

Using Continuum Dislocation Dynamics in a Continuous Field Description to Model Dislocation based Plasticity

Severin Schmitt^{1*}, Katrin Schulz¹, and Peter Gumbsch^{1,2}

¹ Institute for Applied Materials (IAM), Karlsruhe Institute of Technology, Kaiserstr.12, 76133 Karlsruhe, Germany, (Email: severin.schmitt@kit.edu, katrin.schulz@kit.edu, peter.gumbsch@kit.edu), URL:www.iam.kit.edu/zbs/

² Fraunhofer Institute for Mechanics of Materials (IWM), Wöhlerstr.11, 79108 Freiburg, Germany

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Multiscale material modelling has become an important aspect of understanding structural and material behaviour. Physically based plasticity models are necessary to overcome the drawbacks of continuum theories on small scales and to introduce meaningful length scales. In this context, the influence of dislocation motion and interaction has to be considered. The classical dislocation based continuum theory was introduced by Kröner [1] and laid the ground work for the development of new physically based plasticity theories. Hochrainer et al. [2] generalised the concept and introduced a formulation for the evolution of curved dislocations, the Continuum Dislocation Dynamics theory (CDD). CDD allows maintaining information about the orientation and curvature of dislocations while averaging over volume elements. Sandfeld et al. [3] motivated a simplified version of CDD in order to make this theory numerically accessible and proposed first steps towards a continuous field description.

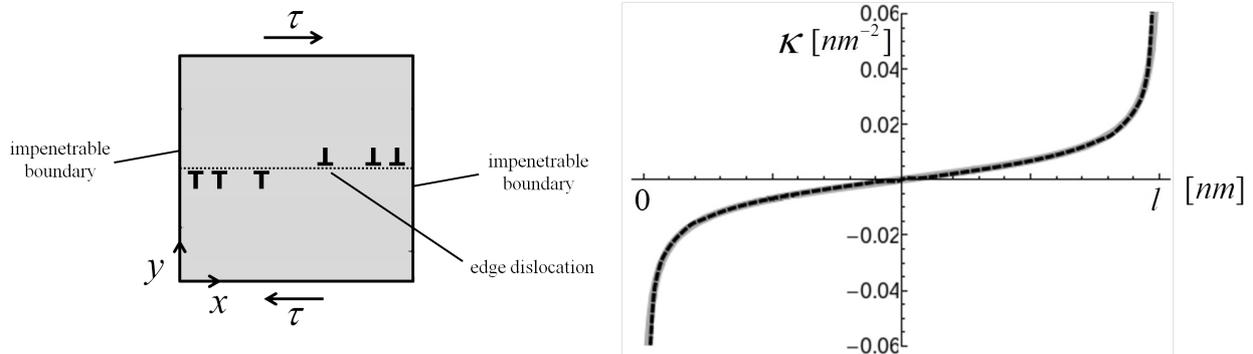


Figure 1: Single slip system subjected to a constant shear stress (left) and comparison of the analytical (—) and numerical (---) solution for the geometrically necessary dislocation density K in a double pileup configuration (right).

Based upon the concept of the simplified CDD, we can fulfill the benchmark test of a dislocation double pileup on a single slip plane, see Fig.1, using an adequate set of stress components according to [4]. The correct representation of the stress field due to the dislocation configuration in two and three dimensions needs a precise description of the continuous fields and the dislocation correlations perpendicular to the slip planes.

We introduce a continuous distribution of slip planes over the height of the plastic domain by piecewise linear interpolation between “representative” slip planes. Theoretical and numerical aspects of their application in our system are discussed, which allows us to compute results in a continuous sense and validate our work by comparing with simulations of discrete dislocation dynamics.

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