Name of scholar : **Pankaj Sheoran**

Name of Supervisor : **Sushant G. Ghosh**

Centre : **Centre for Theoretical Physics**

Title of thesis : **Penrose process and Particle Acceleration in Modified Theories of Gravity**

Abstract

The thesis aims to investigate the process of energy extraction and particle acceleration for rotating black holes in modified theories of gravity, also its properties from theoretical viewpoint. The whole thesis is divided into Seven Chapters. The Chapters 4, 5 and 6 of thesis is devoted to study concerning particle acceleration, while the energy extraction from a black hole due to Penrose process is subject of the Chapter 3. The first chapter of the thesis which is the introductory part contains the introduction of general theory of relativity, a brief history of black holes, and also the short explanation of Penrose and particle acceleration process.

In Chapter 2, we derived the higher dimensional (HD) spinning Non-Kerr black hole solution using the complex coordinate transformation method developed by Newman and Janis.

The Chapter 3 is devoted to the study effect of extra dimensions on the energy extraction from the rotating non-Kerr black hole in particularly via. Penrose process. Here we inspect the properties of the horizons and ergosphere. We also showed the effect of deformation parameter ϵ and the extra dimension on the efficiency of the Penrose process of energy extraction from a black hole. It was shown that the ergosphere size is sensitive to the deformation parameter ϵ as well as to the spacetime dimensions D. This makes the structure of the ergosphere in a higher dimension non-Kerr black hole much richer, thereby making the Penrose process more efficient compared with that of the four-dimensional Kerr black hole.

For particle acceleration process, we took two particles with equal masses moving in the equatorial plane and collide near the horizon of the rotating regular Ayón-Beato-García (ABG) black hole (BH) in Chapter 4. In this chapter the center-of-

mass (CM) energy for the colliding particles for both extremal and nonextremal cases is calclated. It was found that CM energy of these colliding particles depends not only on rotation parameter a but also on charge Q. Particularly for the extremal rotating regular ABG BH, the CM energy could be arbitrarily high when one of the two particles have the critical angular momentum. Furthermore, we also found that, for a nonextremal BH, there exists a finite upper limit of CM energy, which changes with charge Q. In the end of the Chapter, we compared our results with the Kerr and Kerr-Newman black holes.

We apply Banãdos, Silk and West (BSW) process to the rotating nonsingular black hole in Chapter 5, for different values of deviation parameter k, and demonstrate numerically that E_{CM} diverges in the vicinity of the horizon for the extremal cases, thereby suggesting that a rotating nonsingular black hole can also act as a particle accelerator and thus in turn may provide a suitable framework for Planck-scale physics. For a non-extremal case, there always exist a finite upper bound for E_{CM}, which increases with deviation parameter k. A comparison with Kerr and Kerr-Newman black holes is also done.

In Chapter 6, We study collision of two equal mass particle, via BSW mechanism, near the horizon of deformed Kerr (or non-Kerr) black hole, and explicitly bring out the effect of deformation parameter ϵ. The center-of-mass energy (E_{CM}) not only depends on rotation parameter a, but also on deformation parameter ϵ. It is demonstrated that the center-of-mass energy (E_{CM}) could be arbitrary high in the extremal cases when one of the colliding particle has critical angular momentum, thereby suggesting that the Non-Kerr black hole can act as a particle accelerator. Furthermore, we also show that, for a non-extremal black hole, there exists a finite upper limit of E_{CM}, which changes with deformation parameter ϵ. Our results, in the limit $\epsilon \to 0$, goes over to the Kerr black hole.

The thesis ends summerizing results and concluding remarks in chapter 7.