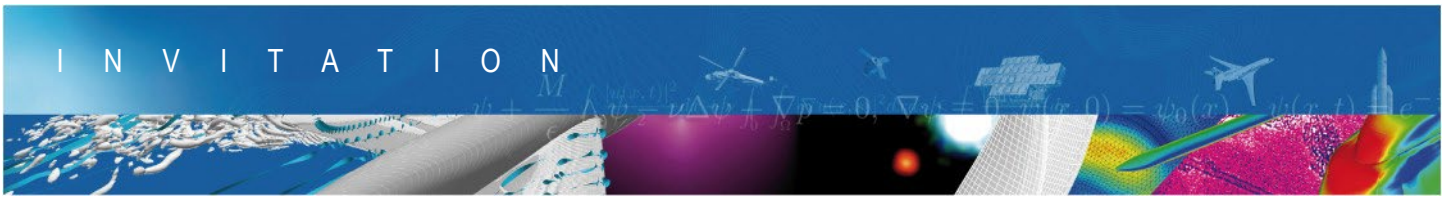

Variational approaches to fracture for the modelling of matrix-cracking phenomena in unidirectional composite laminates

Soutenance de thèse – KAROUI Zakia

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Abstract

Composite materials are now widely used in civil engineering, aviation, space, and sports. Understanding their mechanical behaviour and the possible occurrence of cracks and damage is crucial for their applications. We study here the case of unidirectional, fibre-reinforced, composite laminates. For standard cross-ply with $[0_n/90_m]_s$ sequences in traction, networks of transverse cracks spanning through the thickness of the inner 90° plies are the most important failure mode. First, we present an experimental investigation with a new analysis of the cracking process of the 90° plies, focusing on the size of the segments before and after cracking. This clearly shows a cracking process generating aperiodic patterns for the material under study. Hence, we study the problem of the determination of the optimal crack spacing from the theoretical and numerical point of view.
Using a variational approach and sharp-interface brittle fracture model à la Griffith, we show that a bifurcation between solutions with uniform and non-uniform crack spacings is a consequence of an energy minimality requirement. We characterise the crack spacings and their dependence on the geometrical and material parameters on the basis of a modular approach and the properties of the elastic compliance of the elementary cell. Finally, we perform numerical simulations using a regularised phase-field fracture model, which confirms the qualitative behaviour predicted by the sharp interface model.

Keywords:

fracture, variational methods, laminate composites, matrix-cracking, transverse cracks, damage models, finite elements, phase-field models.