ABSTRACT

Materials with inherent network microstructures are commonly encountered in materials of artificial and natural origin. Examples are polymer elastomers, hydrogels, soft biological tissues, nonwoven fabrics, or cellular foams. On the microscopic level, those are all composed of elongated one-dimensional elements generally addressed as fibers. When macroscopically deformed, the underlying microstructure undergoes a peculiar deformation resulting in forces produced by the deformed filaments and their interaction within the irregular three-dimensional network. The knowledge about the micromechanics of random networks is therefore of major importance to understand the peculiar mechanical properties displayed by those soft materials. In this presentation, a new mean field approach to describe the microscopic deformation and the homogenization of their elastic response is proposed. Employing the concept of maximal advance paths, a kinematic link between its macroscopic affine path and its microscopic averaged deformation is found and solved numerically through a constraint minimization principle. Remarkably, the network functionality highly influences the constraint formulation. The more fibers are connected at a junction point, the higher is the probability to find among them a fiber oriented closely to the advance direction resulting in an affine network deformation. A non-affine network deformation is observed for a functionality of four, for which the constraint takes a particularly interpretable form, as soon as a nonlinear fiber response is valid.