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PHASE-FIELD MODELING AND ENGINEERING APPLICATIONS IN SOLID MECHANICS

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ABSTRACT

Multiple problems in engineering require tracking two or more species or material phases as they evolve and interact over space and time according to a certain set of physical models. A traditional approach to address this challenge would require solving the physics for each phase and explicitly track the ensuing evolution of the interface, which may exhibit an intricate geometric parameterization and undergo complex geometric transformations as a result of the modeled physics. Alternatively, phase-field modeling offers a robust mathematical framework to accommodate the joint description of the dynamics of the participating phases and implicitly track the evolution of the interface. Examples of multi-phase systems in solid mechanics currently span areas as diverse as crystal growth, polymer blends, binary alloys, fracture, complex fluids, additive manufacturing, and solid tumor growth. The key concept of phase-field modeling is to replace a sharp by a diffuse interface, described by a smoothly changing variable. This phase-field variable is governed by partial differential equations, capturing the diffuse interfaces and encoding the interfacial physics at once. The arising coupled system of partial differential equations is inherently non-linear, often with higher-order spatial derivatives that account for the interfacial forces. Moreover, the higher-order terms are scaled with a small coefficient (the interface thickness) that makes the equations singularly perturbed. Phase-field models, thus, bring many challenges for numerical simulations, such as, for example, stiff semi-discretizations, stable time-stepping algorithms, the treatment of sharp internal layers, and the necessity for adaptation of the discretization in space and time. In this minisymposium, we invite contributions on new phase-field modeling and discretization techniques, their numerical analysis, and their application to problems in solid mechanics. We expect a multidisciplinary audience with experts from computational mechanics, computational science and engineering, mathematical modeling, numerical analysis, and related fields.