Dynamic plasticity in metals computed by a discrete element method

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Since their first use by Hoover et al (1974) in models for crystalline materials and Cundall & Strack (1979) in geotechnical problems, Discrete Elements methods (DEM) have found a large field of application in granular materials, soil and rock mechanics. The handling of a set of particles interacting by means of forces and torques allows a variety of models for the expression of these bonds and for the material's behaviour.

In the Mka3D code, the authors [2] have been able to simulate the deformation and fragmentation of a three-dimensional linear elastic brittle material. The discretisation is achieved through rigid convex polyhedral particles. The forces and torques are computed directly through macroscopic quantities like the distance and relative rotation between two particles.

The aim of this presentation is to introduce an extension of this formalism with the goal to compute anisothermal dynamic plasticity with strain rate dependence in metals. The behaviours considered are for instance the Johnson-Cook [1] model. Elements of proof for the well-posedness and convergence of the discretisation will also be given.

A special attention has been given to the correct approximation of the elastic inequality constraint. In addition, since energy dissipation is crucial for cracking phenomena, a special energy-conserving time-integration scheme has been developed to compute the solid dynamics.

References

[1] G.R. Johnson and W.H. Cook. A constitutive model and data for metals subjected to large strains; high strain rates and high temperatures. 1983.

[2] Laurent Monasse and Christian Mariotti. An energy-preserving discrete element method for elastodynamics. *ESAIM: Mathematical Modelling and Numerical Analysis*, 46:1527–1553, 2012.