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SEMINAR OF NUMERICAL ANALYSIS

➤ **WEDNESDAY 25 MARCH 2015 - ROOM INF 119 - 16h15**

Prof. Jean-François MOLINARI, (EPFL, Lausanne) will present a seminar entitled:

"Extreme loads and explosions: numerical modeling of dynamic fragmentation"

Abstract:

The modeling of catastrophic failure of materials and structures is a long standing scientific challenge, with profound societal impact. Arguably, one of the most difficult to analyze and important damage mechanisms is the dynamic fragmentation of a contiguous body. The observation, or prediction, of fragment sizes has, for example, important implications on ballistic impact, crash performance, explosive drilling, and clustering of galaxies resulting from the big bang theory. Upon severe loading, multiple micro-cracks initiate at seemingly random locations. High-speed cameras reveal that these cracks then propagate at high velocities. Their paths may be tortuous, single cracks may form complex branches, but eventually the cracks coalesce, resulting in the formation of fragments. Material failure is accompanied by a complex stress-wave communication network. At first glance, this catastrophic process appears chaotic and unpredictable. Yet, out of the chaos, surprisingly universal features emerge.

In this presentation, we investigate two different classes of methods to investigate dynamic fracture and fragmentation: the cohesive element method (discrete approach) and a non-local continuum damage model (continuum approach). To simulate explosive fragmentation we have recourse to either Continuous or Discontinuous Galerkin approaches coupled to cohesive elements. This framework allows scalable parallel calculations and the convergence of fragmentation results for 3D simulations of brittle plate or hollow-sphere explosion. A comparison between our numerical results and analytical energy models reveal an identical scaling law exponent for the average fragment size as function of strain rate. However, our simulations include stress wave interactions, which yield a higher number of fragments. The calculations give also access to statistics on fragment shapes and orientations. We show that thin membranes generate quite structured fragments, whereas for larger membranes' thickness, crack branching mechanisms bring random fragment orientations. Yet, cohesive approaches suffer from mesh dependency, which limits the robustness of our predictions regarding fragment shapes. In the last part of the presentation, we explore the possibility of extending non-local continuum damage models to dynamic problems to address this mesh dependency. We present a benchmark test of dynamic crack propagation in a PMMA plate.

Lausanne, 24 March 2015/MP/cr