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Electromagnetized Black Holes and Swirling Backgrounds in Nonlinear Electrodynamics: The ModMax case

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This work focuses on constructing electromagnetized black holes and vortex-like backgrounds within the framework of the ModMax theory–the unique nonlinear extension of Maxwell's theory that preserves conformal symmetry and electromagnetic duality invariance. We begin by constructing the Melvin-Bonnor electromagnetic universe in ModMax through a limiting procedure that connects the spacetime of two charged accelerating black holes with that of a gravitating homogeneous electromagnetic field. Building on this result, we proceed to construct the Schwarzschild and C-metric Melvin-Bonnor black holes within the ModMax theory, representing the first black hole solutions embedded in an electromagnetic universe in the context of nonlinear electrodynamics. While the characteristics of the Melvin-Bonnor spacetime and some of its black hole extensions have been widely examined, we demonstrate for the first time that the Schwarzschild-Melvin-Bonnor configuration exhibits an unusual Kerr-Schild representation. Following this direction, we also unveil a novel Kerr-Schild construction for the spacetime of two accelerating black holes, drawing on the intrinsic relationship between the Melvin-Bonnor spacetime and the C-metric. Finally, we expand the spectrum of exact gravitational solutions within Einstein-ModMax theory by constructing a vortex-like background that coexists with the Melvin-Bonnor universe. In this process, the Taub-NUT spacetime in ModMax has played a crucial role. We present this Taub-NUT solution in a different gauge that facilitates the comparison with the Melvin-Bonnor-Swirling case.

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