

ABSTRACT

Discrete Network Approximation for Effective Properties of High Contrast Random Highly Packed Solid and Fluid composites.

Leonid Berlyand,

Department of Mathematics and Materials Research Institute, Penn State University, University Park, PA 16801.

We present a new approach for calculation of effective properties of high contrast random composites (random particles in a matrix or host when properties of the particles and the hosting medium are very different) and provide its rigorous mathematical justification.

The main idea of this approach is the reduction of the original continuum problem, which is described by PDE with rough coefficients, to a discrete random network. We introduce the interparticle distance parameter for irregular (nonperiodic or random) distributions of particles and show asymptotic equivalence of the effective (homogenized) coefficients for the discrete and continuum models in the limit when the relative interparticle distance goes to zero.

Our main objective is to obtain and justify efficient computational formulas for the dependence of the effective conductivity (dielectric constant) and effective viscosity on the geometrical parameters such as the interparticle distances and particle sizes for nonperiodic (random) arrays of particles.

We use the discrete network to compute the effective coefficients (effective dielectric constant, effective viscosity) numerically and draw physical predictions about polydispersed composites (particles of different sizes) in the percolation regime. Our analysis provides an explanation of recent numerical results [6] where the effective viscosity of random suspension of solid particles in an incompressible fluid was found to be different from earlier predictions based on the lubrication approximation.

Our method is based on variational techniques and it provides an exact error estimate in which all constants are explicitly defined. Such results are rare in homogenization: most of the error estimates provide the order of magnitude only and involve some unknown constants.

The work was done jointly with A. Kolpakov [1], with A. Novikov [2], and with L. Borcea and A. Panchenko [3],[4]

References

- [1] L. Berlyand, A. Kolpakov. “ Network approximation in the limit of small interparticle distance for the effective properties of high contrast random dispersed composites”, *Archive of Rational Mechanics and Analysis*, 2001, 159, 3 pp.179-227.
- [2] L. Berlyand, A. Novikov, “ Error of the network approximation for densely packed composites with irregular geometry” *SIAM J. Math. Analysis*” *SIAM J. Math. Anal.*, 34/2, pp. 385-408.
- [3] L. Berlyand, L. Borcea and A. Panchenko, “ Network approximation for effective viscosity of highly loaded suspensions” (preprint, submitted for publication) 2003.
- [4] L. Berlyand and A. Panchenko., “ Geometric Instabilities od Effective Viscosity for Highly Packed Suspensions of Rigid Partciles”, preprint, 2003.
- [5] L. Borcea, J.G. Berryman, and G. Papanicolaou, “Matching pursuit for imaging high contrast conductivity “
- [6] A. Sierou, J. Brady. “Accelerated Stoksian dynamics simulation”, *J. Fluid Mech*, 448, pp 115-146, 2001.