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Interfacial Stabilization at Finite Strains for Weak and Strong Discontinuities in Multi-Constituent Materials

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Abstract

A stabilized interface formulation is developed for debonding at finite strains across general bimaterial interfaces by embedding stabilized Discontinuous Galerkin (DG) ideas in the Continuous Galerkin method.. Introducing an interfacial gap function that evolves subject to constraints imposed by opening and/or sliding interfaces, the proposed Variational Multiscale DG (VMDG) method seamlessly tracks interface debonding by treating damage and friction in a unified way. An internal variable formalism together with the notion of irreversibility of damage results in a set of evolution equations for the gap function. Evolution of the debonding surfaces requires interfacial stabilization that is developed based on residual-based stabilization concepts. Tension debonding, compression damage, and frictional sliding are accommodated, and return mapping algorithms in the presence of evolving strong discontinuities are developed. A significant contribution of the paper is the consistently derived method to model the Lagrange multiplier field via interfacial flux and jump terms and variational embedding of various nonlinear interfacial debonding models at the interfacial boundaries. This derivation variationally embeds the interfacial kinematic models that are crucial to capturing the physical and mathematical properties involving large stains and damage. A set of representative test cases highlight the salient features of the proposed VMDG method and confirm its robustness and range of applicability.

Key Words: Finite strains, Variational Multiscale method, Discontinuous Galerkin, Interfacial debonding, interfacial damage

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