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Λ_c^+ semileptonic decay

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Contents:

- **Review**
- **Semileptonic decay via QCDSR**
- **Results of Λ_c^+ semileptonic decay**
- **Summary**

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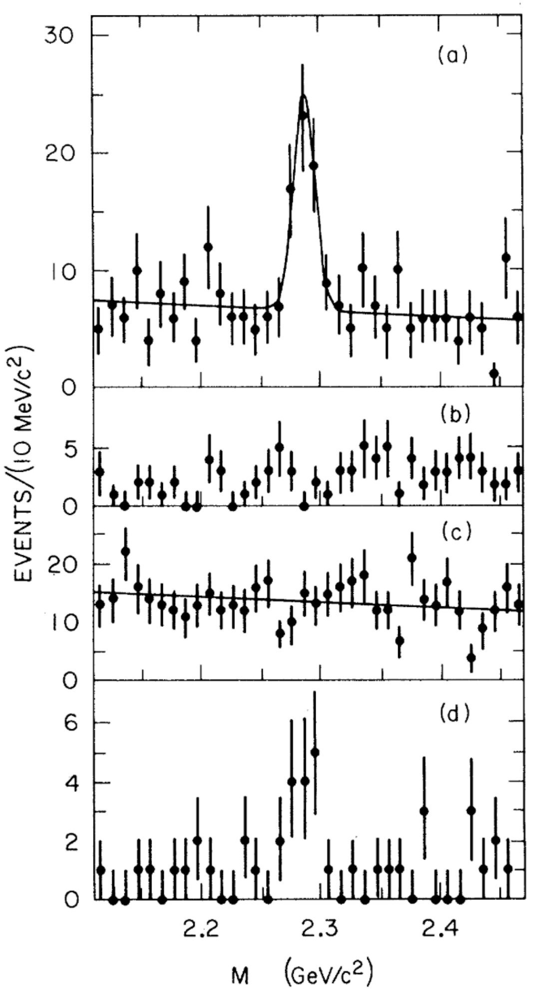
Observation of Λ_c^+ baryon



Phys. Rev. Lett. 44, 10 (1980)

Λ_c: Lightest charmed baryon

- Spin-0 diquark (ud) + charm quark
- $c \rightarrow W^+ + s\,(d)$
- Final state of heavier baryons decay

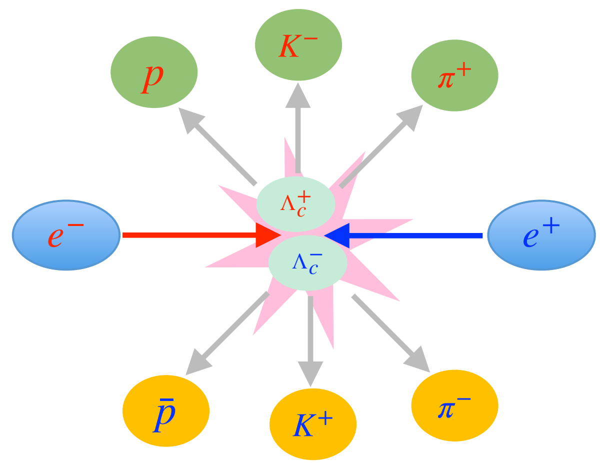
Λ_c^+ hadronic decay

★ BESIII: produce $\Lambda_c^+\bar{\Lambda}_c^-$ at 4.6 GeV, providing a clean environment (2014)

TABLE III. Comparison of the measured BFs in this work with previous results from PDG [4]. For our results, the first uncertainties are statistical and the second are systematic.

Mode	This work (%)	PDG (%)
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30
$pK^-\pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3
$pK_S^0\pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50
$pK_S^0\pi^+\pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35
$pK^-\pi^+\pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0
$\Lambda\pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28
$\Lambda\pi^+\pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3
$\Lambda\pi^+\pi^-\pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7
$\Sigma^0\pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28
$\Sigma^+\pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34
$\Sigma^+\pi^+\pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0
$\Sigma^+\omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0

Phys. Rev. Lett. 116, 052001 (2016).



golden reference channel:

combining measurements of ratios

with $\mathscr{B}(\Lambda_c^+ \to pK^-\pi^+)$

$\mathscr{B}(\Lambda_c^+ \to pK^-\pi^+) = (6.84 \pm 0.24^{+0.21}_{-0.27})\ \%$

Phys. Rev. Lett. 113, 042002 (2014).

Λ_c^+ semileptonic decay

Motivation for studying semileptonic decay:

- Study the strong interactions in a **relatively simple environment**
- Determine the underlying **weak couplings** of quarks to the W boson
- Investigate the decay dynamics (form factors)

1990s: $\sigma(e^+e^- \to \Lambda_c^+ X)\mathscr{B}(\Lambda_c^+ \to \Lambda \ell \nu_\ell)$ Phys. Lett. B 269, 234 (1991)

$\mathscr{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e) \approx (2.53 \pm 0.70)\,\%$ Phys. Lett. B 323, 219 (1994)

$\mathscr{B}(\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu) \approx (2.35 \pm 0.88)\,\%$

2015: $\mathscr{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (3.63 \pm 0.38 \pm 0.20)\,\%$ Phys. Rev. Lett. 115, 221805 (2015).

