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Clockwork Axions at Hadron Colliders

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Multi-axion scenarios have interesting applications in cosmology, especially in the context of inflation. An interesting manifestation of such scenarios arises within the framework of the clockwork mechanism wherein the light axion is localized towards one end of a theory space lattice composed of N scalar fields through a specific form of near-neighbour interactions. This effectively generates a large decay constant for the axion without the need for invoking a large Peccei-Quinn (PQ) symmetry breaking scale. Therefore, even if the light axion is nearly invisible at a high energy collider setting, the associated heavy axion-like particles (ALPs) in such scenarios may be observable by virtue of their decay constants being characterized by a low-scale PQ symmetry breaking. In this talk, I will discuss the possibility of certain interesting as well as unique signatures pertaining to the resonant production of the clockwork ALP spectrum within a QCD axion setup at hadron colliders, particularly in the diphoton channel at the LHC and its forthcoming upgrades. Notably, for ALP masses below the electroweak scale, there exist scenarios where the ALP mass-splittings are small, in which case the collection of resonances could appear as a band of closely-spaced peaks in the invariant mass distribution, or in some cases even smaller such that the resonances effectively appear as a single broad resonance. In addition to these features, a realization of the clockwork axion on a two-dimensional lattice further engenders the possibility of having long-lived ALPs in the spectrum which can be within the sensitivity reach of some of the upcoming displaced vertex detectors such as MATHUSLA.

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