Homogenization of dislocation dynamics

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Abstract. It is well known that the plastic, or permanent, deformation of a metal is caused by the movement of curve-like defects in its crystal lattice. These defects are called dislocations. What is not known is how to use this microscale information to make theoretical predictions at the continuum scale. A mathematical procedure that has proved to be very successful for the micro-to-macro upscaling of equilibrium problems in materials science is Gamma-convergence.

Macroscopic plasticity, however, is heavily dependent on dynamic properties of the dislocation curves. Motivated by this, M.G. Mora, M.A. Peletier and I recently upscaled a time-dependent system of discrete, interacting dislocations by combining Gamma-convergence methods with the theory of rate-independent systems. In the continuum limit we obtained an evolution law for the dislocation density. In this talk I will present this result and discuss its limitations and further extensions towards more realistic and complex systems.