Extended Thermodynamics and Complexity in Gravitational Chern-Simons Theory

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Abstract: I will discuss the three-dimensional Einstein-AdS action in the presence of a gravitational Chern-Simons term and focus on a family of geometries that goes from the BTZ black hole to its "exotic" counterpart. These solutions were first obtained by considering the behaviour of topological matter in $D = 3$ gravity [1]. Such matter does not couple to the spacetime metric but rather only to the connection. The net effect is that the (negative) cosmological constant becomes a constant of integration associated with the topological matter, and the conserved charges of mass and angular momentum become interchanged with one another.

I will present some of the thermodynamic properties of these black holes and focus on the generalized first law and the Smarr formula, along with their thermodynamic volume [2, 3].

In the AdS/CFT correspondence, the complexity $\mathcal{C}$ of a particular state $|\psi\rangle$ can be related to a spacetime region in the bulk using the framework of the conjectured equality Complexity=Action. Given the interplay between mass and angular momentum that the Chern-Simons term introduces, I will also discuss how it affects the complexity growth and if the Lloyd's bound [4] could be valid or violated.

Our considerations suggest that a theory of quantum gravity including exotic black holes should exhibit novel properties compared to the usual approaches [1] to the subject. Any such theory will have to account for their distinct thermodynamic behaviour.

References:

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