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Multiscale Numerical Analysis of Irreversible Deformation, Micro- and Macro-Fracturing of Anisotropic Materials

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This talk will describe various aspects of multiscale numerical modeling of large elasto-plastic deformations, micro- and macro-fracturing processes of isotropic and anisotropic solids, and structures under transient dynamic loading. The physical processes are described by the involution-constrained partial differential equations (PDEs). The existing fundamental issues and evolving theoretical and algorithmic approaches for PDEs with involutions are of significant interest in critical scientific and technological disciplines (e.g., aerospace sector and civil engineering).

Thermomechanical processes observing in deformable solids under intensive dynamic loadings consist of coupled mechanical, thermal, and fracturing stages. Dynamic fracturing is a complicated multiscale process. Simulating fracturing processes under different loading conditions puts many challenges on the numerical methods used, resulting in a need to use more advanced mathematical and numerical techniques. Dr. Lukyanov will present a solution technique based on an at-top partition of unity method (PUM) and explicit normalized-corrected meshless method to discretize and solve the mixed, nonlinear system of governing equations with possible singularities implied by fracturing problems. The meshless approach allows users to apply the full power of the methods, which includes enrichments, stability guarantees, and a linear multilevel (or multiscale) solver, to each of the physical problem components. The governing equations of thermo-visco-elasto-plastic media with micro-defects (micro-pores) are created using the fundamental thermodynamic principles. All of the processes (i.e., irreversible deformation, fracturing, micro-damaging, heat transfer) within a numerical domain are strongly coupled. The flexibility of these proposed techniques allows efficient runs using a large number of micro- and macro-fractures at different scales. This talk also will present and discuss numerical results, as well as outline future studies.

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