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PHASE FIELD MODELS FOR CAPILLARY FLOWS

M. Dehsara[1], H. Fu[2], S. Dj. Mesarovic[1, *], D. P. Sekulic[2, 3] and M. Krivilyov[4]

[1] School of Mechanical and Materials Engineering, Washington State University, Pullman, WA 99164-2920, USA
[2] Department of Mechanical Engineering, University of Kentucky, Lexington, KY, USA
[3] State Key Laboratory for Welding and Advanced Joining, School of Materials Science and Engineering, Harbin Institute of Technology, Harbin, PR China
[4] Laboratory of Condensed Matter Physics, Institute of Mathematics, Informatics and Physics, Udmurt State University, Izhevsk, Russia
[*] Correspondence: mesarovic@mme.wsu.edu, https://mme.wsu.edu/faculty/sinisa-mesarovic/

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Phase field (diffuse interface) models accommodate diffusive triple line motion with variable contact angle, thus allowing for the no-slip boundary condition without the stress singularities. We consider two commonly used classes of phase field models: the compositionally compressible (CC) model with compressibility limited to the fluid mix within the diffuse interface, and the incompressible (IC) model.

The CC model applied to fluids with dissimilar mass densities exhibits the computational instability leading to the breakup of the triple line [1]. We provide a qualitative physical explanation of this instability and argue that the compositional compressibility within the diffuse interface is inconsistent with the global incompressible flow. The IC model is derived as a systematic approximation to the CC model, based on a suitable choice of continuum velocity field, and benchmarked against sharp interface theory and experimental kinetics. The benchmark processes include the spreading of water and silicone oil over non-reactive substrates and the high temperature non-reactive approximation of the liquid metal wetting (liquid Al–Si alloy over solid Al alloy) [2].

The triple line kinetics is well represented by the triple line mobility parameter. We investigate the effects of the bulk phase field diffusional mobility parameter on the kinetics of the wetting process and find that within a wide range of magnitudes the bulk mobility does not affect the flow.

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