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The quantum thermodynamic universe - an emergent perspective

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The close connection between horizons (black hole event horizon, Rindler, de Sitter) and thermodynamics that has already been found can be extended here to a cosmological model, providing a new insight into the cosmological constant problem. The emergent nature of the field equations is interpreted as entropy balance condition of the spacetime. We describe various facets of the emergent gravity approach but concentrating on cosmological context. We discuss the thermodynamics of apparent horizons and derive Friedmann and Raychaudhuri equations from thermodynamical parameters.
If the gravitational field equations are indeed governed by thermodynamics and can be obtained by maximizing the entropy density of spacetime, as shown by Jacobson, it is also possible to go further and study the spacetime as emergent from the dynamics of entanglement in a general cosmological context.
In the paradigm introduced here, the entropy extremisation leads to the equilibrium properties of the Universe. Expansion parameters are found to emerge from the out-of-equilibrium difference between the number of degrees of freedom on the horizon surface and the bulk. The field equations, projected onto a null surface, reduce to Navier-Stokes equations. We study the expansion in terms of holographic equipartition that governs the evolution of spacetime geometry. The holographic principle proposes a deep connection between the degrees of freedom in a bulk region of space and the degrees of freedom on the boundary of the region. The dynamics of the large-scale structure of spacetime and the evolution of Friedmann universe are described as evolution towards a state of holographic equipartition, by reaching an equal number of bulk and surface degrees of freedom in a spacetime region within a Hubble radius. The vanishing of the cosmological constant is a consequence of an underlying symmetry of the theory. When this symmetry is broken, the cosmological constant is nonzero and arises at quantum level from degrees of freedom or microscopic spacetime fluctuations scaling as the surface area. The degrees of freedom are connected to surfaces in spacetime rather than the bulk region and play the most important role in understanding the quantum structure of spacetime. We find that a spacetime without the presence of a cosmological constant cannot reach the holographic equipartition. The dynamics of the asymptotic holographic equipartition will require the presence of a cosmological constant.

Summary

A new approach to gravity is presented here, suggesting a possible emergent paradigm to understand the cosmological constant.We discuss the emergent paradigm and the implications of this novel perspective for the cosmological constant problem.
The scope of the present work is to investigate the thermodynamical properties of quantum fields in curved spacetime and analyze how gravity and thermality are connected at a cosmological scale, based on Sakharov induced gravity concept.

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