

Soft-Hair-Enhanced Entanglement Beyond Page Curves in a Black-hole Evaporation Qubit Model

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We propose a model with multiple qubits that reproduces the thermal properties of 4-dimensional (4-dim) Schwarzschild black holes (BHs) by simultaneously taking account of the emission of Hawking particles and the zero-energy soft hair evaporation at horizon. The results verify that the entanglement entropy between a qubit and other subsystems, including emitted radiation, is much larger than the BH entropy analogue of the qubit, as opposed to the Page curve prediction[1]. Our result suggests that early Hawking radiation is entangled with soft hair, and that late Hawking radiation can be highly entangled with the degrees of freedom of BH, avoiding the emergence of a firewall at the horizon.

References

- [1] D. N. Page, Phys. Rev. Lett. 71, 3743 (1993).
- [2] M. Hotta, Y. Nambu and K. Yamaguchi, arXiv:1706.07520 (accepted in Physical Review Letters).