Moritz Reintjes

Points of General Relativisitic Shock Wave Interaction are "Regularity Singularities" where Spacetime is Not Locally Flat

Moritz Reintjes, Blake Temple

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Abstract

We show that the regularity of the gravitational metric tensor in spherically symmetric spacetimes cannot be lifted from $C^{0,1}$ to $C^{1,1}$ within the class of $C^{1,1}$ coordinate transformations in a neighborhood of a point of shock wave interaction in General Relativity, without forcing the determinant of the metric tensor to vanish at the point of interaction. This is in contrast to Israel's Theorem \cite{Israel} which states that such coordinate transformations always exist in a neighborhood of a point on a smooth {\it single} shock surface. The results thus imply that points of shock wave interaction represent a new kind of singularity for perfect fluids evolving in spacetime, singularities that make perfectly good sense physically, that can form from the evolution of smooth initial data, but at which the spacetime is not locally Minkowskian under any coordinate transformation. In particular, at such singularities, delta function sources in the second derivatives of the gravitational metric tensor exist in all coordinate systems of the $C^{1,1}$ atlas, but due to cancelation, the curvature tensor remains uniformly bounded.

Source: arXiv

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