Preprint Series in Particles and Cosmos Physics

nº IPARCOS-UCM-24-056

Mimicking wormholes in Born-Infeld electromagnetism

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October 2024

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Abstract

In non-linear electrodynamic theories, unlike in Maxwell's theory, the propagation of photons is affected by a background electromagnetic field. In some situations, these effects can be described in terms of an effective geometry, so that it is possible to establish analog models of non-trivial gravitational fields, through the appropriate choice of some non-linear background electromagnetic field. To study these gravitational analogs, we consider a general non-linear electromagnetic theory, and computed the linear evolution of perturbations on top of an electromagnetic background. We show how the propagation of the perturbations can be described in terms of two effective metrics, and analyse under what conditions they are conformally related, so the propagation is governed by one single metric. The results we obtain show that this analog model is valid exclusively in the limit of geometrical optics, where light rays can be described as null geodesics. Afterwards, we specialize the background to the Born-Infeld theory. In this case, the dynamics of perturbations can be described in terms of one single metric. We also study the propagation of perturbations on a purely electric background, created by a static point charge in the Born-Infeld theory. The effective metric is conformal to a metric that describes the geometry of a wormhole. We analyse the trajectories of the photons in terms of the geodesics of the effective metric. The same result is obtained by considering a magnetic background generated by a magnetic monopole.

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