Recent developments in nonlinear homogenization

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Abstract

Some recent techniques [1, 2] for estimating the macroscopic behavior of nonlinear composites and polycrystals will be presented. These homogenization methods follow from variational principles expressing the effective behavior of a nonlinear composite in terms of that of an optimally chosen "linear comparison composite." This allows the use of classical bounds and estimates (e.g., Hashin-Shtrikman, self-consistent) for linear materials to generate corresponding information for nonlinear ones. Comparisons will be made with numerical simulations for the effective behavior and filed fluctuations in porous materials, metal-matrix composites and polycrystals, showing that the new methods are significantly more accurate than earlier ones, especially at high nonlinearity and contrast. The methods can be extended to incorporate evolution of the microstructure and its influence on the effective response under finite strains. An application to forming of porous metals will be given, where the evolution of the anisotropy due to the change in shape and orientation of the pores is accounted for.

References

[1] Ponte Castañeda, P. (2002) "Second-order homogenization estimates for nonlinear composites incorporating field fluctuations: I—Theory." *J. Mech. Phys. Solids* **50**, 737-757.

[2] Liu, Y. and Ponte Castañeda, P. (2003) "Second-order theory for the effective behavior and field fluctuations in viscoplastic polycrystals." *J. Mech. Phys. Solids* **51**, in press.