Connecting strain rate dependence of fcc metals to dislocation avalanche signatures

M.Aissaoui[1*], C. Kahloun[1], O.U. Salman [1], S. Queyreau[1]

[1]*Laboratoire des sciences des procédés et des matériaux*

*<u>missipsa.aissaoui@lspm.cnrs.fr</u>

Résumé pour oral

Strain rate sensitivity is a fundamental aspect of plastic deformation in crystalline materials. Owing to its dynamic nature, this effect is closely tied to dislocation kinetics, whose mesoscale manifestation occurs as intermittent, avalanche-like bursts of activity. The intensity of these avalanches typically follows a power-law distribution, as evidenced by both 2D and 3D discrete dislocation dynamics (DDD) simulations and acoustic emission experiments on single crystals of metals and ice. Outside strain-rate extremes, however, the origin of strain rate sensitivity is not fully understood, and the connection between strain-rate sensitivity and dislocation kinetics has yet to be made explicit.

We explore, through 3D discrete dislocation dynamics simulations, how shifts in strain rate spanning three orders of magnitude reshape the plastic response and avalanche dynamics, particularly within the transition zone bridging low-strain-rate and strain-controlled regimes. Increasing the strain rate enhances avalanche intensity through the superposition of concurrent events, while simultaneously promoting a microstructural reorganization characterized by shorter dislocation segments and stronger junctions.

The statistics of the avalanches are thus directly affected by the strain rate, with both the exponents and cutoffs of their power-law distributions increasing as the strain rate rises. Additionally, cross-slip activity is observed to modulate this behavior. These findings provide a mechanistic framework linking strain rate sensitivity to avalanche dynamics and offer new insight into the collective behavior of dislocation systems under dynamic loading conditions.