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Deciphering the long-distance penguin contribution to double radiative B meson decays

We compute for the first time the long-distance penguin contribution to the double radiative B-meson decays by applying the perturbative factorization theorem. The numerically dominant penguin amplitude arises from the soft-gluon radiation off the light up-quark loop rather than the counterpart charm-loop effect. Importantly, the long-distance up-quark penguin contribution brings about the substantial cancellation of the known factorizable power correction, thus enabling $B_{d,\,s} \to \gamma\gamma$ to become new benchmark probes of physics beyond the Standard Model.

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