Preprint Series in Particles and Cosmos Physics
nº IPARCOS-UCM-25-055

Axion-mediated multiboson production

by Alexandre Salas Bernárdez, Fabian Esser, Verónica Sanz, María Ubiali

October 2025

Plaza de las Ciencias, 1 28040 Madrid, Spain
www.ucm.es/iparcos/

IPARCOS
INSTITUTO DE FÍSICA DE PARTÍCULAS Y DEL COSMOS
UNIVERSIDAD COMPLUTENSE MADRID

IPARCOS
INSTITUTO DE FÍSICA
DE PARTÍCULAS Y DEL COSMOS

Abstract

Axion-like particles (ALPs) provide a well-motivated framework for physics beyond the Standard Model, coupling to gauge bosons through dimension-five operators protected by an approximate shift symmetry. At the LHC, such interactions lead to distinctive signatures in multiboson production, where the ALP appears as an off-shell mediator rather than a narrow resonance. In this work, we present the first global analysis of ALP-mediated multiboson processes, combining measurements of diphoton, ZZ, W^+W^-, dijet, and vector-boson–fusion final states. On the theory side, we assume that the ALP couples only to the gauge sector of the SM, motivated from a UV perspective, and classify the ALP–multiboson vertices that directly govern collider observables. Using Run2 LHC measurements, we extract bounds on the Wilson coefficients (c_{Gt},c_{Wt},c_{Bt}) that parametrise gluonic and electroweak ALP interactions. Our results show that the dijet channel dominates the sensitivity to ALP couplings and determines the limits on c_{Gt}, while diboson and VBF processes provide complementary constraints on the electroweak couplings. We further assess the validity of the EFT expansion given the multi-TeV scales probed in the data. This global study provides the most comprehensive picture to date of ALP–gauge interactions from multiboson production at the LHC and highlights the opportunities for significant improvements with future high-luminosity datasets.

UNIVERSIDAD COMPLUTENSE MADRID