle 0| \left(q_1^a(t_1 n) C\gamma_5 \not{n} q_2^b(t_2 n)\right) h_v^c(0)|H(v)\rangle = f_H^{(2)}\,\Psi_2(t_1,t_2)$$

$$\epsilon^{abc}\langle 0| \left(q_1^a(t_1 n) C\gamma_5 q_2^b(t_2 n)\right) h_v^c(0)|H(v)\rangle = f_H^{(1)}\,\Psi_3^s(t_1,t_2)$$

$$\epsilon^{abc}\langle 0| \left(q_1^a(t_1 n) C\gamma_5 i\sigma_{\bar{n}n} q_2^b(t_2 n)\right) h_v^c(0)|H(v)\rangle = 2f_H^{(1)}\,\Psi_3^\sigma(t_1,t_2)$$

$$\epsilon^{abc}\langle 0| \left(q_1^a(t_1 n) C\gamma_5 \not{\bar{n}} q_2^b(t_2 n)\right) h_v^c(0)|H(v)\rangle = f_H^{(2)}\Psi_4(t_1,t_2)$$

$q_i = u, d, s$ – light quark fields

C – charge conjugation matrix

n^μ, $\bar{n}^\mu$ – two light-like vectors $(n\bar{n}) = 2$

Frame is adopted: $v^\mu = (n^\mu + \bar{n}^\mu)/2$

LCDAs

Couplings $f_H^{(i)}$ are defined by local operators

$$\epsilon^{abc}\langle 0|\left(q_1^a(0)C\gamma_5 q_2^b(0)\right)h_v^c(0)|H(v)\rangle = f_H^{(1)}$$
$$\epsilon^{abc}\langle 0|\left(q_1^a(0)C\gamma_5 \not{v} q_2^b(0)\right)h_v^c(0)|H(v)\rangle = f_H^{(2)}$$

Scale dependence of the couplings:

$$f_H^{(i)}(\mu) = f_H^{(i)}(\mu_0)\left(\frac{\alpha_s(\mu)}{\alpha_s(\mu_0)}\right)^{\gamma_1^{(i)}/\beta_0}\left[1 - \frac{\alpha_s(\mu_0)-\alpha_s(\mu)}{4\pi}\frac{\gamma_1^{(i)}}{\beta_0}\left(\frac{\gamma_2^{(i)}}{\gamma_1^{(i)}} - \frac{\beta_1}{\beta_0}\right)\right]$$

Example: Λ_b-baryon

NLO QCD sum rules [Groote et all., 1997]

$$f_H^{(1)}(\mu_0 = 1\ \mathrm{GeV}) \simeq f_H^{(2)}(\mu_0 = 1\ \mathrm{GeV}) \simeq 0.030 \pm 0.005\ \mathrm{GeV}^3$$

Supported by non-relativistic constituent quark picture

LCDAs

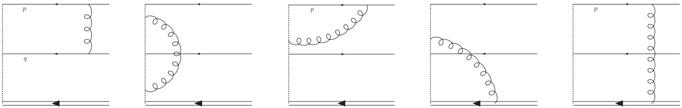
LCDAs $\Psi_i(t_1,t_2)$ are scale dependent

Fourier transrorm to the momentum space:

$$\begin{aligned}\Psi(t_1,t_2) &= \int_0^\infty d\omega_1 \int_0^\infty d\omega_2\, e^{-it_1\omega_1-it_2\omega_2}\psi(\omega_1,\omega_2)\\ &= \int_0^\infty \omega\, d\omega \int_0^1 du\, e^{-i\omega(t_1u+t_2\bar{u})}\,\widetilde{\psi}(\omega,u)\end{aligned}$$

$\omega_1 = u\omega$, $\omega_2 = (1-u)\omega = \bar{u}\omega$ – energies of q_1 and q_2 quarks

LO evolution equation for $\psi_2(\omega_1,\omega_2;\mu)$: derived by identifying UV singularities of one-gluon-exchange diagrams



LCDAs

Evolution equation is expressed in terms of two-particle kernels from evolution equations of B- and pseudoscalar meson LCDAs

$$\mu\frac{d}{d\mu}\psi_2(\omega_1,\omega_2;\mu) = -\frac{\alpha_s(\mu)}{2\pi}\frac{4}{3}\Big\{\int_0^\infty d\omega_1'\,\gamma^{\rm LN}(\omega_1',\omega_1;\mu)\,\psi_2(\omega_1',\omega_2;\mu) + \int_0^\infty d\omega_2'\,\gamma^{\rm LN}(\omega_2',\omega_2;\mu)\,\psi_2(\omega_1,\omega_2';\mu) - \int_0^1 dv\,V(u,v)\,\psi_2(v\omega,\bar{v}\omega;\mu) + \frac{3}{2}\,\psi_2(\omega_1,\omega_2;\mu)\Big\}$$

