Sensitivity of the $\eta^{(\prime)} \to \pi^0\gamma\gamma$ and $\eta' \to \eta\gamma\gamma$ decays to a sub-GeV leptophobic $U(1)_B$ boson

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The sensitivity of the rare decays $\eta^{(\prime)} \to \pi^0\gamma\gamma$ and $\eta' \to \eta\gamma\gamma$ to signatures of a leptophobic B boson in the MeV–GeV mass range is analysed in this work. By adding an explicit B-boson resonance exchange, $\eta \to B\gamma \to \pi^0\gamma\gamma$, to the Standard Model contributions from vector meson dominance and the linear sigma model, and employing experimental data for the associated branching ratios, it allows us to improve the current constraints on the B-boson mass m_B and coupling to Standard Model particles α_B. From these constraints and the analysis of the available experimental $m^2_{\gamma\gamma}$ invariant mass distribution, we show that a B-boson signature in the resonant mass range $m_{\pi^0} \lesssim m_B \lesssim m_\eta$ is strongly suppressed and would be very difficult to experimentally identify, assuming that the leptophobic B boson only decays to Standard Model particles. In contrast, the limits outside this mass window are less stringent and the corresponding t- and u-channel signatures may still be observable in the data, as it occurs with the non-resonant, Standard Model, ρ, ω and ϕ meson exchanges. In addition, we make use of experimental data from the $\eta' \to \pi^0\gamma\gamma$ and $\eta' \to \eta\gamma\gamma$ decays to explore larger B-boson masses. Our results are relevant for the B-boson search programmes at existing and forthcoming light-meson facilities, such as KLOE(-II) and Jefferson Lab Eta Factory experiments.