

Black hole thermodynamics with the cosmological constant as independent variable: Bridge between the enthalpy and the Euclidean path integral approaches

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Thermodynamics of black holes in an AdS background with the cosmological constant as an independent variable is considered. There is one approach which regards the enthalpy as the master thermodynamic variable for the first law of thermodynamics and makes sense if one considers the vacuum pressure due to the cosmological constant acting in a thermodynamic volume inside the horizon. There is another approach based on the Euclidean action principle and its path integral that puts the black hole inside a cavity, defines a quasilocal energy at the cavity's boundary as the master thermodynamic variable, and from which a first law of thermodynamics in a different guise emerges naturally. The first approach has affinities with critical phenomena in condensed matter physics and the second approach is an ingredient necessary for the construction of quantum gravity. The bridge between the two approaches is carried out rigorously, putting the enthalpic thermodynamics with the cosmological constant as independent variable on the same footing as the quasilocal energy approach [1].

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- [1] J. P. S. Lemos and O. B. Zaslavskii, “Black hole thermodynamics with the cosmological constant as independent variable: Bridge between the enthalpy and the Euclidean path integral approaches”, *Physics Letters B* **786**, 296 (2018); arXiv:1806.07910 [hep-th].