Finite deformation Mesoscale Field Dislocation Mechanics

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ABSTRACT

We will describe a model of dislocation mechanics based (crystal) plasticity of unrestricted geometric and material nonlinearity that, when exercised on a sufficiently fine scale, can rigorously predict fields of arbitrary dislocation distributions in finite bodies of arbitrary anisotropy. When exercised at larger scales of resolution adequate for meso/macro scale structural response, suitably adapting established macroscale phenomenology related to kinetics of plastic flow, the model makes predictions up to finite strains of size and rate-dependent mechanical behavior, texture, and mesoscale dislocation microstructure evolution in polycrystalline aggregates and single crystals. The phenomenology used to go to the mesoscale can be systematically improved as the need arises, as can the geometric fields involved along with their governing equations.

The framework will be demonstrated by results on dislocation patterning, size-effects, effects of boundary constraints on plastic flow, volume change due to dislocations, polygonization fields, evolution of lattice rotations, normal stress-effects-in-shear dependent plastic flow instabilities, all up to large strains (sometimes 100%) and with a focus on effects not predictable within linear dislocation statics or dynamics, or geometrically linear or nonlinear phenomenological plasticity theories.