INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The intriguing connections between gravity and thermodynamics have been a long standing subject of study. The conventional laws of black hole mechanics have often provided deep insights into the nature of gravity. In this thesis, we explore the picture of emergence of the gravitational field equations from a classical stand-point and test its validity to theories beyond general relativity. In this thesis, we develop in detail the geometrical construction of a general integrable null hypersurface in the Riemann-Cartan spacetime. The Riemann-Cartan spacetime is a generalization to the usual (pseudo)-Riemannian spacetime (equipped with the Levi-Civita connection) in the sense of allowing non-trivial torsion in it. We develop in detail the evolution equations of certain geometric data established on the null surface. In the thesis, we try to interpret the physical nature of the gravitational field equations on the null surface in the light of the evolution equations constructed. Our first study is the general case of gravitational theories described on spacetimes equipped with the Levi-Civita connection. We show in a covariant fashion that the field equations on the null surface under the process of virtual displacement take up a thermodynamic structure without taking recourse to any explicit coordinate system adapted to the null surface. Next, we take the specific case of scalar-tensor theory and show such a thermodynamic interpretation of the field equations allow us to shed some light on the issue of the physical (in)equivalences between the Einstein and Jordan frame. We also provide a proof of the zeroth law for Killing horizons in the scalar-tensor theory. Next, we take the explicit case of Einstein-Cartan gravity and show similar thermodynamic interpretation exists for the gravitational field equations on the null surface. We also study the dynamics of a geometrical data called the Hajicek 1-form on the null surface in Einstein-Cartan gravity and show that under suitable conditions, it looks like a Cosserat fluid. This strengthens the analogy of the horizon or null surface dynamics to that of a viscous fluid flow, for theories even beyond general relativity. Finally, we conclude the thesis with a brief discussion of the conclusions and potential future directions.