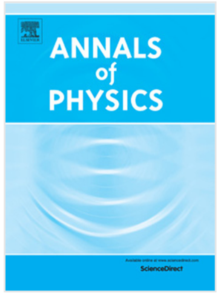

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Constraining the Physical State by Symmetries

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Abstract

After reviewing the hole argument and its relations with initial value problem and general covariance, we shall discuss how much freedom one has to define the physical state in a generally covariant field theory (with or without internal gauge symmetries).

Our analysis relies on Cauchy problems, thus it is restricted to globally hyperbolic spacetimes. We shall show that in generally covariant theories on a compact space (as well as for internal gauge symmetries on any spacetime) one has no freedom and one is forced to declare as physically equivalent two configurations which differ by a global spacetime diffeomorphism (or by an internal gauge transformation) as it is usually prescribed.

On the contrary, when space is not compact, the result does not hold true and one may have different options to define physically equivalent configurations, still preserving determinism.

Keywords: Relativistic theories, Hole argument, General covariance, Relativistic observables.

1. Introduction

After a century since formulation of General Relativity (GR) it is still not clear and unanimously accepted what exactly Einstein discovered and what are the foundations of GR; see [1] and references quoted therein. The emphasis on different assumptions (covariance principle in its active or passive form, equivalence principle in its weak or strong form, Mach's principle, coincidence principle just to quote the most used ones) has been shifted many times since 1915 and modified differently by different authors. Not an exception is the meaning of the hole argument (which will be reviewed below) and