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Variational Upscaling of Elastic Network Models with Damage for Rubberlike Materials

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The talk will introduce and illustrate a non-affine microsphere model for rubberlike materials based on a local minimisation of the network free energy under a maximal advance path constraint (Tkachuk and Linder, 2012). It accounts for any chain weight distribution and for damage such as Mullins softening observed in filled rubber materials. The non-affine equal-force model is compared to the common affine model and a hybrid equal-force model (Verron and Gros, 2017), when considering the isotropic hyperelastic behavior without damage of rubber materials presenting chains of various lengths. The non-affine model shows an improved deformability compared to the affine model limited by the maximal extension of the shorter chains and a significantly softer behavior. Damage is introduced to account for the Mullins softening, by increasing the chain lengths according to the submitted maximal chain traction force. The damage is applied on each chain independently resulting in a directional softening and introduces an evolution of the stress-free configuration that needs to be assessed over the loadings. The model was successfully tested on the cyclic uniaxial tension stretch-stress responses of carbon-black filled styrene butadiene rubbers that were well fitted with three parameters only. The talk will also discuss about different possible perspectives which appear when considering evolving anisotropic chain distributions or more complex kinematic constraints.

References

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