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Discrete Network Approximation for Singular Behavior of the Effective Viscosity of Concentrated Suspensions

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We present a new approach for calculation of effective properties of high contrast random composites and illustrate it by considering highly packed suspensions of rigid particles in a Newtonian fluid.

The main idea of this approach is a reduction of the original continuum problem, which is described by PDE with rough coefficients, to a discrete random network. This reduction is done in two steps which constitute the "fictitious fluid" approach. In Step 1 we introduce a "fictitious fluid" continuum problem when fluid flows only in narrow channels between closely spaced particles, which reflects physical fact that the dominant contribution to the dissipation rate comes from these channels. In Step 2 we derive a discrete network approximation for the latter continuum problem.

Next we use this approach to calculate the effective viscous dissipation rate in a 2D model of a suspension. We show that that under certain boundary conditions the model exhibits an anomalously strong rate of blow up when the concentration of particles tends to maximal. We explore physical ramification of this phenomenon.

We will also discuss how an iterative procedure of the network construction which may be used in the study of dynamics of highly packed suspensions.

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