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Breaking Peccei-Quinn Symmetry at Low Scales

We propose an efficient mechanism to realize an invisible axion from a low scale Peccei-Quinn symmetry breaking. Our basic model only contains a gauge boson, an up-type vector-like quark, two Higgs doublets and two Higgs singlets besides the standard model fermions and gauge bosons. The physical Peccei-Quinn global symmetry is a result of two independent global symmetries connected by the new gauge symmetry. Anyone of these two global symmetries only acts on either the right-handed top quark or the left-handed new quark so that it can avoid the domain wall problem. Thanks to the electroweak and new gauge interactions, the Higgs doublet for the top quark mass generation and the Higgs singlet for the new quark mass generation can only contribute a tiny fraction in the axion. The axion decay constant can be largely enhanced by a factor composed of the vacuum expectation values of the four Higgs scalars. Our mechanism provides a new opportunity to fully test the Peccei-Quinn symmetry at colliders.

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