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Modular Average and Weyl Anomaly in Two-Dimensional Schwarzian Theory

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The gauge formulation of Einstein gravity in AdS_3 background leads to a boundary theory that breaks modular symmetry and loses the covariant form. We examine the Weyl anomaly for the cylinder and torus manifolds. The divergent term is the same as the Liouville theory when transforming from the cylinder to the sphere. The general Weyl transformation on the torus also reproduces the Liouville theory.
The Weyl transformation introduces an additional boundary term for reproducing the Liouville theory, which allows the use of CFT techniques to analyze the theory. The torus partition function in this boundary theory is one-loop exact, and an analytical solution to disjoint two-interval Rényi-2 mutual information can be obtained. We also discuss a first-order phase transition for the separation length of two intervals, which occurs at the classical level but is smoothed out by non-perturbative effects captured by averaging over a modular group in the boundary theory.

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