Modélisation du changement de phase solide/liquide

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Abstract

This research explores the modeling and numerical resolution of solid-liquid phase transitions through the Stefan problem, a critical model in understanding phase change dynamics. The study investigates both deterministic and stochastic approaches to solve the Stefan problem, particularly highlighting the effectiveness of Feynman-Kac representations in approximating temperature fields under uncertainties. A comparison between stochastic methods and the Finite Element Method (FEM) reveals that both approaches yield comparable accuracy, with stochastic methods offering additional flexibility in managing variability in material properties and boundary conditions. A significant portion of this work is devoted to optimizing the geometry and partitioning of domains to enhance thermal management in applications involving Phase Change Materials (PCMs). These materials, known for their latent heat storage capabilities, are investigated for use in electronic cooling and other thermal systems. The study incorporates multi-domain coupling methods and shape optimization to address the complexities of modeling PCMs in irregular geometries. The results demonstrate the potential of combining FEM and stochastic methods to improve simulation accuracy and computational efficiency in phase change problems. Applications in the design of PCM-based thermal systems, particularly for electronic components and refrigeration, highlight the practical implications of this work.