FIELD FLUCTUATIONS IN NONLINEAR COMPOSITES

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Typically, the analysis of composite materials focuses on the estimation of their macroscopic behavior in terms of the behavior of the constituents. However, under many circumstances it is also important, or even essential, to estimate certain statistics of the spatial distribution of the local fields within the composite. For instance, in viscoplastic composites and polycrystals undergoing finite deformations, certain knowledge about the distribution of the strain-rate field (e.g. the phase averages) is necessary to be able to account for the evolution of the microstructure, which can strongly affect the macroscopic behavior. Also, information on the stress distribution can be useful for developing theories of damage nucleation and evolution in heterogeneous material systems.

In this work, the so-called "second-order" homogenization method [1] is used to estimate not only the effective behavior but also the first and second moments of the underlying strain and stress fields in nonlinear random composites. Two-phase fiber composites with power-law phases are considered in detail, for two different heterogeneity contrasts corresponding to fiber-reinforced and fiber-weakened composites. The homogenization estimates are compared with available exact results for power-law composites with transversely-isotropic sequentially-laminated microstructures [2]. Both the exact results and the corresponding "second-order" estimates show that the strain fluctuations in these systems increase, sometimes significantly, and become progressively more anisotropic with increasing nonlinearity. In fact, in the fiber-reinforced case, the strain fluctuations tend to become unbounded in the limiting case of ideally plastic composites. In general, the "second-order" estimates are found to be in good agreement with the exact results, even for high nonlinearities, and they improve, often in qualitative terms, on earlier nonlinear homogenization estimates. Thus, it is demonstrated that the "second-order" method can be used to extract information not only for the macroscopic behavior, but also for the anisotropic distribution of the local fields in nonlinear composites.

References

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