$\Lambda_b \to \boldsymbol{p}$ transition form factors in perturbative QCD

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- Introduction
- Theoretical framework
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Introduction

- 研究对象：$\Lambda_b \to p$

- 研究方法：PQCD

- 研究发现：

①twist-4Λ_b重子LCDAs和twist-4和twist-5质子LCDAs起主要作用

②b夸克质量不够重,更高阶的贡献起着至关重要的作用

Theoretical framework

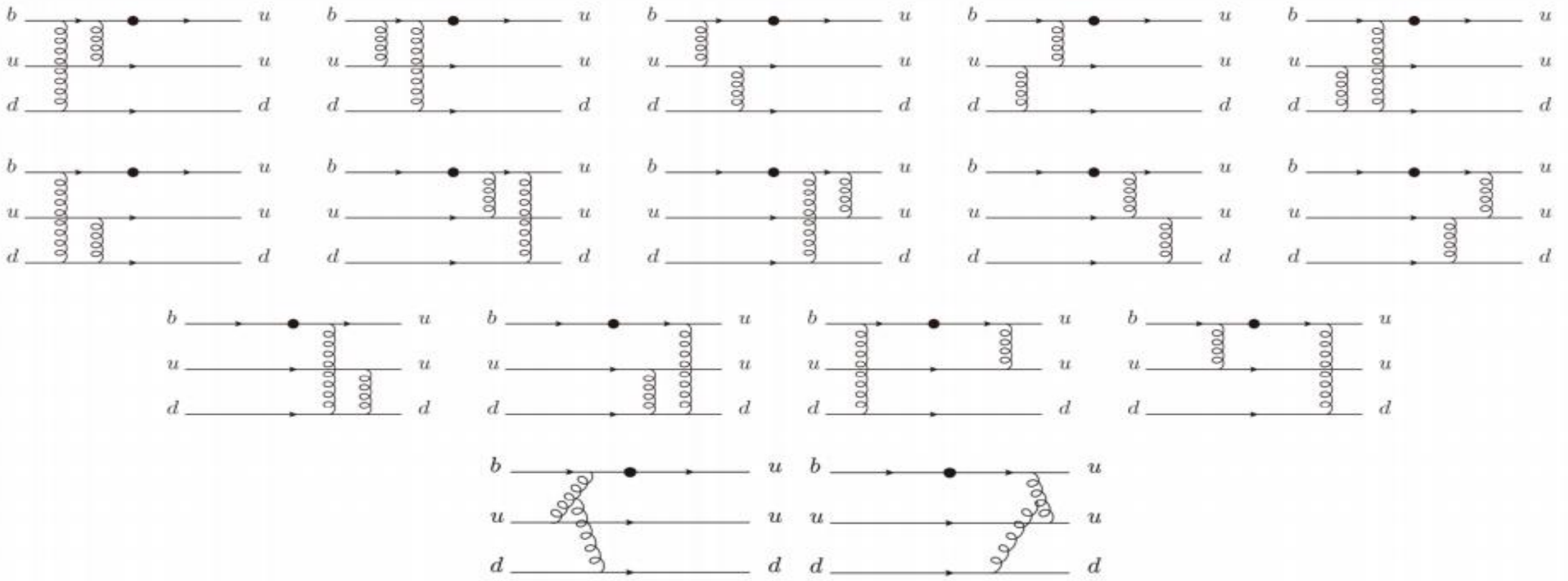

Figure 1: Feynman diagrams for the $\Lambda_b \to p$ transition form factors, where the black dots denote the weak interaction vertices. These diagrams are labelled by D_1, D_2,... and D_{16} in sequence in the text.

