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Searching for light dark bosons in Z decays

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We analyze the Z-boson decay $Z \to \gamma\ X$ into a photon (γ) plus a hypothetical light boson (X) belonging to a dark or secluded sector. The dark boson is assumed to behave as missing energy in the detector. We consider for X the cases of spin-1 (massless dark-photon), spin-0 (axion-like), and spin-2 (graviton-like) particles and explore the way to untangle its spin origin. All these scenarios predict a universal signature for this decay, characterized by a single mono-chromatic photon in the Z center of mass, with energy about half of the Z mass, plus a neutrino-like missing energy associated to the X boson. We analyze first the possibility of searching for a massless dark photon at the LHC, HL-LHC and future lepton colliders, and compare the respective sensitivities. As expected, the best result is found for the lepton colliders running at the Z mass, FCC-ee and CEPC, with a final sensitivity to branching ratios of order $calO(10^{-11})$. Then, we discuss how to use the photon angular distribution of the events in lepton collisions to discriminate between the dark photon and a light invisible axion- or graviton-like particle.

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