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Towards Renormalizable Gravity Without Negative-Energy States

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Towards renormalizable gravity without negative-energy states

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A second-derivative gauge theory with a massless spin-2 boson on flat spacetime is presented. The dynamical symmetry preserves the spacetime metric and follows from an alternative interpretation of the equivalence principle. Gauge ambiguity is eliminated by a choice of reference frame, and the gauge boson propagator is derived from an invariant four-parameter polynomial action involving only dimensionless couplings. It is deduced that the theory is power-counting renormalizable in this gauge for almost all configurations of parameters. Examination of the linearized radiation then shows that, for some of these configurations, all excitations have non-negative canonical energy density. The paper concludes with an analysis of the static isotropic solutions to the weak-field vacuum equations.

CONTENTS

I. INTRODUCTION

To conceive a consistent quantum theory compatible with observable gravitational phenomena is widely recognized as an outstanding challenge of theoretical physics. Unfortunately, applications of established quantum field theory techniques to general relativity fall short due to the form of the implied interactions. Their negative mass dimensionality suggests that ultraviolet divergences cannot be removed by renormalization of a finite number of parameters.

It so happens that pure gravity, as dictated by Einstein's theory, is finite at one loop [1] due to a cancellation particular to four spacetime dimensions. However, coupling to matter—whether it be of scalar [1], Maxwell [2], Yang-Mills [3], or Dirac [4] type—introduces nonrenormalizable divergences at that same order. And even pure gravity diverges at two loops [5].

Recent approaches to the subject involve (a) more general quantization procedures, often with perturbative notions discarded, or (b) exotic frameworks such as string theories. In many cases, one must relinquish ideas from conventional gauge theories