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The nonlinear elastic response of suspensions of rigid inclusions in rubber

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In the first part of the talk, we present a solution for the fundamental problem of the overall elastic response of Gaussian (Neo-Hookean) rubber reinforced by a dilute isotropic distribution of rigid particles under arbitrarily large deformations. The derivation makes use of a novel iterative homogenization technique [1] in finite elasticity that allows to construct exact solutions for the homogenization problem of two-phase nonlinear elastic composites with particulate microstructures. The solution is fully explicit for axisymmetric loading, but is otherwise given in terms of an Eikonal partial differential equation in two variables for general loading conditions. In the limit of small deformations, it reduces to the classical Einstein-Smallwood result for dilute suspensions of rigid spherical particles. The solution is further confronted to 3D finite-element simulations for the large-deformation response of a rubber block containing a single spherical rigid inclusion of infinitesimal size. Good agreement is found for all loading conditions. The implications of this agreement are discussed.

In the second part of the talk, we make use of the dilute solution as a fundamental building block within the context of a new comparison medium method [2] to derive a simple explicit approximate solution for the overall nonlinear elastic response of filled elastomers with finite concentration of particles under arbitrarily large deformations.

REFERENCES

[1] Lopez-Pamies, O., Goudarzi, T., Nakamura, T. 2013. The nonlinear elastic response of suspensions of rigid inclusions in rubber: I — An exact result for dilute suspensions. *Journal of the Mechanics and Physics of Solids* 61, 1–18.

[2] Lopez-Pamies, O., Goudarzi, T., Danas, K. 2013. The nonlinear elastic response of suspensions of rigid inclusions in rubber: II — A simple explicit approximation for finite-concentration suspensions. *Journal of the Mechanics and Physics of Solids* 61, 19–37.