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LOW INTRUSIVE COUPLING OF IMPLICIT AND EXPLICIT TIME INTEGRATION SCHEMES FOR STRUCTURAL DYNAMICS: APPLICATION TO LOW ENERGY IMPACTS ON COMPOSITE STRUCTURES.

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Low energy impacts can be very harmful for composite structures used in the aerospace industry. They can actually cause significant damages (matrix cracking, fiber failure, delamination...) inside the bulk or on the back side (side opposite to the impact) while the residual print left on the impacted side can be almost undetectable to the naked eye. Damages caused can therefore lead to early failure of the structure while they can be unnoticed during a visual inspection, this is related to the concept of BVID (Barely Visible Impact Damage). Controlling such situations is essential for manufacturers. Numerical simulations of this phenomenon could be really helpfull to focus and to rationalize tests campaigns by the use of virtual testing as well as for understanding scale effects. Various studies are conducted in scientific and industrial communities to simulate these impacts but they remain currently hard to implement at the industrial scale because they are very difficult to carry out. The non-regularities introduced in the model (contact, softening damage laws, cohesive zone models...) make convergence difficult to reach for implicit algorithms [1]. Simulations performed in this context are therefore mostly conducted though explicit time integration despite the non-dominance of high frequency wave propagation [2]. Sources of non-regularities are thus better taken into account but small time steps depending on the smallest mesh element are required to ensure stability. Moreover, very fine meshes are usually required (at least locally) to capture the non-linear phenomena occuring during the impact. The large number of increments required could lead to prohibitive computation cost on large structures. Note however that these non-linear phenomena occur on a very localized area around the impact point. Adopting a space/time multiscale strategy therefore appears to be advantageous to solve this kind of multiscale problems. This can be performed through domain decomposition where each subdomain carries its time discretization and its integration class. The purpose of this decomposition is to focus on numerical computation where non-linear phenomena appear. Explicit resolution in the area close to the impact is required because of the roughness of the solution. However, on the complementary area where the solution is smoother, implicit integration is appropriate. Larger time steps can then be used to save CPU time. The present work is based on the Gravouil-Combescure (GC) method [3] and aims at coupling dedicated finite elements codes *Europlexus*[1] and *Z-set/Zébulon*[2]. Adantages of this low intrusive coupling are illustrated through simulations of impact on large stiffened composite panels.

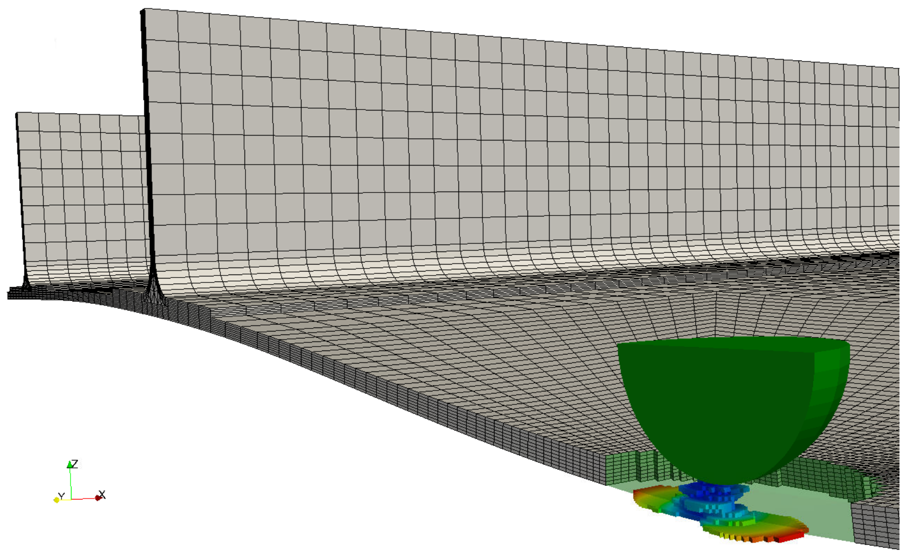

Figure 1: Deflection and damage of the stiffened composite pannel obtained after a 10 Joules impact. The computation is done with a time step ratio egal to 1000. The centered domain (green domain, composed of the impactor and the central disk) is computed with *Europlexus* and the complementary domain (grey domain) is computed with *Z-set*.

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[1] *Europlexus*is dynamic explicit code developed by CEA and the Joint Research Centre in Ispra, Italy, http://europlexus.jrc.ec.europa.eu/

[2] *Z-set/Zébulon* is implicit code developed by Mines ParisTech, Onera and NW Numerics & Modeling, http://zset-software.com/