Discriminating New Physics in $b \to s\mu\mu$ via Transverse Polarization Asymmetry of K^* in $B \to K^*\mu\mu$ decay

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ICHEP 2020 | PRAGUE

40th INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS

VIRTUAL CONFERENCE

28 JULY - 6 AUGUST 2020

PRAGUE, CZECH REPUBLIC

Anomalies in b→sμμ and Global Fits

Measurements of 120+ observables

R_K, R_{K^*}, Br(B_s→μμ),

B→Kμμ:Br and ang-obs,

B→K*μμ:Br and ang-obs,

Br(B→X_sμμ), $Br(B_s \to \phi\mu\mu)$

Main Discrepancies

A) The measured values of the ratios R_K and R_{K^*} disagree with their SM predictions at the level of $\sim 2.5\sigma$. [LHCb,arXiV:1705.05802; LHCb,arXiV:1903.09252]

$$R_{K^{(*)}} = \frac{Br(B \to K^{(*)}\mu\mu)}{Br(B \to K^{(*)}ee)}$$

Violation of Lepton Flavor Universality

B) The measurement of $Br(B_s \to \phi\mu\mu)$ is $\sim 3.5\sigma$ away from the SM predictions. [LHCb,arXiV:1506.08777]

C) Measurement of angular observable P_5' is $\sim 3\sigma$ away from its SM value. [LHCb, arXiV:2003.04831]

New Physics in the form of vector and axial vector in b→sμμ transitions.

$$\mathcal{H}_{\rm NP} = -\frac{\alpha_{\rm em} G_F}{\sqrt{2}\pi} V_{ts}^* V_{tb} \left[C_9^{\rm NP} (\bar{s}\gamma^\mu P_L b)(\bar{\mu}\gamma_\mu \mu) + C_{10}^{\rm NP} (\bar{s}\gamma^\mu P_L b)(\bar{\mu}\gamma_\mu\gamma_5 \mu)\right.$$
$$\left. C_9^{\prime\rm NP} (\bar{s}\gamma^\mu P_R b)(\bar{\mu}\gamma_\mu \mu) + C_{10}^{\prime\rm NP} (\bar{s}\gamma^\mu P_R b)(\bar{\mu}\gamma_\mu\gamma_5 \mu)\right]$$

Several Gobal fits are performed. Some are

Alguer et al, arXiv:1903.09578
Alok et al, arXiV:1903.09617
Ciuchini et al, arXiv:1903.09632
Aebischer et al, aeXiv:1903.10434
Kowalska et al, arXiv:1903.10932
Arbey et al, arXiv:1904.08399

A common Result (arXiV:1903.09617)

NP scenarios	Best fit value	pull
(I) $C_9^{\rm NP}$	-1.09 ± 0.18	6.24
(II) $C_9^{\rm NP} = -C_{10}^{\rm NP}$	-0.53 ± 0.09	6.40
(III) $C_9^{\rm NP} = -C_9^{\prime\rm NP}$	-1.12 ± 0.17	6.43

Transverse Polarization Asymmetry of K* Meson

The vector meson K* has three polarizations

1. one longitudinal $\lambda_{K^*} = 0$ and 2. two transverse $\lambda_{K^*} = +1, -1$

A completeness relation between polarization fractions

Two are independent

$$F_L + F_T^+ + F_T^- = \frac{\Gamma(\lambda_{K^*} = 0)}{\Gamma_{\text{Tot}}} + \frac{\Gamma(\lambda_{K^*} = +1)}{\Gamma_{\text{Tot}}} + \frac{\Gamma(\lambda_{K^*} = -1)}{\Gamma_{\text{Tot}}} = 1$$

F_L is only sensitive to scalar and tensor interactions. It does not help us in this case.

