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Heavy QCD Axions at High-Energy Muon Colliders

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We study the physics potential of heavy QCD axions at high-energy muon colliders. Unlike typical axion-like particles, heavy QCD axions solve the strong CP problem with phenomenology driven by the anomalous gluon ($a\widetilde{GG}$) couplings. Several ultraviolet scenarios are presented in which QCD axions with TeV-scale masses and decay constants arise consistently with a solution to both the strong CP problem and the axion quality problem. We perform a detailed collider analysis for both a 3 and 10˜TeV muon collider, focusing on hadronic axion decays that gives rise to a dijet-resonance signature. Our projections for the axion discovery reach in the multi-TeV mass range demonstrate that a muon collider can significantly extend sensitivity to heavy QCD axions compared to existing experiments.

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