2017: $\mathscr{B}(\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu) = (3.49 \pm 0.46 \pm 0.27)\,\%$ Phys. Lett. B 767, 42–47 (2017) .

2018: $\mathscr{B}(\Lambda_c^+ \to X e^+ \nu_e) = (3.95 \pm 0.34 \pm 0.09)\,\%$ Phys. Rev. Lett. 121, 251801 (2018).

2022: $\mathscr{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (3.56 \pm 0.11 \pm 0.07)\,\%$ Phys. Rev. Lett. 129, 231803 (2022)

2023: $\mathscr{B}(\Lambda_c^+ \to X e^+ \nu_e) = (4.06 \pm 0.10 \pm 0.09)\,\%$ Phys.Rev.D 107, 052003 (2023)

2023: $\mathscr{B}(\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu) = (3.48 \pm 0.14 \pm 0.10)\,\%$ Phys.Rev.D 108, L031105 (2023)

Other possible SL decay mode of Λ_c^+

$$\frac{\mathscr{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e)}{\mathscr{B}(\Lambda_c^+ \to X e^+ \nu_e)} \approx 88\,\%$$

potential exclusive semileptonic decay mode

excited Λ

multi-body decay

neutron: $\Lambda_c^+ \to n \ell \nu_\ell$

……

$\mathscr{B}(\Lambda_c^+ \to \Lambda(1520) e^+ \nu_e) =$ $(1.0 \pm 0.5) \times 10^{-3}$

$\mathscr{B}(\Lambda_c^+ \to \Lambda(1405) e^+ \nu_e) =$ $(0.4 \pm 0.2) \times 10^{-3}$

Phys. Rev. D 106, 112010 (2022)

$\mathscr{B}(\Lambda_c^+ \to \Lambda \pi^+ \pi^- e^+ \nu_e) < 3.9 \times 10^{-4}$

$\mathscr{B}(\Lambda_c^+ \to p K_s^0 \pi^- e^+ \nu_e) < 3.3 \times 10^{-4}$

Phys. Lett. B 843, 137993 (2023)

No available experimental data

Experimental perspective of $\Lambda_c^+ \to n\ell\nu_\ell$

tag technique. For the SCS mode, studying $\Lambda_c^+ \to ne^+\nu_e$ will be challenging due to the presence of two missing particles in the final state and the dominant $\Lambda_c^+ \to \Lambda e^+\nu_e$ backgrounds. However, we still have the opportunity to identify the decay by taking advantage of the well constrained kinematics, the clean reaction environment and neutron shower information inside the electromagnetic calorimeter. Meanwhile, another SCS mode $\Lambda_c^+ \to p\pi^- e^+\nu_e$ can be searched for in the enlarged data set. Chin.Phys.C 44, 040001 (2020)

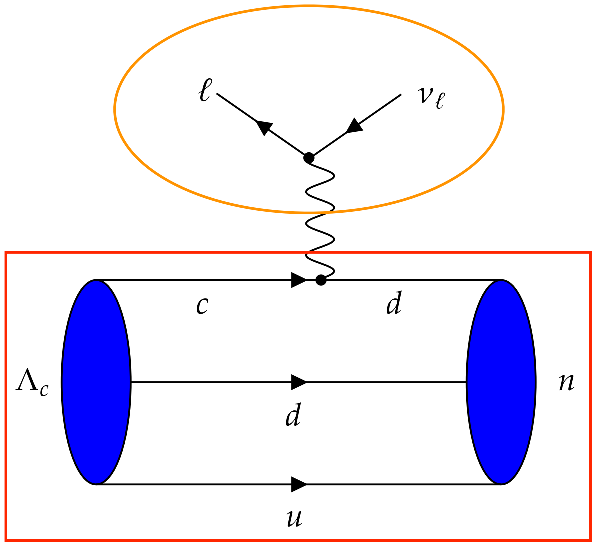
Obstacles → Recent progress (detector performance, analysis technique)

- Two missing particles in $\Lambda_c \to n\ell\nu_\ell$
- Dominant $\Lambda_c \to \Lambda\ell\nu_\ell$ backgrounds

Recent progress:

- $\Lambda_c^+ \to nK_s^0\pi^+$
  Phys. Rev. Lett. 118, 112001 (2017)
- $\Lambda_c^+ \to n\pi^+$
  Phys. Rev. Lett. 128, 142001 (2022)
- $\Lambda_c^+ \to n\pi^+\pi^0$
  Chin. Phys. C 47, 023001 (2023)

Theoretical perspective of $\Lambda_c^+ \to n\ell\nu_\ell$



leptonic part:

- W^+ decay: $W^+ \to \ell\nu_\ell$
- Solved by perturbation theory

hadronic part:

