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Finite deformation non-isotropic elasto-plasticity with evolving structural tensors. A framework

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Summary. — The paper discusses a constitutive model for finite deformation anisotropic elasto-plasticity, within the framework of the multiplicative decomposition of the deformation gradient and of the theory of the structural tensors. It is shown that the driving force for the evolution of the anelastic deformation is not the classic stress, rather a thermodynamic force where the stress is corrected for a term caused by the transformation of the material directions due to plastic deformations. Two scenarios can arise, one in which the material directions do not evolve, and the other in which the material directions can evolve due to anelastic phenomena. The general framework model presented here can be applied to various phenomena in material science.

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1. – Introduction

Finite deformation anisotropic elasto-plasticity raises several questions, among them, the role of the plastic spin, the evolution of the material directions, and the form of the dissipation. Historically, the earliest models referred to crystal plasticity, and it was assumed that during deformation material directions remain attached to the crystal structure, so they are not affected by irreversible processes [1, 2]. However, this is not always true: materials with a fibril structure, such as amorphous polymers, can modify their anisotropic structure when subjected to irreversible stretching, so that the yield locus changes its shape and rotates. Similarly, in the phenomenon of cold drawing, at low extension rate the molecular chains align in the direction of the applied stress, inducing anisotropy, and turning opaque an originally transparent sample. Biotissues, for example blood vessels, are made by collagen fibrils arranged in a cross lamellar fashion [3], and their directions can evolve for two phenomena: an applied stress causes reorientation,