Kernel $\gamma^{\rm LN}(\omega',\omega;\mu)$ controlling evolution of the B-meson LCDA

$V(u,v)$ is the ER-BL kernel

Term $3\psi_2/2$ results of $f_H^{(2)}$ one-loop renormalization subtraction

Evolution equation can be solved eather numerically or semi-analytically [Braun et al., 2008]

LCDAs

$SU(3)_F$ sixtet $\quad J^P = j^p = 1^+ \quad$ axial-vector state

Non-local light-ray operators (longitudinal polarization)

$$\epsilon^{abc} \langle 0| \left(q_1^a(t_1) C \not{n} q_2^b(t_2) \right) h_v^c(0) |H(v,\varepsilon)\rangle = (\bar{v}\varepsilon) f_H^{(2)} \Psi_2^{\parallel}(t_1,t_2)$$

$$\epsilon^{abc} \langle 0| \left(q_1^a(t_1) C \, q_2^b(t_2) \right) h_v^c(0) |H(v,\varepsilon)\rangle = (\bar{v}\varepsilon) f_H^{(1)} \Psi_3^{\parallel s}(t_1,t_2)$$

$$\epsilon^{abc} \langle 0| \left(q_1^a(t_1) C \, i\sigma_{\bar{n}n} q_2^b(t_2) \right) h_v^c(0) |H(v,\varepsilon)\rangle = 2\,(\bar{v}\varepsilon) f_H^{(1)} \Psi_3^{\parallel a}(t_1,t_2)$$

$$\epsilon^{abc} \langle 0| \left(q_1^a(t_1) C \bar{\not{n}} q_2^b(t_2) \right) h_v^c(0) |H(v,\varepsilon)\rangle = (\bar{v}\varepsilon) - f_H^{(2)} \Psi_4^{\parallel}(t_1,t_2)$$

$$\bar{v}^\mu = \left(\bar{n}^\mu - n^\mu\right)/2 \qquad (v\bar{v}) = 0 \qquad (\bar{v}\bar{v}) = -1$$

$$\varepsilon^\mu = \varepsilon_\parallel^\mu + \varepsilon_\perp^\mu \qquad \varepsilon_\parallel^\mu = -\varepsilon\bar{v}^\mu \qquad \sigma_{\bar{n}n} = i\left(\bar{\not{n}}\not{n} - \not{n}\bar{\not{n}}\right)/2$$

LCDAs

$SU(3)_F$ sixtet $J^P = j^p = 1^+$ axial-vector state

Non-local light-ray operators (transverse polarization)

$$\begin{aligned}
\epsilon^{abc}\langle 0|\left(q_1^a(t_1)C\,\gamma_\perp^\mu \not{n} q_2^b(t_2)\right)h_v^c(0)|H(v,\varepsilon)\rangle &= f_H^{(2)}\,\Psi_2^\perp(t_1,t_2)\,\varepsilon_\perp^\mu \\
\epsilon^{abc}\langle 0|\left(q_1^a(t_1)C\,\gamma_\perp^\mu q_2^b(t_2)\right)h_v^c(0)|H(v,\varepsilon)\rangle &= f_H^{(1)}\,\Psi_3^{\perp s}(t_1,t_2)\,\varepsilon_\perp^\mu \\
\epsilon^{abc}\langle 0|\left(q_1^a(t_1)C\,\gamma_\perp^\mu i\sigma_{\bar{n}n} q_2^b(t_2)\right)h_v^c(0)|H(v,\varepsilon)\rangle &= 2f_H^{(1)}\,\Psi_3^{\perp a}(t_1,t_2)\,\varepsilon_\perp^\mu \\
\epsilon^{abc}\langle 0|\left(q_1^a(t_1)C\,\gamma_\perp^\mu \not{\bar{n}} q_2^b(t_2)\right)h_v^c(0)|H(v,\varepsilon)\rangle &= f_H^{(2)}\,\Psi_4^\perp(t_1,t_2)\,\varepsilon_\perp^\mu
\end{aligned}$$

$$\gamma_\perp^\mu = \gamma^\mu - \left(\not{\bar{n}}\not{n} + \not{n}\not{\bar{n}}\right)/2$$

