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Phase-field modelling of evolving adhesive interfaces

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Computational phase-field modelling is a powerful and versatile mathematical technique to describe and solve problems that involve evolving interfaces [1]. In this contribution, we present a new phase-field model for adhesion and discuss its underlying foundations in terms of thermomechanical consistency. The interaction between adhesive interfaces is modelled by the introduction of a coupling term in the classical free energy. The resulting phase-field model is a stiff, higher-order, non-linear partial differential equation, in which adhesive interaction is regularized onto the moving interfaces. We provide numerical examples of adhesion and discuss how unconditionally energy-stable results can be obtained by using the scalar auxiliary variable approach for the time-discretization of the model's equations [2].

Furthermore, we discuss application of the presented adhesion model to problems in cell biology, which is vital in understanding numerous biological processes, including cell migration, maintaining structural integrity and signal transduction [3, 4]. We show how the model can be extended to account for the protein dynamics at the cell's membrane, which govern the binding and unbinding of the cell to its extracellular environment [5]. In addition, we will briefly mention how the underlying free energy of such a model can be learned via a data-driven network.

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