A finite deformation dislocation thermomechanics model without multiplicative decomposition

Gabriel Dante Lima Chaves[1], Amit Acharya[2], and Manas V. Upadhyay[*†1]

[1]Laboratoire de mécanique des solides – Laboratoire de Mécanique des Solides, CNRS, Ecole Polytechnique, Institut Polytechnique de Paris – France

[2]Carnegie Mellon University [Pittsburgh] – United States

Abstract

A finite deformation model for field dislocation thermomechanics based entirely on measurable state variables is proposed. Instead of starting from a physically undetermined ordering-dependent multiplicative decomposition of the total deformation gradient tensor, the widely accepted additive decomposition of the velocity gradient into elastic, plastic and thermal distortion rates is obtained as a natural consequence of the conservation of Burgers vector, extending the results of Acharya and Zhang (2015) in the mechanical setting to the thermomechanical case. Based on this equation, the model consistently captures the contribution of transient heterogeneous temperature field on dislocation density evolution (postulated by Kröner in 1959 and demonstrated in Upadhyay JMPS 145 (2020) 104150 in a small deformation framework). Furthermore, in combination with the First Law, the model allows studying temperature evolution during plastic work and computing the Taylor-Quinney factor without requiring any phenomenological expression for accumulated plastic strain or any other conventional plasticity-based variables. Finally, in the small deformation limit, it reduces to the model proposed in Upadhyay JMPS 145 (2020) 104150.

*Speaker

†Corresponding author: manas.upadhyay@polytechnique.edu