Origins of Information Loss

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Abstract

The origins of the information loss for observers are discussed.

The information paradox of the black-hole evaporation is still under debates. Hawking [1] claimed the recovery of the information. Unruh and Wald [2] argued the loss of the information. We[1] think that the information loss occurs even in the absence[2] of the black hole. In the following we discuss the information loss in the relativistic quantum field theory (r-QFT) in the absence of the black hole.

First we state our point of view. We can analyze[3] a system only via observed data. A system cannot be defined without an observer. Thus we will discuss from the view point of some observer.

Hawking does not care[4] the impossibility of the access to the information on the whole space-time. Unruh and Wald's information loss is the loss of the access to the information. Buchholz and Roberts [3] also take the access seriously and they formulate the observable algebra only in the future light cone. The information for an observer is obtained by the measurements in the observer's future light cone. The observer cannot access to the information outside of the cone. The information is relative to observers. Such a relativity is also the heart of the Unruh effect.

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[1]See http://hdl.handle.net/2324/1955688 and http://hdl.handle.net/2324/2228908.

[2]Unruh and Wald's example of an open system, a living room, also has nothing to do with a black hole.

[3]The quantum theory only describes the observed data.

[4]Hawking's argument lacks an observer.

By the above discussion of the accessibility it is clear that our observable system is inevitably an open system. An open system is described as an mixed state. The conservation of the information is meaningful only among pure states which are related by unitary transformations. In other words the conservation of the information is expected for a closed system. Our observable system is open and mixed so that the information is not conserved.

The above explanation of the information loss is rather practical. In r-QFT the information is lost essentially.[5]

In r-QFT the observable system has infinite degrees of freedom. Such a system is described by the type-III von Neumann algebra. Due to the split property[6] of the type-III algebra all the states described by this algebra are mixed states. Consequently we cannot discuss the conservation of the information in r-QFT.

References

[1] Hawking: arXiv:1509.01147v1.

[2] Unruh and Wald: arXiv:1703.02140v1.

[3] Buchholz and Roberts: arXiv:1304.2794v4.

[5] See http://hdl.handle.net/2324/1955688 and http://hdl.handle.net/2324/2228908.

[6] Our observation is described by an observable algebra in some finite space-time region. Although the region is finite, the algebra is of infinite degrees of freedom. Since the observed system has infinite degrees of freedom, we cannot distinguish this system from its slightly enlarged one. The enlargement is implemented by the enlargement of the space-time region of the observation. The enlarged part plays the role of the reservoir to the original system. Consequently the system is described as a mixed state. Thanks to this property our observation in some laboratory is not affected by uncontrollable events in distant space-time regions even in the presence of the entanglement in the state vector.