

Research project for an M2 stage:
Aspects of black hole evaporation and holography:
entanglement vs encoding

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1 Status of the field

The most promising way to reconcile unitarity with the process of black hole evaporation within a low-energy theory of gravity seems to be that suggested by holography. Some of the degrees of freedom inside the black hole that in the naive calculation of Hawking radiation are entangled with the outgoing radiation are, at a more profound level, *encoded* in it. Rather than belonging to two different Hilbert spaces, they should be thought of as belonging to the same Hilbert space.

2 Background reading

The candidate should become acquainted with the basic modern approaches to information recovery from a black hole [1] and with the role played by quantum error correction in AdS/CFT [2].

3 Aim of the research

Various basic aspects of the difference between encoding and entanglement will be explored, such as the commutation relations of local operators in simple models. It will also be interesting to toy-model the *transfer of encoding* that is believed to happen between the boundary theory and the thermal bath, at the moment of time when the “island” form inside the black hole [1].

References

- [1] A. Almheiri, T. Hartman, J. Maldacena, E. Shaghoulian and A. Tajdini, “The entropy of Hawking radiation,” *Rev. Mod. Phys.* **93** (2021) no.3, 035002 doi:10.1103/RevModPhys.93.035002 [arXiv:2006.06872 [hep-th]].
- [2] D. Harlow, “TASI Lectures on the Emergence of Bulk Physics in AdS/CFT,” *PoS TASI2017* (2018), 002 doi:10.22323/1.305.0002 [arXiv:1802.01040 [hep-th]].