A revisit of a viscoelasticity theory

JU LIU
Department of Mechanics and Aerospace Engineering, Southern University of Science and Technology, Shenzhen
Email: jliu36@sustech.edu.cn, liujuy@gmail.com

The viscoelasticity theory proposed in [1,2] has gained popularity over the years, largely because it is amenable to finite element implementation and convenient in accounting for material anisotropy. Recently, a finite-time blow-up solution has been identified [3], signifying an alerting issue concerning its theoretical root. The lack of a thermodynamic foundation has been viewed as a major drawback of this model.

In this talk, I will address the issue by providing a complete thermomechanical theory for the aforementioned finite viscoelasticity model [4]. The derivation elucidates the origin of the evolution equations of that model, with a few non-negligible differences. It is also shown that the conjugate variable and non-equilibrium stress should be differentiated, an issue that has been ignored in prior works. I will discuss the relaxation property of the non-equilibrium stress in the thermodynamic equilibrium limit and its implication on the form of free energy, which clarifies the failure of a classical model based on the identical polymer chain assumption.

Based on the consistent framework, a set of energy-momentum consistent schemes is constructed for finite viscoelasticity using a *strain-driven* constitutive integration scheme and a generalized *directionality property* for the stress-like variables. I adopt a suite of smooth generalization of the Taylor-Hood element based on Non-Uniform Rational B-Splines for spatial discretization. The element is further enhanced by the grad-div stabilization to improve the discrete mass conservation. I will also discuss recent advancements in designing non-singular algorithmic stresses for energy-momentum consistent schemes [5]. Numerical examples will be provided to justify the effectiveness of the proposed methodology.

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