- Single Cabbibo-suppressed decay mode: $c \to d$ via external W^+ emission
- Parametrized in terms of transition form factors, taking into account nonperturbative effects

nonperturbative techniques needed

Form factors in QCD sum rules

SUM RULES AND THE PION FORM FACTOR IN QCD

V.A. NESTERENKO and A.V. RADYUSHKIN

Laboratory of Theoretical Physics, JINR, Dubna, USSR

Received 12 May 1982

MESON WIDTHS AND FORM FACTORS AT INTERMEDIATE MOMENTUM TRANSFER IN NON-PERTURBATIVE QCD

B.L. IOFFE and A.V. SMILGA

ITEP, Moscow, 117259, USSR

Received 14 September 1982

pion electromagnetic form factor

↓

decay observables

The method of QCD sum rules can be generalized in order to calculate the hadronic matrix elements of electromagnetic and weak transitions. In this case one starts from three-point vacuum correlation functions and uses double dispersion relations. This approach has been extensively used, both for light and heavy hadrons. The applications include the pion electromagnetic form factor,[100] radiative charmonium decays such as $J/\psi \to \eta_c \gamma$,[101] D and B semileptonic and flavor-changing neutral current (FCNC) transitions [102–107] and, more recently, the radiative decays $\phi \to (\eta, \eta')\gamma$.[108]

P. Colangelo et al., *QCD sum rules, a modern perspective*(2000)

→

- Radiative decay
- FCNC transition
- Semileptonic decay
- Strong decay
- ……

Research of SL decay in QCD sum rules

Meson semileptonic decay:

- $D \to K$: [Ball, Braun, Dosch, 1991; M.Z. Yang, 2006]
- $D \to \pi$: [Ball, 1993]
- $B \to \pi$: [Narison, 1992; Belyaev, Khodjamirian, Ruckl, 1993; Ball, 1993]
- $B \to K$: [D.S. Du, J.W. Li, M.Z. Yang, 2004]
- $B_c \to D$: [Leljak, Melic, 2020]
- $B_c \to \eta_c$: [Z.G. Wang, 2014]
- ……

Baryon semileptonic decay:

- $\Lambda_b \to \Lambda_c$: [Y.B. Dai, C.S. Huang, M.Q. Huang, C. Liu, 1996; Dosch, Ferreira, Nielsen, Rosenfeld, 1999; Marques de Carvalho, Navarra, Nielsen, Ferreira, Dosch, 1999; Z.X. Zhao, R.H. Li, Y.L. Shen, Y.J. Shi, 2020]
- $\Lambda_b \to p$: [C.S. Huang, C.F. Qiao, H.G. Yan, 1998]
- $\Lambda_c \to \Lambda$: [Dosch, Ferreira, Nielsen, Rosenfeld, 1999; Marques de Carvalho, Navarra, Nielsen, Ferreira, Dosch, 1999]
- ……

Other methods of SL decay

- Lattice QCD
- Light-front quark model
- MIT bag model
- constituent quark model
- Light-cone sum rules
- relativistic quark model
- $SU(3)$ flavor symmetry
- ……

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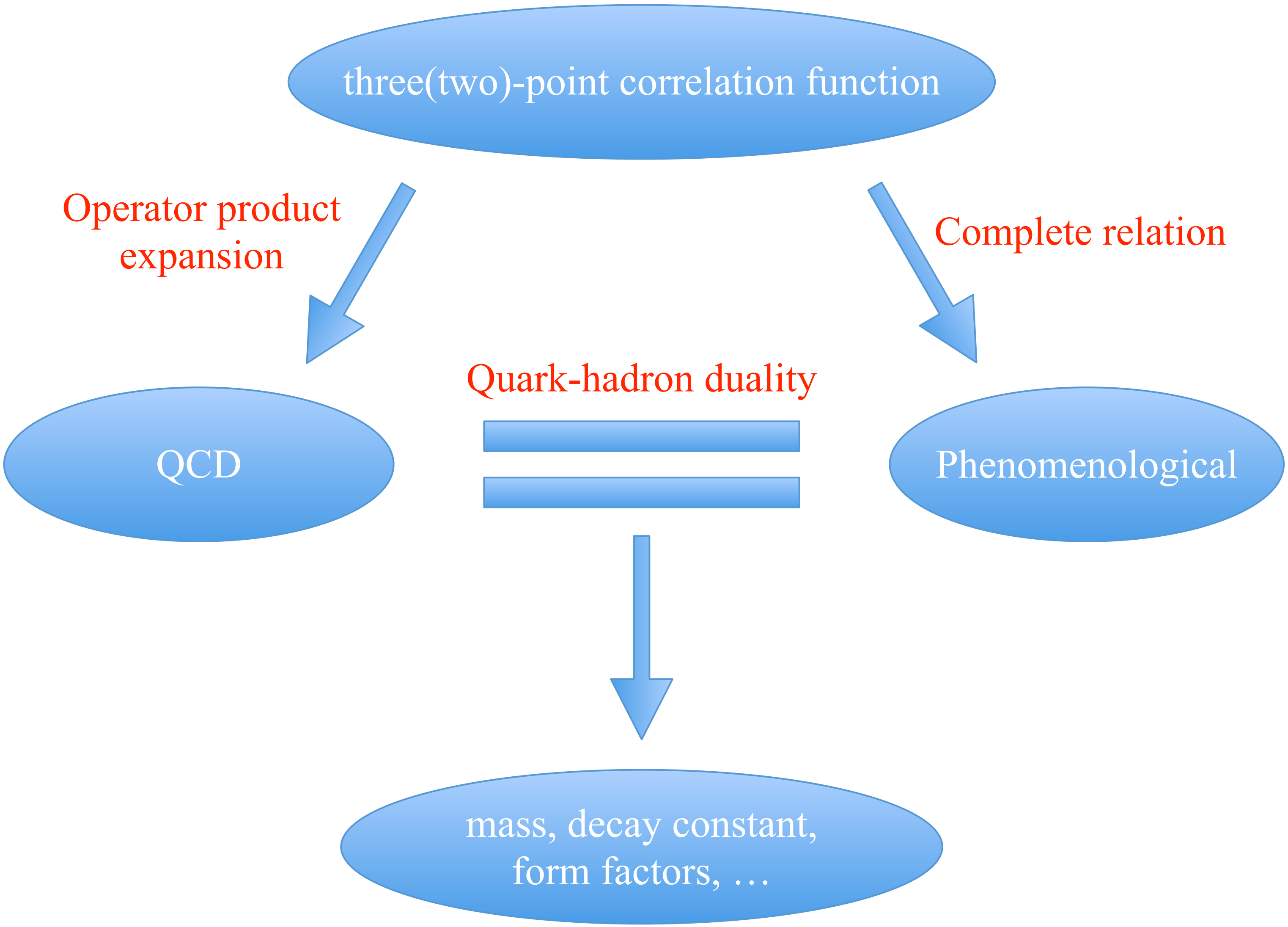
Basic idea


