Non-additive entropies for black holes?

N. Kalogeropoulos
TBA

One of the most fundamental proposals of the last few years has been the holographic principle, which states that the effective degrees of freedom of a system reside at its boundary rather than its bulk. A concrete realization of this principle is the gauge/gravity duality (AdS/CFT correspondence) which has attracted very substantial attention, in the community of string theorists and some condensed matter physicists.

The motivation for the formulation of the holographic principle lies In the thermodynamic entropy of black holes, which shows that is it proportional to the boundary area rather than the bulk volume of a space-like section of a properly defined horizon. The microscopic origin of the black hole entropy, has been a subject of much speculation during the last four decades. Due to lack of experimental data, there is a feeling that it is unlikely that it will be definitively settled In the near future. However, the form of the black hole entropy is a litmus test that is widely believed that any credible candidate for a quantum of gravity should confront and pass.

A recent proposal has been to use non-additive entropies in an attempt to reconcile the holographic principle with the more conventional statistical systems. This is reasonable and largely expected, especially since the non-additive entropies seem to involve systems with thick boundaries where the marginal probabilities between such systems and the environment do not factorize. In particular, an interpolation between the Boltzmann/Gibbs (exponential) and the Tsallis (power-law) entropies has been put forth as a form that may have a role to play in this direction.

In this talk, we state that this is not necessarily so: it is entirely possible that the Boltzmann/Gibbs entropy may be adequate. The issue remains largely unsettled.

We begin by examining the concept of the interior volume of a black hole, a concept that does not have an invariant meaning, but is completely observer-dependent. This is in stark contrast to the area of a spacelike section of the horizon of a black hole. We examine some recent proposals for definitions and corresponding calculations of the volume of the interior of a black hole and conclude with a speculation regarding the relationship between hyperbolicity and the holographic principle.

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