



Reply

Towards a unified theory of the fundamental physical interactions based on the underlying geometric structure of the tangent bundle

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Abstract This paper pursues the hypothesis that the tangent bundle (TB) with the central extended little groups of the $SO(3,1)$ group as gauge group is the underlying geometric structure for a unified theory of the fundamental physical interactions. Based on this hypothesis as a first step, I recently presented a generalized theory of electroweak interaction (including hypothetical dark matter particles) (Herrmann in Eur Phys J C 79:779, 2019). The vertical Laplacian of the tangent bundle possesses the same form as the Hamiltonian of a 2D semiconductor quantum Hall system. This explains fractional charge quantization of quarks and the existence of lepton and quark families. As will be shown, the $SU(3)$ color symmetry for strong interactions arises in the TB as an emergent symmetry similar to Chern–Simons gauge symmetries in quantum Hall systems. This predicts a signature of quark confinement as a universal large-scale property of the Chern–Simons fields and induces a new understanding of the vacuum as the ground state occupied by a condensate of quark–antiquark pairs. The gap for quark–antiquark pairing is calculated in the mean-field approximation, which allows a numerical estimation of the characteristic parameters of the vacuum such as its chemical potential, the quark condensation parameter and the vacuum energy. Note that a gauge theoretical understanding of gravity was previously achieved by considering the translation group $T(3,1)$ in the TB as gauge group. Therefore, the theory presented here can be considered as a new type of unified theory for all known fundamental interactions linked with the geometrization program of physics.

1 Introduction

The development of the Standard Model (SM) of elementary particles was a great triumph of modern physics. However,

despite its enormous success in explaining a large number of experiments, it cannot be considered as the ultimate theory of particle physics. The SM is incomplete and contains several open problems that cannot be solved on the basis of this model, as well as phenomenological elements that have not yet been explained on a microscopic basis. A fundamental problem in the SM is the question of the physical origin of the internal symmetry groups assumed a priori for phenomenological reasons. Several other unanswered questions are the mysterious existence of three families of leptons and quarks (also called generations) that differ only in their masses and the origin of the hierarchy of fermion masses, the microscopic understanding of the spontaneous symmetry breaking by the Higgs mechanism and the hierarchy problem, the lack of understanding of fractional quark charges, the missing explanation of dark matter and dark energy, and others.

There have been many attempts to formulate a unified theory beyond the SM that could solve the above puzzles. In Grand Unified Theories, the electroweak and strong interactions are embedded in a larger gauge group, such as the $SU(5)$ group first proposed by Georgi and Glashow [1] or in the $SO(10)$ group [2]. There have also been some attempts to understand the origin of families in the SM by using a so-called family symmetry [3,4]. Despite many subsequent attempts, no unified model exists that is able to solve all these problems on a unified basis, and none of them is considered to be universally accepted.

The SM of particle physics is based on the gauge principle, with local symmetry transformations of the variables of the phenomenologically determined continuous gauge groups $SU(2) \otimes U(1)$ in electroweak interactions and $SU(3)$ in strong interactions (quantum chromodynamics, QCD) acting in an “internal space” related to the symmetry group. The geometric or physical origin of the internal symmetries given by the gauge transformations remains unknown. Here we follow the hypothesis that the gauge principle is not a

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Symposium Honoring Mathematical Physicist Jean-pierre Vigiér Richard L Amoroso, Louis H Kauffman, Peter Rowlands, 2013-09-18 A truly Galilean class volume this book introduces a new method in theory formation completing the tools of epistemology It covers a broad spectrum of theoretical and mathematical physics by researchers from over 20 nations from four continents Like Vigiér himself the Vigiér symposia are noted for addressing avant garde cutting edge topics in contemporary physics Among the six proceedings honoring J P Vigiér this is perhaps the most exciting one as several important breakthroughs are introduced for the first time The most interesting breakthrough in view of the recent NIST experimental violations of QED is a continuation of the pioneering work by Vigiér on tight bound states in hydrogen The new experimental protocol described not only promises empirical proof of large scale extra dimensions in conjunction with avenues for testing string theory but also implies the birth of the field of unified field mechanics ushering in a new age of discovery Work on quantum computing redefines the qubit in a manner that the uncertainty principle may be routinely violated Other breakthroughs occur in the utility of quaternion algebra in extending our understanding of the nature of the fermionic singularity or point particle There are several other discoveries of equal magnitude making this volume a must have acquisition for the library of any serious forward looking researchers *The Routledge Handbook of Youth Physical Activity* Timothy Brusseau, Stuart Fairclough, David Lubans, 2020-04-07 Over the past three decades the study of pediatric physical inactivity has become a public health concern The decreases in physical activity have been associated with obesity and numerous hypokinetic diseases In accordance with this public health concern the study of pediatric physical activity has become a central part of research in the health and exercise science fields The Routledge Handbook of Youth Physical Activity is the first book to survey the full depth and breadth of the issues facing this field Bringing together many of the world's experts and practitioners the book helps to develop an understanding of the underlying issues related to pediatric physical activity as well as the role physical activity plays on cognitive psychomotor and social aspects of childhood The book addresses issues with physical activity measurement and discuss wide ranging aspects of physical activity interventions With more emphasis than ever on physical activity this book makes an important contribution to the scholars and practitioners working in the field of youth physical activity This is the first single text on the state of current knowledge related to pediatric physical activity which offers a comprehensive guide to students and academics on these subjects The Routledge Handbook of Youth Physical Activity is key reading for all advanced students researchers practitioners and policy makers with an interest in physical activity youth sport public health matters sport studies or physical education **Forthcoming Books** Rose Arny, 2003

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