three(two)-point correlation function
Operator product expansion
Complete relation
Quark-hadron duality
QCD
Phenomenological
mass, decay constant, form factors, …

Three-point correlation function

$$\Pi_\mu(q_1^2, q_2^2, q^2) = i^2 \int d^4x\ d^4y\ e^{i(q_1 x - q_2 y)} < 0 \,|\, T\{j_{\Lambda_c^+}(x) j_\mu(0) j_n^\dagger(y)\} \,|\, 0 >$$

$j_{\Lambda_c^+(n)}$: interpolating current that can couple to the hadronic states

j_μ: weak transition current

$$j_{\Lambda_c^+} = \epsilon_{ijk}\left(u_i^T C \gamma_5 d_j\right) c_k$$

$$j_n = \epsilon_{ijk}\left(u_i^T C \gamma_5 d_j\right) d_k$$

$$j_\mu = \bar{c}\gamma_\mu(1-\gamma_5)d$$

dispersion relations $\Pi_\mu(q_1^2, q_2^2, q^2) = \int ds_1 \int ds_2 \frac{\rho_\mu(s_1, s_2, q^2)}{(s_1 - q_1^2)(s_2 - q_2^2)}$

QCD side

$$\Pi_\mu(q_1^2, q_2^2, q^2) = i^2 \int d^4x\ d^4y\ e^{i(q_1 x - q_2 y)} < 0 | T\{j_{\Lambda_c^+}(x) j_\mu(0) j_n^\dagger(y)\} | 0 >$$

dispersion relations

operator product expansion:

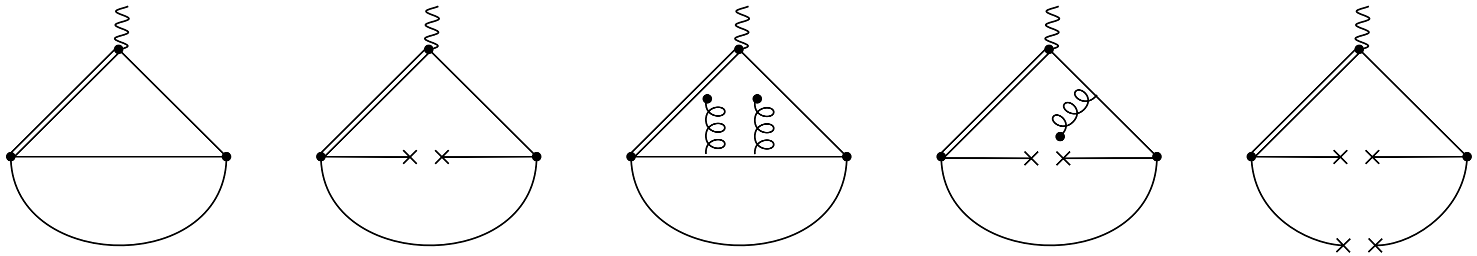
$$\Pi_\mu(q_1^2, q_2^2, q^2) = \sum_d C_{d,\mu}(q_1^2, q_2^2) < 0 | O_d(0) | 0 >$$

$$\Pi_\mu^{\rm QCD}(q_1^2, q_2^2, q^2) = \int_{s_1^{\rm min}}^\infty ds_1 \int_{s_2^{\rm min}}^\infty ds_2 \frac{\rho_\mu^{\rm QCD}(s_1, s_2, q^2)}{(s_1 - q_1^2)(s_2 - q_2^2)}$$

