INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Exploring Pole-Skipping in Holographic Systems

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SHORT ABSTRACT

The thesis consists of five main chapters. Discussion of our work starts from the second chapter. The second chapter comprises two of our research works. In the first work, the holographic phenomena of pole-skipping were studied in the presence of scalar-Gauss-Bonnet interaction in a four-dimensional Anti-de Sitter-Schwarzchild black hole background. We have initiated a novel study to understand the response of those pole-skipping points under the application of external sources. The source is identified with the holographic dual operator of the bulk scalar field with its non-normalizable solutions. We have analysed in detail the dynamics of pole-skipping points in both sound and shear channels, considering linear perturbations in bulk. In the perturbative regime, characteristic parameters for chaos, namely the Lyapunov exponent and butterfly velocity, remain unchanged. However, the momentum values of the pole-skipping points in various modes are found to be affected by the scalar source. Further, the diffusion coefficient has been observed to evolve non-trivially under the application of external sources. In the second work, we have investigated the holographic fermionic pole-skipping phenomena for a class of interacting theories in a charged AdS black hole background. We have studied two types of fermion-scalar interactions in the bulk: Dipole and Yukawa-type interactions. Depending upon the interaction, we have introduced both real and charged scalar fields. We have particularly analysed the effect of scalar condensation on the fermionic pole-skipping points and discussed their behaviour near critical temperatures. In the third chapter, we have analysed the pole-skipping phenomena of finite temperature Yang-Mills theory with quark flavours, which is dual to D3-D7 brane systems in bulk. We have also considered the external electric field in the boundary field theory, which is dual to the world volume electric field on the D7 brane. We have worked in the probe limit where the D7 branes do not back-react to the D3 brane background. In this scenario, we have computed the characteristic parameters of the chaos, namely, Lyapunov exponent λ_L and butterfly velocity v_b from the pole-skipping points by performing the near-effective horizon analysis of the linearised Einstein equations. Unlike pure Yang-Mills, once charged quarks with a background electric field are added to the system, the characteristic parameters of the chaos show non-trivial dependence on the quark mass and external electric field. We have observed that λ_L and v_b decreases with increasing electric field. We have further

performed the pole-skipping analysis for the gauge invariant sound, shear, and tensor modes of the pertu
the bulk and discuss their physical importance in the holographic context. In the fourth chapter, we have investigated two salient chaotic features, namely Lyapunov exponent and butterfly velocity, in the context of an asymptotically Lifshitz black hole background with an arbitrary critical exponent. These features are computed using three methods: entanglement wedge method, out-of-time-ordered correlator computation and pole-skipping. We have presented a comparative study of the aforementioned features, where all of these methods yield exactly similar results for the butterfly velocity and Lyapunov exponent. This establishes an equivalence between all three methods for probing chaos in the chosen gravity background. Furthermore, we have evaluated the chaos at the classical level by computing the eikonal phase and Lyapunov exponent from the bulk gravity. These quantities emerge as nontrivial functions of the anisotropy index. By examining the classical eikonal phase, we uncover different scattering scenarios in the near-horizon and near-boundary regimes. We have also discussed potential limitations regarding the choice of the turning point of the null geodesic in our approach.