Thermodynamics of matter and black hole systems in AdS spaces

Francisco J. Gandum*[1] and José P. S. Lemos[1]

[1]Instituto Superior Técnico, Universidade Técnica de Lisboa – Portugal

Abstract

In the Euclidean path integral approach to quantum gravity, the partition function Z of a gravitational system in the canonical ensemble can be found in zero-order approximation through the Euclidean action I of the system itself by lnZ=-I. The corresponding Helmholtz free energy F then follows from the connection between thermodynamics and statistical physics, namely F=-TlnZ, where T is the temperature of the heat reservoir in contact with the system, and that together with the system size defines the ensemble. An asymptotically anti-de Sitter (AdS) space, a space with negative cosmological constant, supplies a natural heat reservoir located where the metric becomes flat. In this work, we are interested in understanding the thermodynamic gravitational properties of matter and black holes in AdS spaces. For that we calculate the Euclidean action, the partition function, and the free energy of a hot matter self-gravitation shell in such a space, and find its properties, like the thermodynamic energy, the heat capacity, and the thermodynamic stability. Besides the hot matter self-gravitating shell phase, there are other thermodynamic phases in the ensemble, namely, the Hawking-Page AdS black hole phase and the pure hot AdS phase. Since in the canonical ensemble, a system decays spontaneously to the phase which minimizes the Helmholtz free energy F, one can determine, as we do, which thermodynamic phase in these asymptotically AdS spaces is preferable, for each given temperature T of the reservoir.

*Speaker