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The eXtended Finite Element Method and its Application to Multi-material Hydro-dynamics in ALEGRA

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Simulation of physics with complex moving interfaces is ubiquitous in modeling and simulation at Sandia. Although interface effects may significantly impact overall physics, accurately modeling these interfaces requires schemes that can properly capture/resolve them. Accurate treatment of interfaces can be accomplished by allowing the spatial discretization to follow the material motion (Lagrangian mesh). However, this approach is i) limited to relatively small deformations/vorticities, ii) requires conformal meshing of material boundaries and iii) doesn't resolve issues such as non-material related interfaces (e.g. fracture and phase change). Another approach avoids these issues by fixing the mesh and allowing material to flow through. In this Eulerian approach, computational volumes invariably involve multiple materials, each of which has its own constitutive relationship and which might be expected to interact only through their interface.

In this talk I will discuss an approach for treating interface physics by modifying (enriching) the discretization of a background grid via the eXtended Finite Element Method (XFEM). I will discuss an implementation of the XFEM in the ALEGRA hydrodynamics code and provide examples of the impact of properly resolving interface physics on solution accuracy. Finally, I will discuss several other projects that have employed the XFEM to address issues associated with solution discontinuities.