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# Gravitating superconducting solitons in the (3+1)-dimensional Einstein gauged non-linear sigma-model

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**Abstract:**
We show the first analytic examples of (3+1) -dimensional self-gravitating regular cosmic tube solutions which are superconducting, free of curvature singularities and with non-trivial topological charge in the Einstein-SU(2) non-linear $\sigma$-model. These gravitating topological solitons at a large distance from the axis look like a (boosted) cosmic string with an angular defect given by the parameters of the theory, and near the axis, the parameters of the solutions can be chosen so that the metric is singularity free and without angular defect. The curvature is concentrated on a tube around the axis. These solutions are similar to the Cohen–Kaplan global string but regular everywhere, and the non-linear $\sigma$-model regularizes the gravitating global string in a similar way as a non-Abelian field regularizes the Dirac monopole. Also, these solutions can be promoted to those of the fully coupled Einstein–Maxwell non-linear $\sigma$-model in which the non-linear $\sigma$-model is minimally coupled both to the U(1) gauge field and to General Relativity. The analysis shows that these solutions behave as superconductors as they carry a persistent current even when the U(1) field vanishes. Such persistent current cannot be continuously deformed to zero as it is tied to the topological charge of the solutions themselves. The peculiar features of the gravitational lensing of these gravitating solitons are shortly discussed.