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Microscopically Informed Continuum Dislocation Dynamics

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Plastic deformation on the meso- to macro-scale is governed by the collective movement of a large number of dislocations. While the elastic interactions of single dislocations are well-understood from dislocation theory, the properties and evolution of dense dislocation networks, where elastic interactions result in spatial dislocation–dislocation correlations, are poorly understood up to date. Continuum Dislocation Dynamics (CDD) is a continuum theory of crystal plasticity, which is based on an averaged description of dislocations. Until now, the question of how dislocation correlation tensors can be used in the kinetic closure, i.e. the obtaining of driving forces and average dislocation velocities, has only been dealt with on a theoretical level, and disregarding the question of how to obtain CDD correlation tensors from three-dimensional Discrete Dislocation Dynamics (DDD) data [1]. Recently, we made a significant progress in resolving the latter [2]. We present a multi-scale approach where we use correlation data obtained from three-dimensional DDD simulations in order to kinetically close the evolution equations of CDD by averaging the interaction energy and interaction forces of the dislocation network. For the first time, we thus bridge the gap between the well-known physics of single dislocations, and the continuum description of dislocation-based plasticity for three-dimensional networks of dislocations.

REFERENCES

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