Shape disorder as a source for non-linear compression behavior of aligned fibrous matter

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Bundles of nearly fully aligned fibers display an intrinsic fluffiness when the individual strands are not straight but have rather spontaneously curved shapes. Hair tresses, ponytails and other natural fagots provide examples of such materials with non-linear intrinsic compression behavior. Here, we investigate by a combination of experiments, numerical simulations and theory how the statistical properties of the shapes of the fibers control the non-linear collective mechanical behavior of the bundles. We show that a theoretical self-consistent description connecting fiber shape disorder with stack compressibility explains well the observed and simulated strongly non-linear elastic behavior over five decades of stress. This work paves the way for designing aligned fibrous matter with purposed-designed properties from large numbers of individual strands of selected geometry and rigidity[1,2].

Références

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