

Complete classification of the FLRW solutions with linear EOS: p.p. curvature singularities for general geodesics

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Harada, Carr, Igata, CQG 35 (2018) 105011 [arXiv:1801.01966]

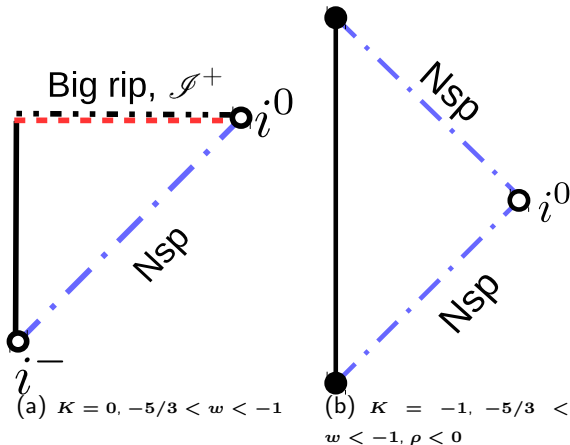
Harada, Igata, Sato, Carr, to appear in CQG [arXiv:2110.13421].

Introduction

- FLRW spacetimes
 - Spatial curvature $K = 0, \pm 1$
 - EOS $p = w\rho$ can be assumed.
- Curvature singularities
 - Singularities may be defined by incomplete geodesics.
 - **P.p. singularities**: At least one component of the Riemann tensor in the parallelly propagated frame is unbounded along the incomplete geodesic. The spacetime cannot be extended.
 - **S.p. singularities**: At least one scalar polynomial of the Riemann tensor is unbounded along the incomplete geodesic. **Big-bang** singularities are included.
- We classify FLRWs with $p = w\rho$ **without** assuming any energy conditions. $w = -5/3$ is an important critical value.

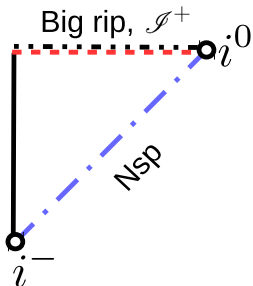
N.s.p. singularities

- **N.s.p. singularities:** P.p. singularities which are not s.p. Both ρ and p are bounded.
- (a) Initial null n.s.p. singularity
- (b) Initial and final null n.s.p. singularities

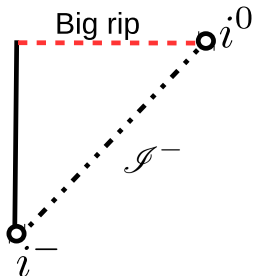


Big-rip singularities

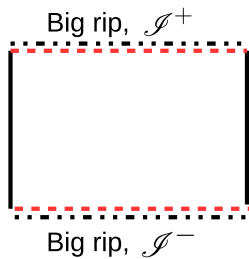
- **Big-rip singularities:** s.p. singularities with $\rho \rightarrow \infty$ and the scale factor $a \rightarrow \infty$ at $t \rightarrow t_s$
- (c) Big-rip singularity for timelike geodesics but \mathcal{I}^+ for null geodesics
- (d) Big-rip singularity for both timelike and null geodesics
- (e) Both future and past big-rip singularities



(c) $K = 0$, $-5/3 < w < -1$



(d) $K = 0$, $w < -5/3$



(e) $K = 1$, $-5/3 \leq w < -1$