Some Results on Black Hole Horizons: A Covarint Approach

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Abstract

We study general properties of black holes using a covariant approach. In particular, we consider some topological properties and the evolution of black holes, as well as flux properties associated with the horizons of black holes in context of the $1+1+2$ spacetime splitting geometric and thermodynamic variables. It is shown that in spacetimes with null geodesics normal to the 2-surfaces (which we name NNF spacetimes) the horizon of a black hole foliated by these 2-surfaces on which the outgoing null expansions vanish is topologically LRS II. Our procedure allowed us, in a relatively easy manner, to provide bounds on the parameter σ in the Robertson-Walker spacetimes, for both causal characterization of horizons and stability of the leaves foliating the horizons (the marginally trapped surfaces. or MTS). Stability analysis is carried out on MTS in the Lemaitre-Tolman-Bondi spacetimes, and it is shown that only spacelike horizons (and necessarily so) have stable MTS and that this guarantees no shell crossing. Finally, computing the surface gravity in terms of the $1+1+2$ scalar variables, an explicit proof is provided for the third law of black hole thermodynamics for LRS II spacetimes. This proof can be extended to NNF spacetimes.

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