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The canonical ensemble of a self-gravitating matter thin shell in asymptotically AdS

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We construct the canonical ensemble of a matter thin shell in asymptotically AdS using the Euclidean path integral approach. We impose spherical symmetry, the Hamiltonian and momentum constraints, the hot AdS regularity conditions and the asymptotic behaviour of AdS on the metrics summed in the path integral and obtain the reduced action, which can be regarded as a generalized free energy. We then perform the zero loop approximation, i.e. the path integral is given solely by the contribution of the stationary points of the action. We obtain the equations of stationarity and stability in general, showing that stability is guaranteed if the gravitational radius increases as temperature increases and if the shell is mechanically stable. We show this system can be described as a particular case of a system only dependent on the gravitational radius although one looses the mechanical stability condition. We use a specific equation of state for the shell and find five solutions for the shell, with two solutions being stable: one with no shell, i.e. hot AdS; and one with a shell. We obtain the thermodynamic quantities of the ensemble, the mean energy, the mean pressure and the entropy, which in this case corresponds to the entropy of the shell. The ensemble is thermodynamically stable if the heat capacity is positive, while the mechanical stability cannot be described by thermodynamic variables of the system. We compare the two stable solutions and the stable black hole solution of Hawking and Page in the context of phase transitions and determine the favorable solution for fixed temperatures, by analyzing which solution has the lowest free energy.

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