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M. Reintjes: On the regularity implied by the assumptions of geometry

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The Regularity Transformation (RT)-equations are an elliptic system of partial differential equations which determines coordinate and gauge transformations that remove apparent singularities in space- time by furnishing optimal metric regularity. The resulting gain of one derivative for connections above their L_p curvature suffices to establish Uhlenbeck compactness. By developing an existence theory for the RT-equations we prove optimal regularity and Uhlenbeck compactness in Lorentzian geometry, including general affine connections and connections on vector bundles with both compact and non-compact gauge groups. As an application in General Relativity, our optimal regularity result proves that the Lorentzian metrics of shock wave solutions of the Einstein-Euler equations are non-singular—geodesic curves, locally inertial coordinates and the Newtonian limit all exist in a classical sense. It is currently an open problem whether the RT-equations could provide a general procedure for removing apparent singularities at black hole horizons.

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