Abstract

In this study, we investigate solutions based on degenerate and non-degenerate tetrad phases of first-order gravity, where they are joined smoothly across the phase boundaries. We apply this framework to address the issue of causal singularities in vacuum gravity theory. In particular, we show that using both these phases in first-order vacuum gravity it is possible to eliminate the closed time-like curves. This is done by constructing a new continuation of Taub spacetime which does not evolve into a NUT phase. Next, we show how four-dimensional degenerate geometries could source an apparent electric and magnetic charge. We discuss the implication for the point charge singularity as is typical in standard Einsteinian gravity and also for the observability of magnetic monopoles in nature. In addition, we provide a topological interpretation of these emergent charges in pure gravity in terms of the Euler and (torsional) Nieh-Yan topological numbers respectively.

In the final part of our thesis we apply the degenerate metric phase to lower dimensions in order to construct a degenerate tetrad solution of first-order gravity. We construct a two-dimensional theory of gravity as a generalization of Jackiw-Teitelboim constant curvature gravity. This is done by invoking an appropriate dimensional reduction in three dimensions. We also provide proof of the fact that the emergent two-dimensional theory of gravity remains preserved under the inclusion of higher-order Lovelock terms when the spacetime dimension is greater than three ($D = 3 + 2n$).

Keywords: Degenerate metric, General Relativity, First Order Formulation.