LCDAs

Switching on the heavy quark spin

r.h.s. of matrix elements of all non-local operators must be multiplied on the Dirac spinor $U(v)$ of the heavy quark h_v

$$\not{v}\, U(v) = U(v) \qquad \overline{U}(v)\, U(v) = 1$$

Scalar state: $J^P = j^p = 0^+ \Longrightarrow J^P = 1/2^+ : \quad H(v) \equiv U(v)$

Axial-vector state: $J^P = j^p = 1^+ \Longrightarrow J^P = 1/2^+ ,\, J^P = 3/2^+$

$$\begin{aligned}\varepsilon_\mu\, U(v) &= \left[\varepsilon_\mu\, U(v) - \frac{1}{3}(\gamma_\mu + v_\mu)\not{\varepsilon}\, U(v)\right] + \frac{1}{3}(\gamma_\mu + v_\mu)\not{\varepsilon}\, U(v) \\ &\equiv R^{3/2}_\mu(v) + \frac{1}{3}(\gamma_\mu + v_\mu)\, H(v)\end{aligned}$$

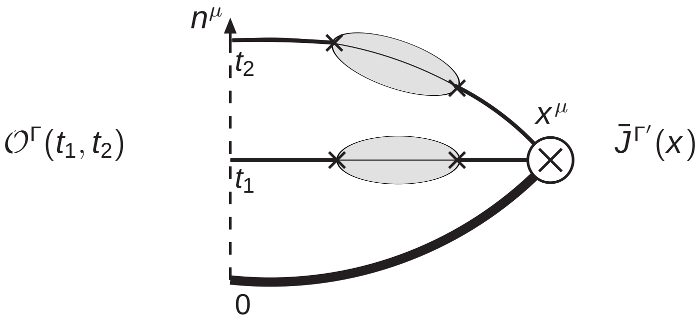
Rarita-Schwinger vector-spinor $R^{3/2}_\mu(v)$:

$$\not{v}\, R^{3/2}_\mu(v) = R^{3/2}_\mu(v), \quad v^\mu R^{3/2}_\mu(v) = 0, \quad \gamma^\mu R^{3/2}_\mu(v) = 0$$

QCD Sum Rules

Models for LCDAs can be obtained using QCD sum rules

Correlation functions involve the non-local light-ray operators and a suitable local current



QCD Sum Rules

Heavy baryon local operators

$$\bar{J}^{\Gamma'}(x) = \epsilon^{abc}\left(\bar{q}_2^a(x)\,[A + B\,\not{v}]\,\Gamma' C^T \bar{q}_1^b(x)\right)\bar{h}_v^c(x)$$

Arbitrariness in the choice of local currents (variation in $A \in [0, 1]$ and $B = 1 - A$ is adopted as an error estimate

Result are calculated for $A = B = 1/2$: supported by a constituent quark model picture [Braun et al., 2008]

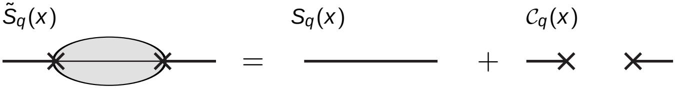
$$j^p = 0^+ \Longrightarrow \Gamma' = \gamma_5$$

$$j^p = 1^+ \Longrightarrow \Gamma' = \gamma_{\parallel},\, \gamma_{\perp}$$

QCD Sum Rules

Propagators of the light quark fields $\tilde{S}_q(x)$ are not free

To take effects of the QCD background inside baryons into account, method of nonlocal condensates is used



$$S_q(x) = \frac{i\not{x}}{2\pi^2 x^4} - \frac{m}{4\pi^2 x^2} \qquad \mathcal{C}_q(x) = \frac{1}{12}\langle \bar{q}(x) q(0) \rangle$$

Non-local condensate is chosen according to the model ($a = 3 + 4\lambda/m_0^2$) [Braun et el., 1994; Braun et al., 2003]

$$\mathcal{C}_q(x) = \langle \bar{q} q \rangle \int_0^\infty d\nu \, e^{\nu x^2/4} f(\nu), \qquad f(\nu) = \frac{\lambda^{a-2}}{\Gamma(a-2)} \nu^{1-a} e^{-\lambda/\nu}$$

