

## ISDMM09, Trento, July 6-9, 2009

### A thick level-set approach to damage mechanics

N. Moës\*, C. Stolz\*\* & N. Chevaugeon\*

\* *GeM Institute, UMR6183, Ecole Centrale de Nantes, 1 rue de la Noé, 44321 Nantes, France, Email [nicolas.moes@ec-nantes.fr](mailto:nicolas.moes@ec-nantes.fr), [nicolas.chevaugeon@ec-nantes.fr](mailto:nicolas.chevaugeon@ec-nantes.fr)*

\*\* *Laboratoire de Mécanique des Solides, Ecole Polytechnique, Email [stolz@lms.polytechnique.fr](mailto:stolz@lms.polytechnique.fr)*

In this paper, we present a model for damage evolution in solids. It is well known that fracture mechanics alone, despite all the advances in numerical techniques to represent cracks, can not represent easily the initiation process or the change of topology in the crack shape. To model properly such phenomena, damage mechanics models are more adapted. But damage models have their own weaknesses. Damage models are usually written locally for a given material, which cause well known spurious numerical localization and force the use of complex techniques, be it averaging the local material law over a region or using second gradient models. Those techniques are numerically expensive and difficult to implement. Lot of questions are still open concerning for e.g boundary conditions or transition to rupture and crack localization when damage tends to one. Recently, new type of descriptions appeared, that we see as means to bridge the gap between damage and fracture.

In Francfort Bourdin and Marigo (2008), brittle damage is regarded as a minimization problem on a “crack field” and the mechanical fields. The crack field represent the crack position by a continuous function over the full domain, whose value is 0 close to the crack and 1 far from it. The physics community (Karma 2001) developed an other model, the so called “phase field approach”. Here, the phase field, represent the damage and a global phase equation is coupled to the mechanical equations to describe the damage evolution. A level set technique was proposed by Salac et al. (2007), where a level set function is used to separate the fully damaged zone from the undamaged one. The damage front is piloted by a driven force computed locally, that depends on the curvature of the front. The first two descriptions force to solve a global equation on the full computation domain. The last one was developed with micro-crack in mind and do not appear to be able to describe crack initiation.

Inspired by Nguyen (1989), we propose a new model that might improve the previous one. In our model, a level set is used to separate the undamaged zone from the damaged one. In the damaged zone, the damage variable is an explicit function of the level set, e.g. an explicit function of the distance to the front. This function is a parameter to the model, it contain a length scale  $lc$ , that describe the distance from the front where the material is fully damaged. The damage growth is then resolved using a level-set propagation, driven by configurational force (Nguyen 1989) which is non local : it averages information over the thickness  $lc$  of the front.

In this paper we will describe in details the mathematical model. We will discuss it's properties, in particular the description of the crack initiation and the computation of the driving forces from some given classical damage model. We will then describe our numerical implementation on octree grid and illustrate by some simulations examples.

Karma, A., D. Kessler and H. Levine (2001). Phase-field model of mode III dynamic fracture. *Physical Review Letters*, 8704 (4).

Salac, D. and W. Lu (2007). A level set approach to model directed nanocrack patterns. *Computational Materials Science*, 39 (4), 849–856.

Bourdin, B., G. Francfort, and J.-J. Marigo (2008). *The variational approach to fracture*.

Springer. Q.S. Nguyen, Q.S. . and R.M. Pradeilles, R.M. and C. Stolz C. (1989). Sur une loi de propagation régularisante en rupture et endommagement fragile, *comptes rendus de l'académie des sciences*, 309, 1515-1520.