$B \to D^*$ Form Factors from Light-Cone Sum Rules

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Motivations: why do we need B to D* FFs?

- $|V_{cb}|$ extraction from branching ratios of $B \to D^* \mu\nu$
- prediction of R_{D^*} in the SM, i.e. to constrain NP contributions to $b \to cl\bar{\nu}$

- LCSRs complement Lattice results and Heavy Quark Expansion relations used in present analyses
- B-LCSRs have $1/m_b$ corrections (related to twist expansion), but there is no $1/m_c$ expansion!

- we present new twist 4 corrections to the $B \to D^*$ LCSRs, higher twists are expected to give corrections only of the order $O(1/m_b^2)$
- $O(\alpha_s)$ corrections are not considered

Light-Cone Sum Rules in a nutshell

- determine products of exclusive hadronic matrix elements from an artificial, less-exclusive, non-local hadronic matrix element $\Pi(k^2, q^2)$
- $\Pi(k^2, q^2)$ calculable for kinematics that impose light-cone dominance of the non-local operator
- results

$$\Pi(k^2, q^2) = f_B m_B \int ds \sum_{n,t} \frac{J_{n,t}(s, q^2)}{[k^2 - s]^n} \phi_t(s)$$

- $J_{n,t}$ can be computed from a hard scattering kernel
- B-meson Light-Cone Distribution Amplitudes (LCDAs) ϕ_t are necessary non-perturbative input
  - general $B \to V$, $B \to P$ results available [Khodjamirian et al. '06 + '08]
  - new insights on LCDAs triggered our revisiting of these sum rule results [Braun/Ji/Manashov '17]

Preliminary Results and Comparison

$B \to D^*$ FF	FKKM2008	GKvD2018		
			NEW Contrib.	
	2pt tw2+3 +3pt	2pt tw2+3	2pt tw4	3pt tw3+4
$A_1(q^2=0)$	0.73	0.65	-0.11	?
$A_2(q^2=0)$	0.66	0.57	-0.21	?
$A_0(q^2=0)$	0.78	0.70	-0.01	?
$A_0(0)/A_1(0)$	1.07	1.08	+0.21	?

[using the same input parameters, with q^2 the dilepton mass square]

ϕ_+, ϕ_- 2-particle L+NL twist contributions [Faller/Khodjamirian/Klein/Mannel '06]

$\mathbf{g}_+$ **new** 2-particle NNL twist contributions [Gubernari/Kokulu/van Dyk w.i.p.]

ϕ_3, ϕ_4 **new and self-consistent** 3-particle NL+NNL twist contr. [Gubernari/Kokulu/van Dyk w.i.p.]

Plans for presentation of results

- we plan to give numerical results for all form factors at $q^2 = 0$ and $q^2 = -5\,\text{GeV}^2$
- we consider $q^2 = +5\,\text{GeV}^2$ as an additional point, but will check convergence of the twist expansion first before committing to use it
- we plan to provide correlation matrices across form factors and across q^2
- we plan to provide numerical results in machine-readable form
  - probably JSON/YAML files, similar to what has been done for light-meson LCSRs [Bharucha/Straub/Zwicky '15]
- numerical evaluations are carried out with EOS and the code will be made publicly available at `https://github.com/eos/eos`

Backup slides

Power corrections

- correlator is calculated with on-shell B meson, using its Light-Cone Distribution Amplitudes (LCDAs)
- B-meson LCDAs are defined for bi-local currents involving an HQET field h_v
- power corrections to this involve power of the covariant derivative iD^μ
- strings of the type $iD^{\mu_1}\, iD^{\mu_2} \ldots iD^{\mu_n}$ are incorporated in LCDAs of increasing (collinear) twist

Benefits of the Braun et al. basis

- ϕ_3, ϕ_4, ... are LCDAs of definite collinear twist 3, 4, ...
- LCDAs of twists ≥ 5 are expected to contribute *beyond* the next-to-leading $1/m_b$ corrections! [Braun/Ji/Manashov '17]
- inserting a gluon field adds at least one unit of twist
  - 2-particle LCDAs start at twist 2, and are included in our results (up to and including twist 4)
  - 3-particle LCDAs start at twist 3, and are included in our results (up to and including twist 4)
  - 4-particle LCDAs start at twist 4, and are *not included in our results*
  - 4-particle LCDAs have autonomous RG behaviour, *do not mix with 3-particle LCDAs*

[Braun/Ji/Manashov '17]