$\langle \bar{q} q \rangle$ – local quark condensate, λ – correlation length,

m_0 – ratio of the mixed quark-gluon and quark condensates

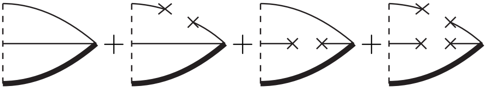
QCD sum rules

Double Fourier transform of the correlation function

$$\Pi_{\Gamma\Gamma'}(\omega_1,\omega_2;E) = i\int_{-\infty}^{\infty}\frac{dt_1\,dt_2}{(2\pi)^2}\,e^{i(\omega_1 t_1+\omega_2 t_2)}\int d^4x\,e^{-iE(vx)}\,\langle 0|\mathcal{O}^{\Gamma}(t_1,t_2)\,\bar{J}^{\Gamma'}(x)|0\rangle$$

In momentun space, correlation function reads diagramatically

$$\Pi(\omega,u;E) =$$



Heavy quark condensate term is suppressed by $1/m_Q$

Sum rule reads

$$|f_H|^2\,\psi^{\Gamma}(\omega,u)\,e^{-\bar{\Lambda}_H/\tau} = \mathbb{B}[\Pi](\omega,u;\tau,s_0) \qquad (1)$$

$\mathbb{B}$ means the Borel-Transform, $\bar{\Lambda}_H = m_H - m_Q$

s_0 – momentum cutoff from applying the quark-hadron duality

QCD sum rules

Analytic result for leading twist transversal LCDA at $\mu_0 = 1$ GeV

$$f_H^{(2)}\left(Af_H^{(1)} + Bf_H^{(2)}\right)\tilde{\psi}_2^{SR}(\omega,u)\,\mathrm{e}^{-\bar{\Lambda}/\tau} =$$
$$\frac{3\tau^4}{2\pi^4}\left[B\hat{\omega}^2\,u\bar{u} + A\,\hat{\omega}\,(\hat{m}_2 u + \hat{m}_1\bar{u})\right]E_1(2\hat{s}_\omega)\mathrm{e}^{-\hat{\omega}}$$
$$-\frac{\langle\bar{u}u\rangle\tau^3}{\pi^2}\left[A\hat{\omega}\bar{u} + B\hat{m}_2\right]f(2\tau\omega u)\,E_{2-a}(2\hat{s}_\kappa)\,\mathrm{e}^{-\hat{\omega}}$$
$$-\frac{\langle\bar{q}_2 q_2\rangle\tau^3}{\pi^2}\left[A\hat{\omega}u + B\hat{m}_1\right]f(2\tau\omega\bar{u})\,E_{2-a}(2\hat{s}_{\bar{\kappa}})\,\mathrm{e}^{-\hat{\omega}}$$
$$+\frac{2B}{3}\langle\bar{u}u\rangle\langle\bar{q}_2 q_2\rangle\,\tau^2\,f(2\tau\omega u)\,f(2\tau\omega\bar{u})\,E_{3-2a}(2\hat{s}_{\kappa\bar{\kappa}})\,\mathrm{e}^{-\hat{\omega}},$$

Occured convenient to introduce the function

$$E_a(x) = \frac{1}{\Gamma(a+1)}\int_0^x dt\, t^a \mathrm{e}^{-t} = 1 - \frac{\Gamma(a+1,x)}{\Gamma(a+1)}$$

$$s_\omega = s_0 - \omega/2, \quad \kappa = \lambda/(2u\omega\tau), \quad \bar{\kappa} = \lambda/(2\bar{u}\omega\tau)$$
$$\hat{\omega} = \omega/(2\tau), \quad \hat{s}_\omega = s_\omega/(2\tau), \quad \hat{m}_{1,2} = m_{1,2}/(2\tau)$$
$$\hat{s}_\kappa = \hat{s}_\omega - \kappa/2, \quad \hat{s}_{\bar{\kappa}} = \hat{s}_\omega - \bar{\kappa}/2, \quad \hat{s}_{\kappa\bar{\kappa}} = \hat{s}_\omega - \kappa/2 - \bar{\kappa}/2$$

QCD sum rules

QCD sum rules constrain certain moments

$$\langle f(\omega,u)\rangle_k \equiv \int_0^{2s_0} \omega d\omega \int_0^1 du\, f(\omega,u)\, \tilde{\psi}_t^{\mathrm{SR}}(\omega,u)$$

