

Drainage in foams with surfactant-covered interfaces

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A macroscopic foam-drainage equation is frequently used to predict the macroscopic dynamics of wet foams including buoyancy-driven forced drainage and capillary-driven free-drainage. Its derivation follows from a Darcy's-law description for porous media augmented by Plateau's laws to describe the equilibrium microstructure of a foam. Accordingly, it is usually assumed that the microstructure is only slightly perturbed from local equilibrium by the dynamics of drainage. The problem simplified further for foams with low liquid content which is an important regime for many applications and is the regime most often studied. Despite the foregoing simplifications, macroscopic descriptions of foam drainage dynamics are often unreliable due to uncertainty regarding the permeability of foams. The widely-used classical model of foam permeability was derived by Leonard and Lemlich (1965) who analyzed the unidirectional flow in straight, three-sided channels of a Plateau border network. The effects of surface viscosity were included, with no-slip boundary conditions recovered for large values of this parameter. However, surfactant conservation is neglected and thus Marangoni stresses are ignored. More recent studies have assumed that Marangoni stresses result in no-slip boundary conditions inside the Plateau borders. In this talk, a model of foam permeability is presented that incorporates surfactant conservation and thus Marangoni stresses. It is shown that Marangoni stresses do not, in fact, result in no-slip boundary conditions but rather enforce surface incompressibility on the interfaces. The distinction between no-slip boundary conditions and the surface incompressibility constraint is shown to qualitatively affect the microscopic flow in the Plateau borders, leading to much larger foam permeability than predicted if no-slip boundary conditions are assumed.