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Scaling effects and homogenization of reaction-diffusion problems with nonlinear drift.

Abstract

We study the homogenization of reaction-diffusion problems with nonlinear drift. The microscopic model is derived as the hydrodynamic limit of a totally asymmetric simple exclusion process of interacting particles. We first look into a situation when the interacting particles cross a thin composite layer. To understand the effective transmission condition, we perform the homogenization and dimension reduction of the model with variable scalings. One physically interesting scaling that we look at separately is when the drift is large. In this case, we consider the overall process taking place in an unbounded porous media. We first upscale the model using the asymptotic expansions with drift. Then, using two-scale convergence with drift, we rigorously derive the homogenization limit for a similar microscopic problem with a nonlinear boundary condition. Additionally, we show the strong convergence of the corrector function. In the large drift case, the resulting upscaled model is a nonlinear reaction-dispersion equation strongly coupled with a system of nonlinear elliptic cell problems. We study the solvability of a similar strongly coupled two-scale system with nonlinear dispersion by constructing an iterative scheme. Finally, we illustrate the behavior of the solution using the iterative scheme.