Black hole’s response to external perturbations will carry significant information about these exotic objects. Its response, shortly after the initial ‘kick’, is known to be ruled by the damped oscillation of the perturbing field, called quasinormal modes (QNMs), followed by the tails of decay and is the characteristic of the background black hole spacetime.

In the last three decades, several shortcomings came out in the Einstein’s General Theory of Relativity (GTR). Such issues come, especially, from observational cosmology and quantum field theory. In the first case, for example, the observed accelerated expansion of the universe and the hypothesized mysterious dark energy still lack a satisfactory explanation. Secondly, GTR is a classical theory which does not work as a fundamental theory, when one wants to achieve a full quantum description of gravity. Due to these facts modification to GTR or alternative theories for gravity have been considered. Two potential approaches towards these problems are the quintessence model for dark energy and Hořava-Lifshitz (HL) gravity. Quintessence is a dynamical model of dark energy which is often realized by scalar field mechanism. HL gravity is the recently proposed theory of gravity, which is renormalizable in power counting arguments. The two models are considered as a potential candidate in explaining these issues.

In this thesis, the signature of these new theories are probed on the evolution of field perturbations on the black hole spacetimes in the theory.

Chapter 1 gives a general introduction to black holes and its perturbation formalism. Various concepts in the area covered by the thesis are also elucidated in this chapter.
Chapter 2 describes the evolution of massive, charged scalar field perturbations around a Reissner-Nordstrom black hole surrounded by a static and spherically symmetric quintessence. The complex frequencies of the normal modes associated with the evolution are evaluated using third order WKB approximation approach. The influences of quintessence on the QNMs are studied. The dependence of QNMs on the charge of the black hole, mass and charge of perturbing scalar field and the quintessential parameters are also clarified.

Chapter 3 comprises the evolution of massless scalar, electromagnetic and gravitational fields around spherically symmetric black hole whose asymptotes are defined by the quintessence, with special interest on the late-time behavior. The complete evolution profile is obtained through numerical methods for different values of quintessence state parameter and compare the results with case in the absence of quintessence. We examine how the different multipoles of perturbation for different spin fields evolve with time. Possible reasons for the different behavior of late-time tails are discussed.

Chapter 4 examines the evolution of Dirac field around a Schwarzschild black hole surrounded by quintessence. Detailed numerical simulations are done to analyze the nature of field on different surfaces of constant radius.

Chapter 5 is dedicated to the study of the evolution of massless fields around the black hole geometry in the HL gravity. From a knowledge of the evolution of scalar, electromagnetic and Dirac perturbations around black holes, we try to distinguish the the nature of the HL theory from that of GTR. QNM and tail phases are studied using the numerical integration and the WKB approximation method.

Chapter 6 concerns the study of the evolution of massive scalar field in the spacetime geometry of black hole in HL gravity by numer-
ical analysis. Different regimes of the late-time evolution are studied in detail.

Chapter 7 summarizes the substantial findings of the works presented in the thesis and suggests future scopes of the works that can be undertaken.

Notations and conventions

Throughout the thesis we have chosen the natural unit systems with $c = 1 = G$. Signature of spacetime metric: $(-, +, +, +)$. Semicolon after a vector or tensor stand for its covariant derivative. Prime over any quantity denotes derivative of that quantity w.r.t the radial coordinate and dot represents the time derivative. Indices $\mu, \nu, a$ and $b$ generally run over $0, 1, 2, 3$. The letter $c$ is used in this thesis for the normalization factor of quintessence.

Publications related to the work presented in the thesis:

In refereed journals


5. “Decay of Dirac field around Schwarzschild black hole surrounded by quintessence”, Nijo Varghese and V. C. Kuriakose. (to be submitted for publication)

**In conferences/seminars**


**Other publications to which author has contributed:**