Theoretical framework

- Twist-3 LCDAs

$$V_1(x_i) = 120 x_1 x_2 x_3 [\phi_3^0 + \phi_3^+ (1 - 3x_3)], \tag{18}$$

$$A_1(x_i) = 120 x_1 x_2 x_3 (x_2 - x_1) \phi_3^-, \tag{19}$$

$$T_1(x_i) = 120 x_1 x_2 x_3 [\phi_3^0 + \frac{1}{2}(\phi_3^- - \phi_3^+)(1 - 3x_3)]. \tag{20}$$

Theoretical framework

- Twist-4 LCDAs

$$V_2(x_i) = 24x_1x_2[\phi_4^0 + \phi_4^+(1-5x_3)], \tag{21}$$

$$V_3(x_i) = 12x_3[\psi_4^0(1-x_3) + \psi_4^-(x_1^2+x_2^2-x_3(1-x_3)) + \psi_4^+(1-x_3-10x_1x_2)], \tag{22}$$

$$A_2(x_i) = 24x_1x_2(x_2-x_1)\phi_4^-, \tag{23}$$

$$A_3(x_i) = 12x_3(x_2-x_1)[(psi_4^0+\psi_4^+) + \psi_4^-(1-2x_3)], \tag{24}$$

$$T_2(x_i) = 24x_1x_2[\xi_4^0 + \xi_4^+(1-5x_3)], \tag{25}$$

$$\begin{aligned} T_3(x_i) =& 6x_3[(\xi_4^0+\phi_4^0+\psi_4^0)(1-x_3) + (\xi_4^- + \phi_4^- - \psi_4^-)(x_1^2+x_2^2-x_3(1-x_3)) \\ &+ (\xi_4^+ + \phi_4^+ + \psi_4^+)(1-x_3-10x_1x_2)], \end{aligned} \tag{26}$$

$$\begin{aligned} T_7(x_i) =& 6x_3[(-\xi_4^0+\phi_4^0+\psi_4^0)(1-x_3) + (-\xi_4^- + \phi_4^- - \psi_4^-)(x_1^2+x_2^2-x_3(1-x_3)) \\ &+ (-\xi_4^+ + \phi_4^+ + \psi_4^+)(1-x_3-10x_1x_2)], \end{aligned} \tag{27}$$

$$S_1(x_i) = 6x_3(x_2-x_1)[(\xi_4^0+\phi_4^0+\psi_4^0+\xi_4^++\phi_4^++\psi_4^+) + (\xi_4^- + \phi_4^- - \psi_4^-)(1-2x_3)], \tag{28}$$

$$P_1(x_i) = 6x_3(x_2-x_1)[(\xi_4^0-\phi_4^0-\psi_4^0+\xi_4^+-\phi_4^+-\psi_4^+) + (\xi_4^- - \phi_4^- + \psi_4^-)(1-2x_3)]. \tag{29}$$

Theoretical framework

- Twist-5 LCDAs

$$V_4(x_i) =3[\psi_5^0(1-x_3)+\psi_5^-(2x_1x_2-x_3(1-x_3))+\psi_5^+(1-x_3-2(x_1^2+x_2^2))], \tag{30}$$
$$V_5(x_i) =6x_3[\phi_5^0+\phi_5^+(1-2x_3)], \tag{31}$$
$$A_4(x_i) =3(x_2-x_1)[-\psi_5^0+\psi_5^-x_3+\psi_5^+(1-2x_3)], \tag{32}$$
$$A_5(x_i) =6x_3(x_2-x_1)\phi_5^-, \tag{33}$$
$$\begin{aligned} T_4(x_i) =&\frac{3}{2}[(\xi_5^0+\psi_5^0+\phi_5^0)(1-x_3)+(\xi_5^-+\phi_5^--\psi_5^-)(2x_1x_2-x_3(1-x_3)) \\ &+(\xi_5^++\phi_5^++\psi_5^+)(1-x_3-2(x_1^2+x_2^2))], \end{aligned} \tag{34}$$
$$T_5(x_i) =6x_3[\xi_5^0+\xi_5^+(1-2x_3)], \tag{35}$$
$$\begin{aligned} T_8(x_i) =&\frac{3}{2}[(\psi_5^0+\phi_5^0-\xi_5^0)(1-x_3)+(\phi_5^--\phi_5^--\xi_5^-)(2x_1x_2-x_3(1-x_3)) \\ &+(\phi_5^++\phi_5^+-\xi_5^+)(\mu)(1-x_3-2(x_1^2+x_2^2))], \end{aligned} \tag{36}$$
$$S_2(x_i) =\frac{3}{2}(x_2-x_1)[-(\psi_5^0+\phi_5^0+\xi_5^0)+(\xi_5^-+\phi_5^--\psi_5^0)x_3+(\xi_5^++\phi_5^++\psi_5^0)(1-2x_3)], \tag{37}$$
$$P_2(x_i) =\frac{3}{2}(x_2-x_1)[(\psi_5^0+\phi_5^0-\xi_5^0)+(\xi_5^--\phi_5^-+\psi_5^0)x_3+(\xi_5^+-\phi_5^+-\psi_5^0)(1-2x_3)]. \tag{38}$$

