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Title of the Thesis: Black holes in modified theories of gravity and their properties

ABSTRACT

The present thesis is based on the ”Black holes in modified theory of gravity” and ”Black hole thermodynamics”. The main findings of the thesis is as follows.

The problem is defined and a survey of the work already in the literature has been made. A brief outline of the present work is also included in the introduction with possible future scopes.

We have discussed in detail about obtaining the rotating black hole solutions from their non rotating counterparts using NJA. We have obtained the spinning higher dimensional EYM black hole solution, higher dimensional Non-Kerr black hole solution and higher dimensional BTZ solution. We further discuss the properties of the rotating higher dimensional EYM black hole such as horizons and ergosphere. Rotating black holes solutions in higher dimensions are known as Myers-Perry black holes. The thermodynamical quantities associated with the rotating higher dimensional EYM black hole are also calculated. Further we demonstrate that the thermodynamical quantities of this black hole go over to corresponding quantities of Myers-Perry black hole and Kerr black hole. The NJA is applied to spherically symmetric radiating f (R) black hole solutions, and the corresponding radiating rotating solutions, namely radiating f (R) Kerr-Newman metrics are obtained. We investigate further the structure and location of horizons of the radiating f (R) Kerr-Newman metric. We consider whether f (R) gravity 2plays any special role in the formation of horizons. We also discuss briefly basic equations of HD f (R) gravity.

We have also investigate the apparent shape of a 5D Myers-Perry solution to visualize the shape of the shadow and compare the results with the images for the Kerr black hole. We have studied the effect of rotation parameter on the shape of the shadow. We have discussed in detail about the 5D Myers-Perry black hole solution, presented the particle motion around the 5D black hole to discuss about the shadow of the black hole. Two observables the radius and the distortion parameter are introduced to discuss about the apparent shape of the shadow of the black hole. We also extended our analysis to study the shadow of 5D Myers-Perry naked singularity, which have two parts the dark arc and distorted circular shape. The results are similar to the Kerr / Kerr Newman naked singularities, where the shadow has two parts, the dark arc and the dark spots. We also observe the deviation of the peak of effective potential towards the central object.

We have obtained exact static spherically symmetric black hole solutions to general relativity, Einstein-Gauss-Bonnet gravity, and the third order Lovelock gravity in the background of a cloud of strings in arbitrary N = n + 2 dimensions. Thus we have generalized the static, spherically symmetric black hole solutions for these theories in the strings cloud background. We then proceeded to find exact expressions, in the Einstein-Gauss-Bonnet gravity, for the thermodynamic quantities like the black hole mass, Hawking

temperature and entropy, and in turn also analyzed the thermodynamic stability of black holes for the case of first and second order theories. In addition, we explicitly brought out the effect of a background strings cloud on black hole solutions and their thermodynamics. Here we have also discussed about the behaviour of rotating Hayward regular black hole by analyzing its thermodynamic properties.

We obtained, at the apparent horizon, a thermodynamical identity from the Einstein field equations for the case of nonstationary radiating black holes which have dynamical horizons. In particular, we consider the case of radiating black holes, 3in 3 + 1 and N + 1 dimensions, and the case of radiating rotating black holes in N + 1 dimensions for which we demonstrate that the Einstein field equations near the horizon can be written in the form of a thermodynamical identity.