$< 0 | O_d(0) | 0 >$

- vacuum condensate
- describe nonperturbative effect

$$\rho_\mu^{\rm QCD}(s_1, s_2, q^2) = \rho_\mu^{\rm pert}(s_1, s_2, q^2) + \rho_\mu^{\langle\bar{q}q\rangle}(s_1, s_2, q^2) + \rho_\mu^{\langle g_s^2 G^2\rangle}(s_1, s_2, q^2) + \rho_\mu^{\langle g_s \bar{q}\sigma\cdot Gq\rangle}(s_1, s_2, q^2) + \rho_\mu^{\langle\bar{q}q\rangle^2}(s_1, s_2, q^2)$$



Phenomenological side

$$\Pi_\mu(q_1^2, q_2^2, q^2) = i^2 \int d^4x\, d^4y\, e^{i(q_1 x - q_2 y)} < 0 \,|\, T\{ j_{\Lambda_c^+}(x)\, j_\mu(0)\, j_n^\dagger(y)\} \,|\, 0 >$$

dispersion relations

$$\sum_H |H\rangle \langle H| = 1$$

$$\Pi_\mu^{\mathrm{phe}}(q_1^2, q_2^2, q^2) = \sum_{\mathrm{spins}} \frac{< 0 \,|\, j_{\Lambda_c} \,|\, \Lambda_c(q_1) > \;\; < \Lambda_c(q_1) \,|\, j_\mu \,|\, n(q_2) > \;\; < n(q_2) \,|\, j_n \,|\, 0 >}{(q_1^2 - M_{\Lambda_c}^2)(q_2^2 - M_n^2)}$$

+higher resonances and continuum states,

$$< 0 \,|\, j_{\Lambda_b} \,|\, \Lambda_c(q_1) > \; = \lambda_{\Lambda_c} u_{\Lambda_c}(q_1)$$

$$< 0 \,|\, j_n \,|\, n(q_2) > \; = \lambda_n u_n(q_2),$$

$$< \Lambda_c(q_1) \,|\, j_\mu \,|\, n(q_2) > \; = \bar{u}_{\Lambda_c}(q_1) \left[f_1(q^2)\gamma_\mu + i f_2(q^2)\sigma^{\mu\nu} \frac{q_\nu}{M_{\Lambda_c}} + f_3(q^2) \frac{q_\mu}{M_{\Lambda_c}} \right] u_n(q_2)$$
$$- \bar{u}_{\Lambda_c}(q_1) \left[g_1(q^2)\gamma_\mu + i g_2(q^2)\sigma^{\mu\nu} \frac{q_\nu}{M_{\Lambda_c}} + g_3(q^2) \frac{q_\mu}{M_{\Lambda_c}} \right] \gamma_5 u_n(q_2)$$

$$\Pi_\mu^{\mathrm{phe}}(q_1^2, q_2^2, q^2) = \frac{\lambda_n \left(\not{q}_2 + M_n \right) \left[f_1(q^2)\gamma_\mu + i f_2(q^2)\sigma^{\mu\nu} \frac{q_\nu}{M_{\Lambda_c}} + f_3(q^2) \frac{q_\mu}{M_{\Lambda_c}} \right] \lambda_{\Lambda_c} \left(\not{q}_1 + M_{\Lambda_c} \right)}{(q_1^2 - M_{\Lambda_c}^2)(q_2^2 - M_n^2)}$$
$$- \frac{\lambda_n \left(\not{q}_2 + M_n \right) \left[g_1(q^2)\gamma_\mu + i g_2(q^2)\sigma^{\mu\nu} \frac{q_\nu}{M_{\Lambda_c}} + g_3(q^2) \frac{q_\mu}{M_{\Lambda_c}} \right] \gamma_5 \lambda_{\Lambda_c} \left(\not{q}_1 + M_{\Lambda_c} \right)}{(q_1^2 - M_{\Lambda_c}^2)(q_2^2 - M_n^2)}.$$

Borel transformation

Suppress the higher excited states and continuum states contributions

$$\mathscr{B}[g(Q^2)] \equiv g(M_B^2) = \lim_{\substack{Q^2, n \to \infty \\ n/Q^2 = 1/M_B^2}} \frac{(-1)^n (Q^2)^{n+1}}{n!} \left(\frac{\partial}{\partial Q^2} \right)^n g(Q^2)$$

Quark-hadron duality

Establish the equivalence between two sides

$$\Pi_\mu^{\text{phe}}(q_1^2, q_2^2, q^2) \simeq \int_{s_1^{\min}}^{s_1^0} ds_1 \int_{s_2^{\min}}^{s_2^0} ds_2 \frac{\rho_\mu^{\text{QCD}}(s_1, s_2, q^2)}{(s_1 - q_1^2)(s_2 - q_2^2)}$$