- Twist-6 LCDAs

$$V_6(x_i) =2[\phi_6^0+\phi_6^+(1-3x_3)], \tag{39}$$
$$A_6(x_i) =2(x_2-x_1)\phi_6^-, \tag{40}$$
$$T_6(x_i) =2[\phi_6^0+\frac{1}{2}(\phi_6^--\phi_6^+)(1-3x_3)], \tag{41}$$

Numerical results

Table 1: Twist classification of the proton LCDAs in Eq. (16).

	twist-3	twist-4	twist-5	twist-6
Vector	V_1	V_2, V_3	V_4, V_5	V_6
Pseudo-Vector	A_1	A_2, A_3	A_4, A_5	A_6
Tensor	T_1	T_2, T_3, T_7	T_4, T_5, T_8	T_6
Scalar		S_1	S_2	
Pesudoscalar		P_1	P_2	

Table 2: Parameters in the proton LCDAs in units of 10^{-2} GeV^2 [73]. The accuracy of those parameters without uncertainties is of order of 50%.

	ϕ_i^0	ϕ_i^-	ϕ_i^+	ψ_i^0	ψ_i^-	ψ_i^+	ξ_i^0	ξ_i^-	ξ_i^+
twist-3 ($i=3$)	0.53 ± 0.05	2.11	0.57						
twist-4 ($i=4$)	-1.08 ± 0.47	3.22	2.12	1.61 ± 0.47	-6.13	0.99	0.85 ± 0.31	2.79	0.56
twist-5 ($i=5$)	-1.08 ± 0.47	-2.01	1.42	$1.61 \pm .047$	-0.98	-0.99	0.85 ± 0.31	-0.95	0.46
twist-6 ($i=6$)	0.53 ± 0.05	3.09	-0.25						

Numerical results

Table 3: Form factors in units of 10^{-3} from the leading-twist Λ_b baryon LCDA in Eq. (15) and the proton LCDAs of various twists.

	Twist-3	Twist-4	Twist-5	Twist-6	Total
f_1	1.9	6.3	1.0	-0.015	9.2
f_2	0.12	-0.45	-0.63	~ 0	-0.96
f_3	-0.015	0.84	0.66	~ 0	1.5
g_1	2.5	8.4	0.71	-0.008	11.6
g_2	0.12	-0.30	-0.66	~ 0	-0.84
g_3	-0.027	0.90	0.64	~ 0	1.5

Summary

◆twist-4 Λ_b重子LCDAs和twist-5（twist-4）质子LCDAs主导了对形状因子$f_{1,2,3}$ 和$g_{1,2}$(形状因子g_3)的贡献，而twist-6质子LCDAs的贡献确实受到了抑制。

◆来自高twist LCDAs的端点贡献可以在PQCD形式中得到适当地处理。

谢谢！