Computational Mechanics of Evolving Discontinuities

René de Borst
Department of Mechanical Engineering
Eindhoven University of Technology

Multi-scale methods are quickly becoming a new paradigm in many branching of science, including in simulation-based engineering. This also holds true for computational mechanics, where multi-scale approaches are among the most important strategies to further our understanding of the behavior of engineering and biomedical materials. Indeed, this understanding and the tools that are being developed in multi-scale computational mechanics also greatly assist the engineering of new materials.

In multi-scale analyses a greater resolution is sought at ever smaller scales. In this manner it is possible to incorporate the physics more properly and therefore, to construct models that are more reliable and have a greater range of validity at the engineering scales. When resolving smaller and smaller scales, discontinuities become more and more prominent. Whereas at the macroscopic scales, one is used to think merely of cracks and shear bands, now also discontinuities like grain boundaries, solid-solid boundaries such as in phase transformations, and discrete dislocation movement come into consideration. Moreover, non-mechanical effects, like magneto-electro-chemical fields, humidity and temperature, can cause non-negligible effects, and have to be considered simultaneously.

In this lecture, we will start by a concise classification of multi-scale computational methods. Next, we will focus on evolving discontinuities that arise at different scales, and discuss methods that can describe them. Examples will be given at a macroscopic scale, a mesoscopic scale and within a multi-scale framework. Finally, some examples will be given of multi-scale analyses where coupling of evolving discontinuities is considered with non-mechanical fields.