
Statistics of fluctuations in mesoscopic tensorial model of crystal plasticity: the effect of different energy minimization algorithms.

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Abstract

Significant efforts have been dedicated recently to the understanding of fluctuations associated with crystal plasticity (1). The scale-free statistical signature of such fluctuations is not resolved by the engineering continuum plasticity and is computationally too costly to be studied by molecular dynamics. Recently a mesoscopic tensorial model (MTM) has emerged as a promising compromise (2-4). Unlike discrete dislocation dynamics, which relies on phenomenologically prescribed rules, the MTM is a finite element approach which relies exclusively on a globally periodic energy landscape compatible with lattice-invariant shears. Under quasistatic loading, the mathematical problem reduces to incremental energy minimization, and the system proceeds through intermittent dislocation avalanches (5,6). However, it has been unknown whether the statistics of the ensuing scale-free fluctuations is affected by the choice of the energy minimization algorithm. To answer this question we tested three algorithms: the state-of-the-art Limited-Memory Broyden-Fletcher-Goldfarb-Shanno (L-BFGS) method, the more classical Conjugate Gradient (CG) method, and the pseudo-inertial Fast Inertial Relaxation Engine (FIRE). We showed that despite driving the system through rather different set of local minima, all these three 'dynamical approaches' are practically statistically indistinguishable in the sense that they yield similar scale-free avalanche size distributions and predict very close values of the power law exponents. Our findings highlight the robustness of the MTM approach to crystal plasticity and point to the universality of the corresponding scaling regimes. References

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