



The Heterogeneous Multiscale Methods for Interface Tracking

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Research Program: In my thesis I investigate the heterogeneous multiscale methods (HMM) for interface tracking and apply these techniques to the simulation of combustion fronts and epitaxial growth. HMM relies on an efficient coupling between the macroscale and microscale models. When the macroscale model is not fully known explicitly or not valid in localized regions, HMM provides a procedure for supplementing the missing data from a microscale model.

For the application to the combustion processes, the goal is to overcome the numerical difficulties, which are caused by different time scales between the transport part and the reactive part in the combustion model equations. I design and analyze a multiscale scheme in which a localized microscale model resolves the details in the model and a phase field or a front tracking method defines the interface on the macroscale. This multiscale technique overcomes the difficulty of stiffness within common problems in combustion processes. Numerical results for Majda's model and reactive Euler equations in one and two dimensions show substantially improved efficiency over traditional methods. Modeling epitaxial growth is another highly multiscale problem in which the physical processes are operative over a vast range of length and time scales, from the atomistic to the continuum. Therefore, I use the HMM framework to combine the macroscopic and microscopic formulations in order to take the advantages of both the simplicity and efficiency of the level set island dynamics model on the continuum level, as well as of the accuracy of the kinetic Monte Carlo simulations on the atomistic scale. Numerical tests for modeling the island growth and the step edge evolutions demonstrate the efficacy of our hybrid coupling methodology.

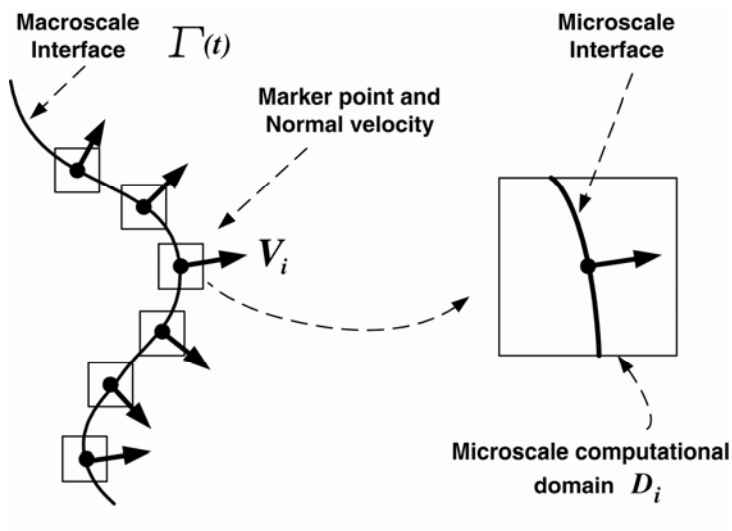


Illustration for HMM in the 2-D case.