LCDAs normalization can be fixed by

$$\int_0^{2s_0} \omega d\omega \int_0^1 du\, \tilde{\psi}_t^{\mathrm{SR}}(\omega,u) \equiv 1$$

Numerical values of the parameters

τ	0.6 ± 0.2	m_s (1 GeV)	128 ± 21 MeV
$\langle \bar{q}q \rangle$ (1 GeV)	$-(242^{+28}_{-19})$ MeV^3	$\langle \bar{s}s \rangle / \langle \bar{q}q \rangle$	0.8 ± 0.3
m_0^2	0.8 ± 0.2 GeV^2	λ	0.16 GeV^2

Numerical analysis

Numerical values of first several moments

H_Q	t	$\langle \omega^{-1} \rangle$	$\langle C_1^{3/2} \rangle$	$\langle \omega^{-1} C_1^{3/2} \rangle$	$\langle C_2^{3/2} \rangle$	$\langle \omega^{-1} C_2^{3/2} \rangle$
Λ_b	2	$1.65^{+0.91}_{-0.47}$	0	0	$1.00^{+0.54}_{-1.03}$	$0.61^{+0.76}_{-1.45}$
Ξ_b	2	$1.61^{+0.71}_{-0.42}$	$0.10^{+0.10}_{-0.06}$	$0.08^{+0.07}_{-0.04}$	$0.98^{+0.49}_{-0.82}$	$0.69^{+0.63}_{-1.07}$
H_Q	**t**	**$\langle \omega^{-1} \rangle$**	**$\langle C_1^{1/2} \rangle$**	**$\langle \omega^{-1} C_1^{1/2} \rangle$**	**$\langle C_2^{1/2} \rangle$**	**$\langle \omega^{-1} C_2^{1/2} \rangle$**
Λ_b	3s	$2.16^{+0.70}_{-0.36}$	0	0	$-0.032^{+0.022}_{-0.041}$	$-0.29^{+0.14}_{-0.27}$
	3σ	0	1	$1.54^{+0.14}_{-0.22}$	0	0
	4	$2.84^{+0.88}_{-0.46}$	0	0	$-0.108^{+0.035}_{-0.018}$	$-0.41^{+0.08}_{-0.15}$
Ξ_b	3s	$2.08^{+0.50}_{-0.29}$	$0.11^{+0.10}_{-0.06}$	$0.063^{+0.080}_{-0.047}$	$0.87^{+0.08}_{-0.14}$	$0.84^{+0.27}_{-0.45}$
	3σ	$0.00054^{+0.00033}_{-0.00054}$	1	$1.51^{+0.12}_{-0.19}$	$0.054^{+0.033}_{-0.054}$	$0.098^{+0.061}_{-0.098}$
	4	$2.73^{+0.61}_{-0.35}$	$0.12^{+0.09}_{-0.05}$	$0.05^{+0.09}_{-0.05}$	$0.55^{+0.18}_{-0.11}$	$0.99^{+0.16}_{-0.09}$

Numerical analysis

Simple models for the baryon LCDAs at the scale $\mu_0 = 1$ GeV are proposed

$$\tilde{\psi}_2(\omega,u) = \omega^2 u(1-u) \sum_{n=0}^{2} \frac{a_n^{(2)}}{{\epsilon_n^{(2)}}^4} C_n^{3/2}(2u-1)\, e^{-\omega/\epsilon_n^{(2)}},$$

$$\tilde{\psi}_{3s}(\omega,u) = \frac{\omega}{2} \sum_{n=0}^{2} \frac{a_n^{(3)}}{{\epsilon_n^{(3)}}^3} C_n^{1/2}(2u-1)\, e^{-\omega/\epsilon_n^{(3)}},$$

$$\tilde{\psi}_{3\sigma}(\omega,u) = \frac{\omega}{2} \sum_{n=0}^{3} \frac{b_n^{(3)}}{{\eta_n^{(3)}}^3} C_n^{1/2}(2u-1)\, e^{-\omega/\eta_n^{(3)}},$$

$$\tilde{\psi}_4(\omega,u) = \sum_{n=0}^{2} \frac{a_n^{(4)}}{{\epsilon_n^{(4)}}^2} C_n^{1/2}(2u-1)\, e^{-\omega/\epsilon_n^{(4)}},$$

