

Section 12. Black Holes, Holography, and the Information Paradox

This optional section extends QIA into black hole information physics. If the universe is a lossless entropic network, then black holes must be interpreted not as information-destroying objects but as extreme routing structures—regions where scrambling and boundary re-encoding reach maximal intensity. The goal here is not to reproduce the full technical machinery of quantum gravity, but to show that QIA naturally yields a consistent informational mechanism aligned with “information not lost,” while providing a distinct explanatory emphasis compared to standard approaches.

12.1 Black hole as an extreme entropic router (maximal scrambling node)

In QIA, a black hole is modeled as an extreme entropic router: a node whose internal routing cost landscape forces incoming information to be rapidly mixed and redistributed across a vast correlation space. The defining feature is not the geometric horizon alone but the existence of an entropic boundary that creates maximal scrambling. Any wave-pattern codeword entering the black hole node becomes re-encoded into a highly distributed form such that local reconstruction becomes practically impossible. Thus, black holes are interpreted as maximal scrambling nodes in the entropic network.

12.2 “Information not lost” as boundary re-encoding across degrees of freedom

Within CUWF, information conservation is a global principle of the network. Therefore, “information not lost” is not an assumption but a necessary consequence of lossless architecture. QIA interprets the black hole horizon as a boundary interface where information is re-encoded into boundary degrees of freedom. The observer’s perception of loss arises because the encoding becomes inaccessible

behind entropic bottlenecks, not because the information is destroyed. In this view, the horizon acts as a re-encoding surface that compresses and redistributes wave-pattern structure into boundary-linked correlations.

$$I_{\text{total conserved: apparent loss}} = \text{inaccessible re-encoding across boundary DOF}$$

12.3 Page curve interpretation in routing terms

The Page curve describes how the entanglement entropy of Hawking radiation first increases and later decreases if information is recovered. In QIA, this behavior is interpreted as a routing-mechanism transition. Early radiation corresponds to output channels that are weakly coupled to the internal encoding, leading to growing entanglement with the remaining black hole node. After a critical routing threshold—associated with the redistribution of code-coupling topology—routing begins to leak structured information into external channels. The turning point of the Page curve is interpreted as a change in dominant routing pathways and compatibility weights, enabling progressively more recoverable encoding in radiation.

12.4 Holography as boundary-compressed code

QIA provides a natural informational reading of holography. If information is encoded as wave-pattern structure in a network, then under strong entropic boundaries it becomes advantageous for the network to represent interior encoding by boundary-compressed codes. Holography is therefore interpreted as a boundary compression mechanism: the boundary degrees of freedom carry a code that is sufficient to reconstruct the relevant interior informational content, at least in principle. This is not merely a geometric conjecture but a statement about optimal routing and storage under extreme entropic constraints.

Holography

≈ boundary

– compressed encoding that preserves interior routing

– consistency

12.5 CUWF-specific difference from standard approaches

The CUWF/QIA approach differs from standard black hole information discussions in emphasis and mechanism. Standard approaches often begin with a quantum gravity assumption (e.g., AdS/CFT duality, replica wormholes, or specific semiclassical computations) and then infer information recovery. QIA begins from the opposite direction: the universe is postulated as a lossless entropic network with routing dynamics, and black holes are treated as extreme nodes within that same architecture. The key CUWF distinction is that collapse, decoherence, and scrambling share one unified mechanism—information re-routing under entropic constraints—rather than being separate postulates. Therefore, information recovery in black hole evaporation is not an exceptional miracle but an expected consequence of lossless routing with boundary re-encoding. In this sense, QIA aims to supply a single mechanistic narrative linking ordinary measurement physics to black hole information physics.