$s_{1(2)}^0$: threshold parameters

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$\Lambda_c^+ \to n\ell\nu_\ell$ form factors at $q^2 = 0$

General procedure of exclusive SL decay:

- Step1: determinate the form factors at a particular value of q^2
- Step2: extrapolation over the entire q^2 region
- Step3: construct decay observables via form factors

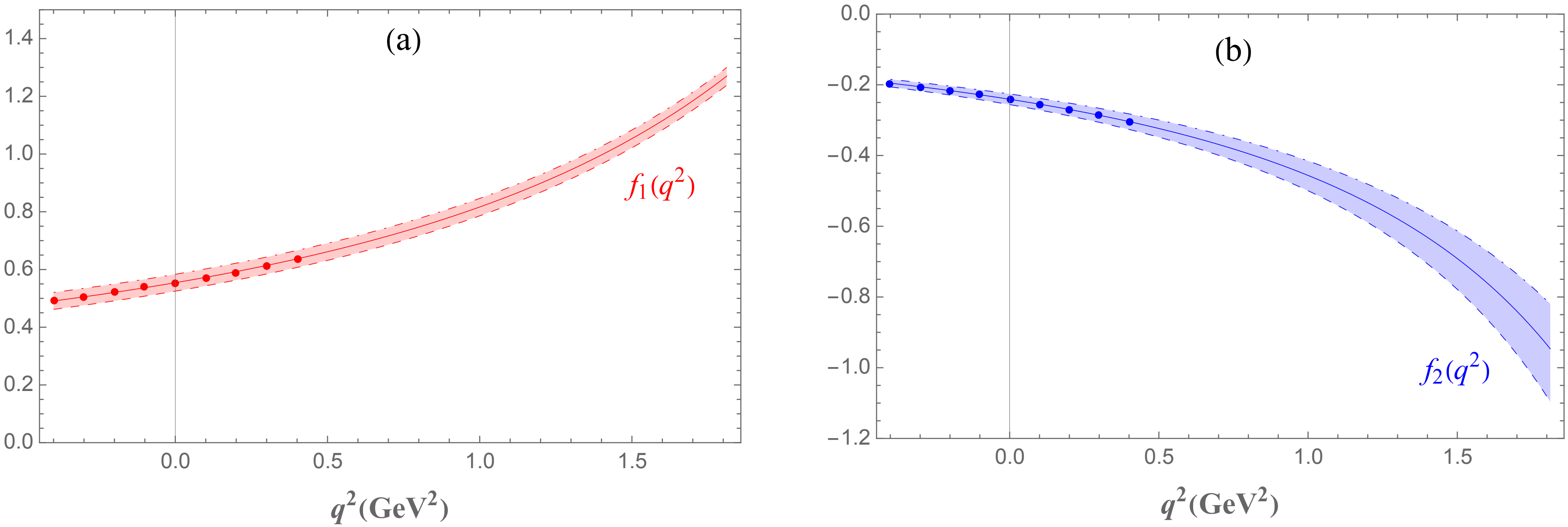
method	$f_1(0)$	$f_2(0)$	$g_1(0)$	$g_2(0)$	Refs
QCDSR	0.53 ± 0.04	-0.25 ± 0.03	0.53 ± 0.04	-0.25 ± 0.03	this work
LCSR	$0.59^{+0.15}_{-0.16}$	$-0.43^{+0.13}_{-0.12}$	$0.55^{+0.14}_{-0.15}$	$-0.16^{+0.08}_{-0.05}$	Khodjamirian et al., JHEP(2011)
LF	0.513	-0.266	0.443	-0.034	Z.X. Zhao, CPC(2021)
CCQM	0.47	-0.246	0.414	0.073	T. Gutsche et al., PRD(2014)
RQM	0.627	-0.259	0.433	0.118	R. N. Faustov et al., EPJC(2016)
MBM	0.40	-0.22	0.43	0.07	C. Q. Geng et al., PRD(2020)
LQCD	0.672 ± 0.039	-0.321 ± 0.038	0.602 ± 0.031	0.003 ± 0.052	S. Meinel, PRD(2018)

$\Lambda_c^+ \to n\ell\nu_\ell$ form factors

Need entire kinematic region $q^2 \in [m_\ell^2, (M_{\Lambda_c} - M_n)^2]$

- QCD sum rules is applicable in the large recoil region
- Employ dipole parametrization to extrapolate the obtained value

$$f_i(q^2) = \frac{f_i(0)}{\left(1 - q^2/M_{\Lambda_c}^2\right)\left(1 - a_1 q^2/M_{\Lambda_c}^2 + a_2 (q^2/M_{\Lambda_c}^2)^2\right)}$$



$\Lambda_c^+ \to n\ell\nu_\ell$ decay observables

- differential decay width:

$$\frac{d\Gamma\left(\Lambda_c \to n\ell\nu_\ell\right)}{dq^2} = \frac{G_F^2 \left|V_{cd}\right|^2 q^2 \sqrt{Q_+ Q_-}}{384\,\pi^3 M_{\Lambda_c}^3}(1-\frac{m_\ell^2}{q^2})^2 H_{\rm tot}$$

