A discrete-to-continuum transition strategy towards modelling dislocation pattern formation

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ABSTRACT

Proper formulation of multiple-scale dislocation interactions is crucial for continuum models of dislocation to capture the various types of dislocation patterns formed in crystalline materials. In this talk, we will present a homogenisation-based strategy for the description of the collective behaviour of discrete dislocation dynamics (DDD) [1]. By making use of the singular nature displayed by short-range dislocation interactions, the dynamics of self-locked dislocation structures (SLDSs) can be simply described quasi-statically during the macroscopic evolution of geometrically necessary dislocations (GNDs) in the proposed framework1. Compared to the existing statistical-averaging schemes, some key statistically-invariant dislocation mechanisms can be effectively captured at the continuum level[2]. Under this guideline, a (continuum) flow stress formula for multi-slip systems, which resolves more details from the underlying dynamics than the ubiquitously adopted Taylor-type formulae, is derived. Moreover, the continuum dynamics of the formation, migration and dissociation of SLDSs on parallel slip planes can be successfully formulated in good accordance with the underlying DDD[3]. The method will also be generated for examining the collective behaviour of grain boundary dislocations upon irradiation[4].

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