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Approach to scaling in axion string networks

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In the QCD axion dark matter scenario with post-inflationary Peccei-Quinn symmetry breaking, the number density of axions, and hence the dark matter density, depends on the length of string per unit volume at cosmic time t, by convention written ζ/t^2. The expectation has been that the dimensionless parameter ζ tends to a constant ζ_0, a feature of a string network known as scaling. It has recently been claimed that in larger numerical simulations ζ shows a logarithmic increase with time. This case would result in a large enhancement of the string density at the QCD transition, and a substantial revision to the axion mass required for the axion to constitute all of the dark matter. With a set of new simulations of global strings we compare the standard scaling (constant-ζ) model to the logarithmic growth. We also study the approach to scaling, through measuring the root-mean-square velocity v as well as the scaled mean string separation x. We find good evidence for a fixed point in the phase-space analysis in the variables (x, v), providing a strong indication that standard scaling is taking place. We show that the approach to scaling can be well described by a two parameter velocity-one-scale (VOS) model, and show that the values of the parameters are insensitive to the initial state of the network. We conclude that the apparent corrections to ζ are artifacts of the initial conditions, rather than a property of the scaling network.

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