INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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In recent years, researchers' attention has been sparked by the thermal and geometrical characteristics of black hole horizons as well as their intimate relationship with the dynamics of particle motion surrounding them. Because of this, research into near-horizon physics has received a lot of interest recently. Over time, systems have begun to exhibit some intriguing behaviours whenever they come under the dominance of this mysterious one-way membrane, according to scientists. One of these traits is the appearance of chaotic dynamics in a system in the vicinity of the horizon. It has been found that the influence of horizon on a system can introduce chaos within the system. Research on chaos in the presence of horizons has been ongoing for a long time, but the reason for this special feature of the horizon is still not apparent. Similarly, it is crucial to take into account in this context why all horizons (whether static or stationary) express the same phenomenological quality.

Contrarily, the idea of black hole thermodynamics has been around for a while and is based on an analogy between the laws governing black holes and those governing typical thermodynamical systems. However, no one has ever really addressed why these thermodynamical quantities are connected to the horizon. In actuality, we still don't fully understand the underlying physical process that generates temperature in the horizon system. For instance, the kinetic theory of gases explains that the temperature of a gas contained in a cylinder is caused by the kinetic energy of the gas particles. However, it is unknown at this time whether a similar mechanism will operate in the scenario of a horizon. As a result, it is also unknown which microscopic degrees of freedom (MDOF) are in charge of such a property. Despite numerous tries, there are currently no conclusive explanations.

Therefore, in the present thesis, for the first time, we have tried to provide a unified reason for both the characteristics of horizon, i.e. the reason for chaotic influence on a system and the underlying possible reason for the thermal behaviour of it and have tried to find out if there is any connection between them. We begin the thesis with a thorough explanation of the characteristics of classical black holes. After the introductory part we introduce the first part where we present some classical results for a system that is located in the vicinity region of an event horizon. Interestingly, we find that the system begins to exhibit chaotic behaviour as soon as it is exposed to the horizon's influence. In the second part we try to figure out why a system in the near horizon area behaves in such a chaotic manner. In the third part we study the quantum consequences of the results we obtained in the classical scale in the near horizon region. We find that the near-horizon instability may be a reason for the chaotic situation and also the thermal behaviour of the horizon. In the fourth part we apply the same formalism to more generalised backgrounds in order to better grasp the core reason for thermality in those circumstances. Finally, the thesis is concluded with a brief discussion of our conclusions and potential future applications.