Discrete element modeling of complex continuous materials: bridging the material scales

M. Jebahi*, D. André, I. Terreros, I. Iordanoff, F. Dau, J. L. Charles

DuMAS-I2M, UMR 5295, Arts et Métiers ParisTech
Esplanade des arts et métiers
33405 Talence cedex – France

E-mail: mohamed.jebahi.1@ulaval.ca

Abstract

Numerical simulation of continuous materials is generally performed by continuum methods, which are classically used to simulate mechanical problems having length scales much greater than the interatomic distances and for which the continuity assumption is valid and remains valid during simulation. The major drawback of these methods is that the associated governing equations are stemming from continuum mechanics. Therefore, they face great difficulties to predict most of the complex effects, at small scales, which can strongly influence the macroscopic behavior of the studied material, *e.g.* fracture, fatigue and durability. On the contrary, the Discrete Element Method (DEM) presents a good alternative to simulate these effects. Indeed, this method which is based on discrete mechanics can naturally take into account singularities, and then there is no need for complex transition procedure from continuum phase to discontinuum one. This method can be regarded as the connecting link between small scales (of discrete methods) and the structure scale (of continuum methods). The domain of interest is modeled by a discrete system made up of fully persistent discontinuities delimiting a set of rigid (or pseudo-deformable) bodies in interaction with each other. However, lack of theoretical basis has seriously restricted the DEM application on continua until recent years. Mainly, two significant challenges must be tackled to this end: (i) the first concerns the choice of the cohesive links (interactions) between adjacent discrete elements and the identification of their microscopic parameters so as to ensure the right macroscopic behavior; (ii) the second concerns the construction of a discrete domain taking into account the structural properties of the original problem domain, *e.g.* homogeneity and isotropy, such that the macroscopic mechanical behavior is independent of the number of discrete elements. This work aims to address these challenges and provides a comprehensive and robust methodology to model mechanical behavior, thermal conduction and brittle fracture of continuous materials by the Discrete Element Method [1, 2, 3, 4].

References

[1] D. André, I. Iordanoff, J. L. Charles, and J. Néauport. Discrete element method to simulate continuous material by using the cohesive beam model. Computer Methods in Applied Mechanics and Engineering, 213-216:113–125, 2012.

[2] D. André, M. Jebahi, I. Iordanoff, J. L. Charles, and J. Néauport. Using the discrete element method to simulate brittle fracture in the indentation of a silica glass with a blunt indenter. Computer Methods in Applied Mechanics and Engineering, 265:136–147, 2013.

[3] M. Jebahi, D. André, F. Dau, J. L. Charles, and I. Iordanoff. Simulation of Vickers indentation of silica glass. Journal of Non-Crystalline Solids, 378:15–24, 2013.

[4] I. Terreros, I. Iordanoff, and J.L. Charles. Simulation of continuum heat conduction using DEM domains. Computational Materials Science, 69(0):46–52, 2013.