Alok et al, PRD 95 (2017) 11, 115038

Take asymmetry between two transverse components

$$A_T = F_T^+ - F_T^- = \frac{|H_+|^2 - |H_-|^2}{|H_0|^2 + |H_+|^2 + |H_-|^2}$$

Transforming helicity amplitudes H's to transversity amplitudes using relations

$$A_{\perp,\parallel} = (H_+ \mp H_-)/\sqrt{2}, \quad A_0 = H_0$$

[Altmannshofer et al, JHEP 0901, 019 (2009)]

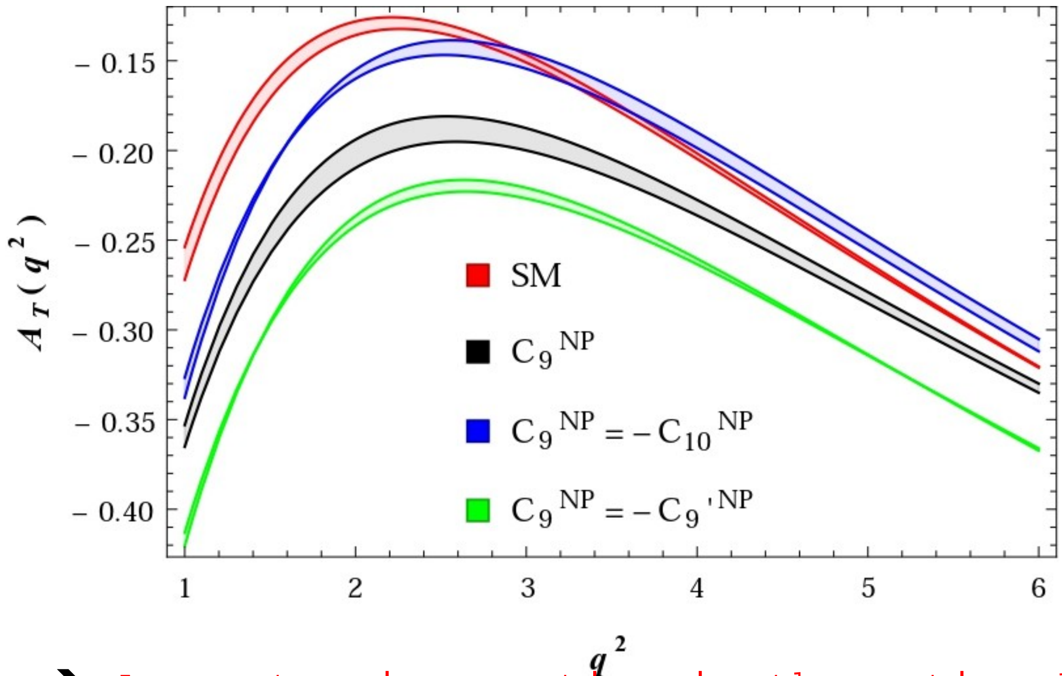
The asymmetry takes the form

$$A_T = \frac{2\,\text{Re}\left(A_\parallel A_\perp^*\right)}{|A_\parallel|^2 + |A_\perp|^2 + |A_0|^2}$$

Where $A_i A_j^* = A_{iL} A_{jL}^* + A_{iR} A_{jR}^*, \quad (i, j = 0, \perp, \parallel).$

Papers on Transverse asymmetry in different prospectives: Melikhov et al, PLB 442, 381 (1998); Kruger, Matias, PRD 71, 094009 (2005); Becirevic, Schneider, NPB 854, 321 (2012)

Predictions and Distinguishing Ability



NP scenarios	$\langle \lvert A_T \rvert \rangle_{[1,6]}$ in %
SM	20.7 ± 0.48
(I) $C_9^{\rm NP}$	24.9 ± 0.57
(II) $C_9^{\rm NP} = -C_{10}^{\rm NP}$	21.3 ± 0.50
(III) $C_9^{\rm NP} = -C_9'^{\rm NP}$	28.4 ± 0.66

- ➔ Asymmetry is negative in the entire low-q^2 range for all cases. The peak value of SM prediction is -0.13 at q^2 = 2.2 GeV^2.

- ➔ The peak values for NP scenarios I and III are -0.19 and -0.22 respectively. The deviation is largest for the scenario III.

- ➔ For NP scenario II, the prediction is similar to that of SM for $q^2 > 3$ GeV^2 whereas the prediction is suppressed for $q^2 < 3$ GeV^2.

- ➔ From the table, it is also evident that prediction of the asymmetry for each NP scenario is substantially different from each other. Hence an accurate measurement of this asymmetry can lead to a clear distinction between three NP scenarios.

Thank You !