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causal description of marginally trapped regions in D dimensions

In this paper, we analyze the causal aspects of evolving marginally trapped surfaces in a D dimensional spherically symmetric spacetime, sourced by perfect fluid with a cosmological constant. The norm of the normal to the marginally trapped tube is shown to be the product of lie derivatives of the expansion parameter of future outgoing null rays along the incoming and outgoing null directions. We obtain a closed form expression for this norm in terms of principal density, pressure, areal radius and cosmological constant. For the case of a homogeneous fluid distribution, we obtain a simple formula for determining the causal nature of the evolving horizons. We obtain the causal phase portraits and highlight the critical radius. We identify many solutions where the causal signature of the marginally trapped tube or marginally anti-trapped tube is always null despite having an evolving area. These solutions do not comply with the standard inner and outer horizon classification for degenerate horizons. We propose an alternate prescription for this classification of these degenerate horizons

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