

More is Different: Multi-Axion Dynamics Changes Topological Defect Evolution

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We study topological defects in multi-axion models arising from multiple Peccei-Quinn (PQ) scalars. Using a simplified two-axion system, we reveal fundamental differences in the evolution of these defects compared to single-axion scenarios. This finding is particularly significant because, despite the fact that integrating out heavier axions reduces these models to an effective single PQ scalar theory at low energies, the actual physical behavior of topological defects differs markedly from single-axion predictions. Unlike single-axion models where conventional cosmic strings form, multi-axion scenarios with post-inflationary or mixed initial conditions generically produce networks of strings interconnected by high-tension domain walls. This results in a severe cosmological domain wall problem. We determine string-wall network instability conditions and discuss cosmological implications including the application to the QCD axion and gravitational wave generation. Our findings highlight that multi-axion dynamics can lead to qualitatively different outcomes for topological defects, challenging the conventional picture of cosmic evolution of topological defects based on single-axion models.

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