Vacuum Polarization Effects From Dark Fermion Loops in Z' Mediator Models and Their Impact on Angular Observables in Rare B Meson Decays

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Rare flavour-changing neutral current decays such as a B->Kmu+mu- are a sensitive probe of beyond Standard Model (SM) Physics. The angular observable P5' has exhibited a persistent deviation from SM predictions, remaining at approximately 3s in the central q2 bin of [1.1, 6.0] GeV2. In this work, I investigated whether vacuum polarization (VP) effects from a dark fermion ? coupled via a Z' portal, can induce a nontrivial q2-dependent shifts in C9, potentially improving agreement with experimental data. I derived the loop-corrected Z' propagator, incorporated the resulting correction into the effective weak Hamiltonian, and computed bin-averaged angular observables using Flavio. A systematic parameter scan over 34,997 configurations was performed across three chiral realizations of the Z' (left-handed, left-right asymmetric, and left-right symmetric). The preferred solutions are vector-dominant but chirally asymmetric, yielding a best-fit point that reduces the central-bin C9 deviation from the SM expectation to approximately 0.12s, an approximately 96% improvement. The model produces an effective shift in C9 which matches with global EFT fits and the VP term is highly loop-suppressed but introduces a non-negligible momentum-dependent structure in the propagator. The model is compatible with complementary angular observables and decays. I extended the Z' couplings to neutrinos, and investigated the optimal chiral structure of Z'-lepton couplings by jointly constraining C9 and C10. Overall, this study suggests that energy-dependent effects arising from dark-sector dynamics may provide a viable and phenomenologically consistent contribution to the P5' tension and is a useful benchmark that motivates future experimental studies through finer q2 binning.

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