- the leptonic forward-backward asymmetry:

$$A_{FB}(q^2) = \frac{\frac{d\Gamma}{dq^2}(\text{forward}) - \frac{d\Gamma}{dq^2}(\text{backward})}{\frac{d\Gamma}{dq^2}} = \frac{3}{4}\frac{H^2_{\frac{1}{2},1} - H^2_{-\frac{1}{2},-1} - 2\frac{m_\ell^2}{q^2}(H_{\frac{1}{2},0}H_{\frac{1}{2},t} + H_{-\frac{1}{2},0}H_{-\frac{1}{2},t})}{H_{\rm tot}}$$

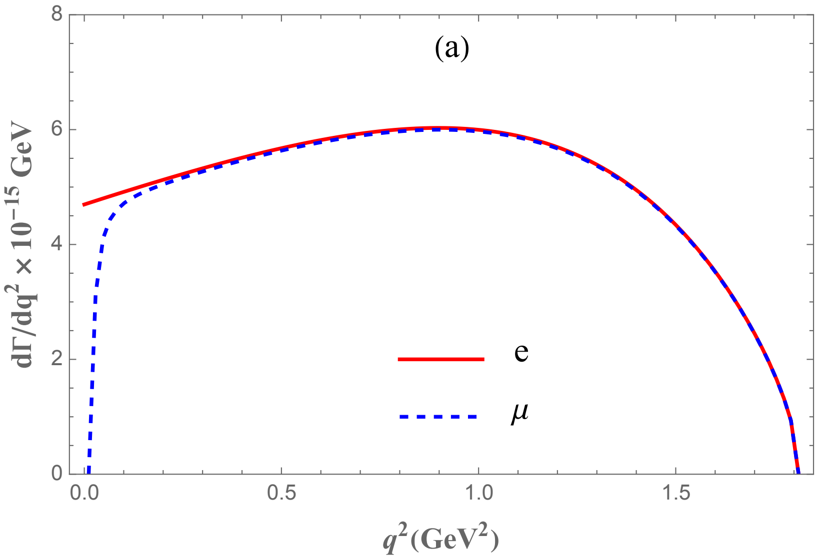
- asymmetry parameter:

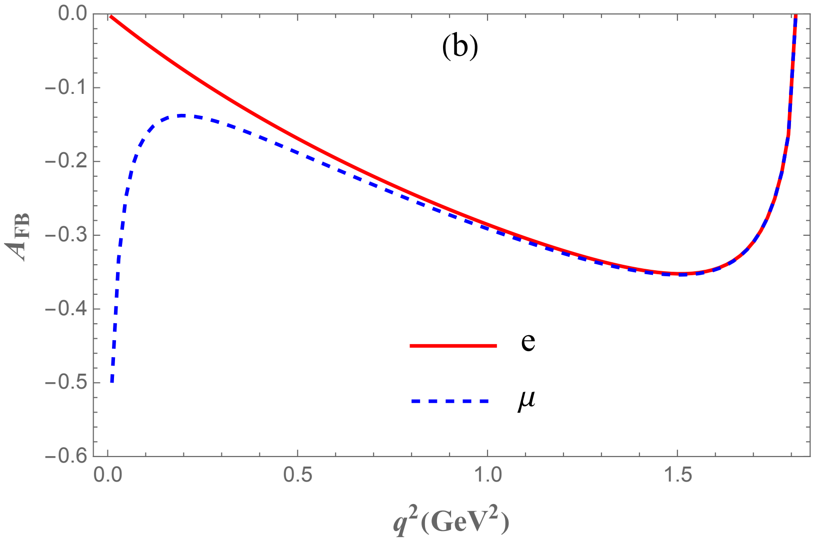
$$\alpha_{\Lambda_c}(q^2) = \frac{d\Gamma^{\lambda'=\frac{1}{2}}/dq^2 - d\Gamma^{\lambda'=-\frac{1}{2}}/dq^2}{d\Gamma^{\lambda'=\frac{1}{2}}/dq^2 + d\Gamma^{\lambda'=-\frac{1}{2}}/dq^2}$$

