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On Convexity Conditions in Spatial and Material Settings of Hyperelasticity

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In this contribution convexity conditions for the spatial and material motion problem are investigated. Whereas the spatial motion problem corresponds to the usual equilibrium equations, the material motion problem is driven by the inverse deformation gradient, thus it deals with material or configurational forces that are energetically conjugated to material variations, i.e. variations at fixed spatial positions. The duality between the two problems is elaborated in terms of balance laws, their linearisations including the consistent tangent operators and in particular the so-called acoustic tensors. Issues of convexity and in particular of rank-one-convexity are discussed in both settings. As a remarkable result it turns out, that if the rank-one-convexity condition is violated, the loss of well-posedness of the governing equations occurs simultaneously in the spatial and in the material motion problem. Thus, the inclusion of the material motion problem does not lead to additional requirements to maintain rank-one-convexity or ellipticity. The results are developed for the hyperelastic case in general and highlighted analytically and numerically for a material of Neo-Hookean type.

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