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Entropy Functional and Second Law in Curvature Squared Gravity

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Nonrenormalizability of Einstein gravity has made us to believe that it is a low
energy effective theory of a more fundamental theory, for example string theory. This low energy effective action generally contains an infinite number of higher curvature terms apart from the lowest order Einstein Hilbert term. It is thus important to survey the effects of such higher curvature terms on known features of General Relativity like thermodynamics of Black Holes (BH). This work addresses issues related to entropy of BH in higher curvature theories.

Summary

Standard methods for calculating the black hole entropy beyond general relativity are ambiguous when the horizon is non-stationary. We fix these ambiguities in all quadratic curvature gravity theories, by demanding that the entropy be increasing at every time, for linear perturbations to a stationary black hole. Our result matches with the entropy formula found previously in holographic entanglement entropy calculations. We explicitly calculate the entropy increase law for Vaidya-like solutions in Ricci 2 gravity to show that
(unlike the Wald entropy) the holographic entropy obeys a Second Law. Recently we have extended the analysis of the linearized second law for arbitrary curvature squared theories of gravity. We have shown that for a general four derivative theory of gravity, only the holographic entanglement entropy functionals obey the second law at linearized order in perturbations. We also derive bounds on the higher curvature couplings in several examples, demanding the validity of the second law for higher order perturbations.

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