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ORIGINAL ARTICLE

Entropic gravity resulting from a Yukawa type of correction to the metric for a solar mass black hole

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Abstract There has been a renewed interest in the recent years in the possibility of deviations from the predictions of Newton's "inverse-square law" of universal gravitation. One of the reasons for renewing this interest lies in various theoretical attempts to construct a unified elementary particle theory, in which there is a natural prediction of new forces over macroscopic distances. In this paper we study the entropic gravity correction to the gravitational force on the horizon of a black hole whose metric has been modified by a Yukawa term. We find that the gravitational radius of such a black hole is given in-terms of the Lambert function, and the entropic force introduces a extra term that depends on the square of the coupling constant α of the Yukawa potential. In the case *alpha* equals zero we recover the Newtonian gravitational force on the horizon. In a first effort to obtain a relation between geometry and information, we calculate the Ricci scalar and through entropy we establish a relation to the number of information N where this is given in nats. Finally, we calculate a critical entropy value as well as a critical information number N_c for which the curvature becomes identically zero which implies that the space becomes flat.

Keywords Yukawa potential · Yukawa black hole · Entropic gravity correction · Ricci scalar · Information number nat

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1 Introduction

Approximately three decades ago a deep connection between thermodynamics and relativity was discovered. The works of Bekenstein (1973), Hawking (1975), and Unruh (1976), are pioneer works, and their discoveries have been investigated to great detail. From the statistical mechanics point of view, the existence of microscopic degrees of freedom gives rise to thermodynamical laws. Recently, in his paper Verlinde (2010), demonstrated that gravity can be interpreted as an entropic force caused by the changes in information associated with the positions of material bodies. In his new proposal, Verlinde could successfully obtained Newton's law of gravitation, Poisson's equation, and also Einstein field equations. This was achieved by the successful employment of the holographic principle together with the equipartition energy law. Verlinde's idea of gravity opens new horizon's towards possibility of gravitational deviations in the weak field, the limit that it is most accessible to the observation, and also for testing quantum gravity phenomenology (Camelia and Smolin 2009). On the other hand Verlinde's idea has received a fare amount of criticism. Li and Pang (2010) have shown that the accommodation of Verlinde's entropic force in an inflationary scenario results to a negative holographic screen temperature introducing the a non energy conservation puzzle. Furthermore, if one tries to modify the derivation of Einstein's equations so that the negative temperature is avoided, it proves to be impossible. Similarly, in Roveto and Munoz (2012) the authors claim that an examination of Verlinde's derivation leads to a number of questions that sevely weaken his arguments, that claims that his theory correctly reproduces Newton's laws or Einstein's gravity. The author's claim that Newtonian and Einstein gravity are uniquely determined by Verlinde's postulates.