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MATTER, FIELDS, AND REPARAMETRIZATION-INVARIANT SYSTEMS

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Abstract. We study reparametrization-invariant systems, mainly the relativistic particle and its D-dimensional extended object generalization d-brane. The corresponding matter Lagrangians naturally contain background interactions, like electromagnetism and gravity. For a d-brane that doesn't alter the background fields, we define non-relativistic equations assuming integral sub-manifold embedding of the d-brane. The mass-shell constraint and the Klein–Gordon equation are shown to be universal when gravity-like interaction is present. Our approach to the Dirac equation follows Rund's technique for the algebra of the γ-matrices that doesn't rely on the Klein–Gordon equation.

1. Introduction

There are two very useful methods in classical mechanics: the Hamiltonian and the Lagrangian approach [14, 10, 11, 16, 4]. The Hamiltonian formalism gives rise to the canonical quantization, while the Lagrangian approach is used in the path-integral quantization. Usually, in classical mechanics, there is a transformation that relates these two approaches. However, for a reparametrization-invariant systems there are problems when changing from the Lagrangian to the Hamiltonian approach [10, 11, 16, 20, 15]. Classical mechanics of a reparametrization-invariant system and its quantization is the topic of the current study.

Fiber bundles provide the mathematical framework for classical mechanics, field theory, and even quantum mechanics if viewed as a classical field theory. When studying the structures that are important to physics, we should also understand why one fiber bundle should be more "physical" than another, why the