Eliminating singularities using non-Einsteinian phases:
The problem of closed timelike curves and Dirac strings in vacuum gravity

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Abstract:

Einsteinian gravity theory is known to admit vacuum solutions that exhibit closed timelike worldlines and Dirac string pathologies, the Taub-NUT geometry being a celebrated example. These singularities remain robust against possible analytic extensions based on invertible metrics. Thus, at least within Einsteinian gravity theory in vacuum, there happens to be no choice but to live with such acausal solutions, which defy a satisfactory physical interpretation.

Here, we address the problem of these singularities within the generic context of first order gravity, which exhibits Einsteinian (based on invertible metrics) as well as non-Einsteinian (based on non-invertible metrics) phases. To be precise, we demonstrate that closed timelike curves and Dirac strings may be eliminated from any vacuum solution of gravity theory, provided zero-determinant metric phases are introduced along with the invertible phases at appropriate regions of the full spacetime. The method is elucidated first for the Taub-NUT geometry, which is superceded by a smooth solution of first order field equations. The resulting spacetime is defined to be a unique extension of the Taub Universe to a degenerate metric phase. As an additional feature, this framework naturally provides a geometric interpretation of the magnetic charge in the context of gravity theory without matter. Using this general procedure, we also find a (smooth and unique) continuation of the Misner geometry, which in its original form is a simpler analogue of the Taub-NUT spacetime with similar pathologies.

We also touch upon the issue of curvature singularies in this context, through a discussion of possible degenerate extensions of the Schwarzschild geometry defined by everywhere regular field-strength components.

References:

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