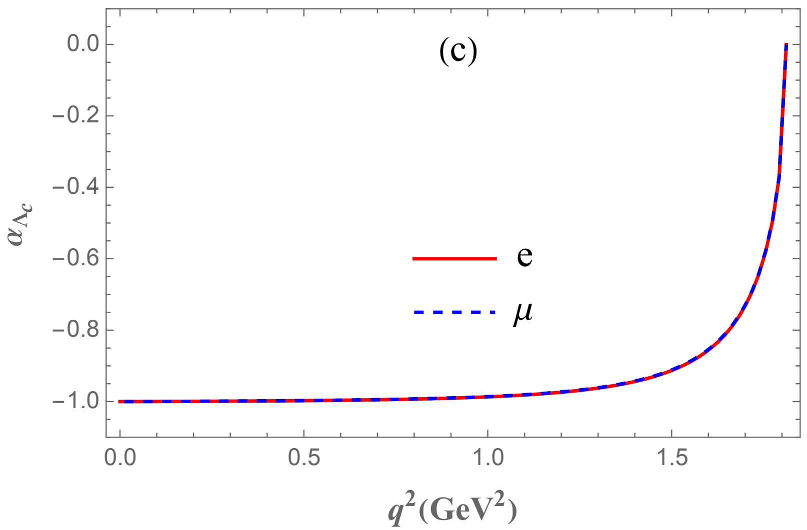
H: helicity amplitude

contain the information of form factors

$\Lambda_c^+ \to n\ell\nu_\ell$ decay observables







- $q^2 \to m_\ell^2$: the dependence of $d\Gamma/dq^2$ and A_{FB} on the lepton mass is significantly different
- $q^2 \to q_{max}^2$: the dependence of three decay observables on the lepton mass is consistent
- α_{Λ_c} is indistinguishable throughout the entire physical region

$\Lambda_c^+ \to n\ell\nu_\ell$ numerical results

channel	method	$\mathcal{B}(\%)$	$\langle A_{FB}\rangle$	$\langle \alpha_{\Lambda_c}\rangle$	Ref
$\Lambda_c \to ne^+\nu_e$	QCDSR	0.280 ± 0.031	-0.23 ± 0.01	-0.94 ± 0.03	this work
	LF	0.201			Z.X. Zhao, CPC(2018)
	CCQM	0.207	-0.236		T.Gutsch et al., PRD(2014)
	CQM	0.270			M.Pervin et al., PRC(2005)
	RQM	0.268	-0.251	-0.91	R.N. Faustov et al., EPJC(2016)
	$SU(3)$	0.289 ± 0.035			C.D. Lü et al., PRD(2016)
	$SU(3)$	0.51 ± 0.04		-0.89 ± 0.04	C.Q. Geng et al., PLB(2019)
	MBM	0.279		-0.87	C.Q. Geng et al., PRD(2020)
	LFCQM	0.36 ± 0.15		-0.96 ± 0.04	C.Q. Geng et al., PRD(2020)
	LQCD	0.410 ± 0.026			S. Meinel, PRD(2018)
$\Lambda_c \to n\mu^+\nu_\mu$	QCDSR	0.274 ± 0.030	-0.26 ± 0.01	-0.94 ± 0.03	this work
	CCQM	0.202	-0.260		T.Gutsch et al., PRD(2014)
	RQM	0.262	-0.276	-0.90	R.N. Faustov et al., EPJC(2016)
	LQCD	0.400 ± 0.026			S. Meinel, PRD(2018)

$\Lambda_c^+ \to \Lambda \ell \nu_\ell$ numerical results

$$j_n = \epsilon_{ijk}\left(u_i^T C\gamma_5 d_j\right) d_k \xrightarrow{d \to s} j_\Lambda = \epsilon_{ijk}\left(u_i^T C\gamma_5 d_j\right) s_k$$

channel	method	$\mathcal{B}(\%)$	$\langle A_{FB} \rangle$	$\langle \alpha_{\Lambda_c} \rangle$	Ref
$\Lambda_c \to \Lambda e^+ \nu_e$	QCDSR	3.37 ± 0.36	-0.20 ± 0.01	-0.88 ± 0.02	this work
	LQCD	3.80 ± 0.22	-0.20 ± 0.06	-0.87 ± 0.10	S. Meinel, PRL(2017)
	RQM	3.25	-0.21	-0.86	R.N. Faustov, EPJC(2016)
	CQM	2.78	-0.21	-0.87	T. Gutsche et al., PRD(2016)
	HBM	3.78 ± 0.25		-0.83	C.Q. Geng et al., PRD(2023)
	Exp	$3.56 \pm 0.11 \pm 0.07$	-0.24 ± 0.03	-0.86 ± 0.04	BESIII, PRL(2022)
$\Lambda_c \to \Lambda \mu^+ \nu_\mu$	QCDSR	3.26 ± 0.35	-0.23 ± 0.01	-0.88 ± 0.02	this work
	LQCD	3.69 ± 0.22	-0.17 ± 0.07	-0.87 ± 0.10	S. Meinel, PRL(2017)
	RQM	3.14	-0.24	-0.86	R.N. Faustov, EPJC(2016)
	CQM	2.69	-0.20	-0.87	T. Gutsche et al., PRD(2016)
	HBM	3.67 ± 0.23		-0.82	C.Q. Geng et al., PRD(2023)
	Exp	3.48 ± 0.17	-0.22 ± 0.04	-0.94 ± 0.08	BESIII, PRD(2023)

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- We calculated the transition form factors of $\Lambda_c \to n\ell\nu_\ell$ in the frame work of QCD sum rules.
- We predicted the branching fractions and decay asymmetry observables based on the obtained form factors. They are expected to be measured at BESIII, BELLEII, and LHCb experiment.
- We analyze the semileptonic decay mode $\Lambda_c^+ \to \Lambda\ell\nu_\ell$. Our results exhibit a strong agreement with the experimental data.
- Potential improvement: NLO corrections

Thanks