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The Thick Level Set (TLS) approach to fracture and its implementation using the eXtended Finite Element Method (X-FEM)

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The Thick Level Set (TLS) model [1] is a theoretical model that was introduced as a mean to bridge the gap between damage and fracture mechanics. The TLS both regularizes local damage model (by introducing a length) and allows for cracks to appear with a displacement jump across the crack faces. The model may thus be classified both in the strong discontinuity and diffuse approaches to fracture.

The extended finite element method (X-FEM) [2,3] is a numerical method which allows to introduce displacement discontinuities (or other kind of discontinuities) inside a mesh while keeping a traditional displacement variational principle. The X-FEM is not per se a mechanical model but rather a finite element technology. Often, it is used to grow an existing crack with a linear fracture mechanics model but it is not its only use in the fracture community.

When used to implement the TLS, the X-FEM allows to grow cracks without stress intensity factors but using appropriate constitutive models around the crack tip. This is particularly important for quasi-brittle failure or ductile failure for which stress intensity factors are not the relevant quantities for crack growth.

Through several examples in 2D or 3D and quasi-static or dynamics, the talk will show how the TLS is able to model complex crack path (including initiation, branching and coalescence) while the X-FEM allows numerically displacement jumps to appear in the mesh. Also, we will show that the TLS model allows not only to grow traction free cracks but also cohesive type cracks within diffuse degraded zones. This is quite important for crack growth under contact.

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