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On the Accounting of Dislocation Internal Stress in Continuum Plasticity

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We discuss existing gradient plasticity proposals that are intended to represent internal stress effects of dislocation distributions, and show by a common and simple example that all such proposals overestimate the strain energy or stress of a dislocated medium by the introduced phenomenology. Based on the above observation, we propose a model of crystal plasticity of unrestricted nonlinearity, both in material response and kinematics, that does not have the above defect. The model phenomenologically accounts for short-range interactions through the usual strength-based hardening assumptions of conventional crystal plasticity and calculates the long-range stress and evolution of so-called geometrically necessary dislocation distributions, at the desired scale of resolution, in a mechanically rigorous manner. We present computational results for a simplified version of the model. The development of microstructure is a natural consequence of the model.

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