Numerical analysis

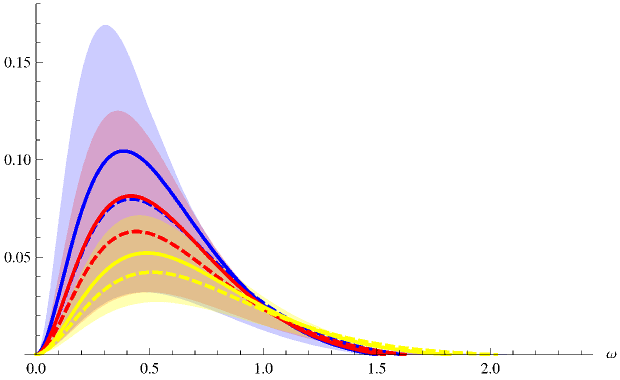
Estimates of the parameters entering the theoretical models for the heavy baryon LCDAs

H_Q	t	$\varepsilon_0^{(t)}$	$\varepsilon_1^{(t)}$	$\varepsilon_2^{(t)}$	$a_1^{(t)}$	$a_2^{(t)}$
Λ_b	2	$0.201^{+0.143}_{-0.059}$	0	$0.551^{+\infty}_{-0.356}$	0	$0.391^{+0.279}_{-0.279}$
	3	$0.232^{+0.047}_{-0.056}$	0	$0.055^{+0.010}_{-0.020}$	0	$-0.161^{+0.108}_{-0.207}$
	4	$0.352^{+0.067}_{-0.083}$	0	$0.262^{+0.116}_{-0.132}$	0	$-0.541^{+0.173}_{-0.090}$
Ξ_b	2	$0.207^{+0.073}_{-0.063}$	$0.461^{+0.620}_{-0.284}$	$0.469^{+\infty}_{-0.559}$	$0.058^{+0.058}_{-0.034}$	$0.380^{+0.189}_{-0.319}$
	3	$0.218^{+0.043}_{-0.047}$	$0.877^{+0.820}_{-0.152}$	$0.049^{+0.005}_{-0.012}$	$0.037^{+0.032}_{-0.019}$	$-0.027^{+0.016}_{-0.027}$
	4	$0.378^{+0.065}_{-0.080}$	$2.291^{+\infty}_{-0.842}$	$0.286^{+0.130}_{-0.150}$	$0.039^{+0.030}_{-0.018}$	$-0.090^{+0.037}_{-0.021}$

H_Q	t	$\eta_1^{(t)}$	$\eta_2^{(t)}$	$\eta_3^{(t)}$	$b_2^{(t)}$	$b_3^{(t)}$
Λ_b	3	$0.324^{+0.054}_{-0.026}$	0	$0.633^{+0.0??}_{-0.0??}$	0	$-0.240^{+0.240}_{-0.147}$
Ξ_b	3	$0.218^{+0.043}_{-0.047}$	$0.877^{+0.820}_{-0.152}$	$0.049^{+0.005}_{-0.012}$	$0.037^{+0.032}_{-0.019}$	$-0.027^{+0.016}_{-0.027}$

Numerical analysis

Twist-2 LCDAs of Σ (blue), Ξ (red) and Ω (yellow) baryons at the energy scales $\mu_0 = 1$ GeV (solid line) and $\mu = 2.5$ GeV (dashed line) estimated within the range $A \in [0, 1]$



Numerical analysis

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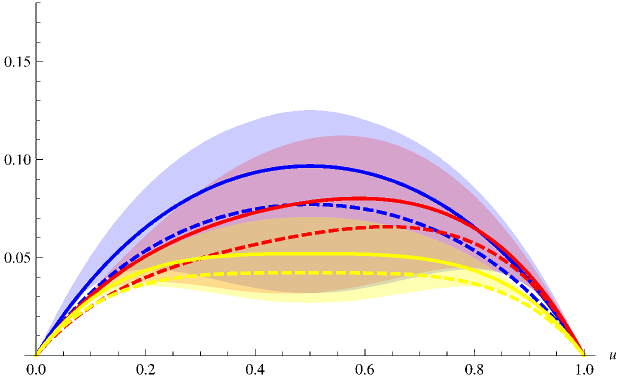

Conclusions

- The total set of the non-local light-ray operators for the ground-state heavy baryons is constructed in the framework of HQET
- Their matrix elements between the heavy-baryon state and vacuum determine the LCDAs of different twist through the diquark operator
- First several moments are calculated within the method of QCD sum rules
- Simple theoretical models for the LCDAs have been proposed and their parameters are fitted based on the QCD sum rules estimations
- $SU(3)_F$ breaking effects are of order 10%