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A Noncompact Weyl-Einstein-Yang-Mills Model: A Semiclassical Quantum Gravity

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We construct and study perturbative unitarity (i.e., ghost and tachyon analysis) of a $3+1$-dimensional *noncompact* Weyl-Einstein-Yang-Mills model. The model describes a local noncompact Weyl's scale plus $SU(N)$ phase invariant Higgs-like field, conformally coupled to a generic Weyl-invariant dynamical background. Here, the Higgs-like sector generates the Weyl's conformal invariance of system. The action does not admit any dimensionful parameter and genuine presence of de Sitter vacuum spontaneously breaks the noncompact gauge symmetry in an analogous manner to the Standard Model Higgs mechanism. As to flat spacetime, the dimensionful parameter is generated within the dimensional transmutation in quantum field theories, and thus the symmetry is radiatively broken through the one-loop Effective Coleman-Weinberg potential. We show that the mere expectation of reducing to Einstein's gravity in the broken phases forbids anti-de Sitter space to be its stable vacua. The model is unitary in de Sitter and flat vacua around which a massless graviton, $N^2 - 1$ massless scalar bosons, N massless Dirac fermions, $N^2 - 1$ Proca-type massive Abelian and non-Abelian vector bosons are generically propagated.

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I. INTRODUCTION

The recent discovery of gravitational wave has shown us one more time why Einstein's gravity deeply deserves to be the only universally acknowledged gravity theory. As is well-known, the theory was constructed on a novel geometrical pattern possessing a non-linear relation with the matter sector through Einstein field equation. Here, in the geometry sector, the metric is the *only* dynamical variable that governs type of geometry and affine dynamics of manifolds. This unique property of metric in Einstein's gravity is the corollary of imposed constraints, that is the torsionlessness and metric compatibility, on a generic connection. With those constraints, the degrees of freedom (DOF) coming from torsion and non-metricity are automatically ruled out, and thus the only solutions that comprise the Levi-Civita connection are picked up as viable solutions of the theory. As for the generic case, this obviously does not have to be the situation and one has to allow for all the other DOF to get a well-behaved larger geometrical representation of gravitational force. This will inherently upgrade the fundamental behavior of Einstein's gravity [1–4]. The necessity of readdressing these disregarded DOF particularly arises due to the UV problem of theory: recall that Einstein's gravity possesses Newton's constant which has mass dimension -2 as coupling constant. Having the dimensionful coupling constant particularly causes troubles in the perturbative study of theory. More precisely, as one moves ahead of the one loop self interactions of *pure* theory in the radiative aspect, due to being a dimensionful parameter, Newton's constant necessitates infinite number of counter-terms for the renormalization. Thus, since the catastrophic

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