Dislocations dynamics: from microscopic models to macroscopic crystal plasticity

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Dislocations are moving defects in crystals that can be described at several scales by different models. We first consider a 1D evolution equation arising in the Peierls-Nabarro model, which is a phase field model describing dislocation dynamics at a microscopic scale. Differently from the previous literature, we treat the case in which dislocations do not occur all with the same orientations (i.e. opposite orientations are allowed as well). We show that, at a long time scale, and at a mesoscopic space scale, the dislocations have the tendency to concentrate as pure jumps at points which evolve in time, driven by the external stress and by a singular potential. Due to differences in the dislocations orientation, these points may collide in finite time. Then we consider the Peierls-Nabarro model in any dimension and we identify at a large scale an evolution model for the dynamics of a density of dislocations. This model is a macroscopic model for crystal elasto-visco-plasticity. The results that will be presented have been obtained in some papers in collaboration with E. Valdinoci.