Resolving the Black Hole Information Paradox via Recursive Information Encoding

Abstract:

We present a theoretical resolution to the black hole information paradox based on the principle of recursive information encoding.

This approach reconciles quantum unitarity with Hawking radiation by framing the event horizon as a reflective boundary that preserves quantum states through holographic and entangled emission.

Our model aligns with the soft hair conjecture, Page curve behavior, and AdS/CFT correspondence, providing a cohesive explanation that avoids information loss without violating known physics.

1. The Paradox:

In general relativity, black holes appear to destroy information.

But in quantum mechanics, information must always be conserved.

Hawking radiation is thermal, implying randomnessand thus a paradox.

2. Recursive Encoding:

The event horizon acts like a reflective mirror.

Falling information gets encoded on its surface (soft hair, holographic principle).

As the black hole evaporates, it releases radiation that slowly encodes and reveals that information.

3. Supporting Theories:

- Soft Hair Theory: horizon stores quantum info as low-energy modes.
- AdS/CFT: boundary theory encodes full interior bulk.
- Replica Wormholes: simulate Page curve, supporting information conservation.

4. Resolution in Physics Terms:

Let | be an infalling state. It becomes entangled at the boundary.

Eventually, Hawking radiation emits these entangled echoes.

Over time, all the info escapesscrambled but recoverable.

5. Conclusion:

Black holes dont destroy datathey encode it.

Radiation is not random. Its recursive, entangled, delayed information.

The paradox is resolved by recognizing black holes as coherent encoders, not erasers.