

Exploring the $B^+ \rightarrow K^+ \nu \bar{\nu}$ anomaly with a Scalar Singlet Higgs Portal

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The rare decay $B^+ \rightarrow K^+ \nu \bar{\nu}$ offers a powerful window into physics beyond the Standard Model (SM) due to its theoretical cleanliness and sensitivity to new light invisible particles. Within the SM, this flavor-changing neutral current (FCNC) process occurs only at loop level and it is strongly suppressed by the Glashow–Iliopoulos–Maiani (GIM) mechanism. Its final state contains two neutrinos, leading to missing energy signatures in experiments that complicate event reconstruction. The Belle II collaboration recently reported a branching ratio of $(2.3 \pm 0.7) \times 10^{-5}$, deviating by approximately 2.7σ from the SM prediction of $(4.6 \pm 0.5) \times 10^{-6}$.

This tension motivates the exploration of new physics scenarios capable of accounting for the excess. One compelling possibility is the Higgs portal framework, which introduces a real scalar singlet field S that is a gauge singlet under the SM and can serve as a dark matter candidate. Though S does not directly couple to SM fermions or gauge bosons, it can interact with the Higgs boson via a renormalizable portal term $H^\dagger H S$. If kinematically accessible, the decay $B^+ \rightarrow K^+ S$ can contribute to the observed branching ratio and mimic the missing energy signature attributed to neutrinos.

In this talk, we will see the scalar singlet extension of the Higgs sector and analyze the contribution of the $B^+ \rightarrow K^+ S$ channel to the total missing energy signal observed in B decays. We compute the relevant branching ratios as a function of the mixing angle and the scalar mass, and compare them to the Belle II experimental result. This analysis provides a minimal and testable framework to interpret current anomalies and constrain Higgs portal models using flavor observables.

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