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Nonresonant Searches for Axion-Like Particles in Vector Boson Scattering Processes at the LHC

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We propose a new search for Axion-Like Particles (ALPs), targeting Vector Boson Scattering (VBS) processes at the LHC. We consider nonresonant ALP-mediated VBS, where the ALP participates as an off-shell mediator. This process occurs whenever the ALP is too light to be produced resonantly, and it takes advantage of the derivative nature of ALP interactions with the electroweak Standard Model bosons. We study the production of ZZ, $Z\gamma$, $W^{\pm}\gamma$, $W^{\pm}Z$ and $W^{\pm}W^{\pm}$ pairs with large diboson invariant masses in association with two jets. Working in a gauge-invariant framework, upper limits on ALP couplings to electroweak bosons are obtained from a reinterpretation of Run 2 public CMS VBS analyses. The constraints inferred on ALP couplings to ZZ, $Z\gamma$ and $W^{\pm}W^{\pm}$ pairs are very competitive for ALP masses up to 100 GeV. They have the advantage of being independent of the ALP coupling to gluons and of the ALP decay width. Simple projections for LHC Run 3 and HL-LHC are also calculated, demonstrating the power of future dedicated analyses at ATLAS and CMS.

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