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PECULIARITIES OF THE GRAVITATIONAL ENTROPY

A. Plastino

National University of La Plata, Argentina

ABSTRACT

Entropy is lack of information, i.e., ignorance. How does this ignorance manifests itself physically. In variegated ways, of course. Just to fix ideas, we concentrate our attention now in an emblematic example: the Harmonic Oscillator (HO). The basic physical quantity one has to know in dealing with an HO is its frequency ω.
Let us begin with quantum HO at the temperature T . Let k_B stand for Boltzmann's constant, β for the inverse temperature T, and $e_{\pm} = \exp[\pm\beta\hbar\omega]$. Then we have

$$S_{qHO} = -k_B \ln(1 - e_-) + (\hbar\omega/T)[\frac{e_-}{1 - e_-}]. \quad (1)$$

It diverges if $\omega = 0$. Our ignorance is infinite. Consider now the classical HO. We have

$$S_{cHO} = -k_B \ln(\frac{\hbar\omega}{k_B T}) + constant, \quad (2)$$

that also diverges for $\omega = 0$. We see then that if the critical quantity for the theory vanishes, the ignorance augments without bounds. We will be concerned next with gravity. The critical piece of knowledge is the gravitational constant G, or more properly, the quantity $x = Gm_1m_2/k_BT$ if the m's are the interacting masses, T the temperature, and k_B Boltzmann's constant. What happens for $G = 0$? The answer is much more complicated in this scenario, as we discuss in the talk. As it is well known, appealing to conventional integration tools the gravitational thermodynamic functions turn out to be not finite . This difficulty can be circumvented by using special mathematical techniques. This involves using a combination of 1) a generalization of the dimensional regularization method and 2) an analytical extension of an associated integral made by Gradshtein and Rizik in their celebrated Table.

Keywords: entropy, information, gravity, harmonic oscillator

Corresponding Author E-Mail: plastino@fisica.unlp.edu.ar