ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Multi-scale complexity of plastic flow during macroscopically stable and unstable flow

Mikhail Lebyodkin[1], Tatiana Lebedkina[1,2]

[1]Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux (LEM3), CNRS, Université de Lorraine, Arts & Métiers ParisTech, 7 rue Félix Savart, 57070 Metz, France

[2]Center of Excellence "LabEx DAMAS", Université de Lorraine, 7 rue Félix Savart, 57070 Metz, France

*mikhail.lebedkin@univ-lorraine.fr

The plastic flow of solids provides striking examples of self-organization in complex nonlinear systems. Moreover, the collective behavior of crystal structure defects, dislocations *par excellence*, manifests itself on multiple scales. The examples include the avalanche-like dislocation glide that can be detected, e.g., by recording the concomitant acoustic emission, dislocation patterning observed in an electron microscope, various patterns of plastic strain localization accessible to optical methods, the propagation of macroscopic deformation bands visible with the naked eye. The latter involve such a considerable part of the sample into the collective process that result in serrations on the deformation curves, or jerky flow. The analysis of the respective time evolutions and spatial structures revealed diverse self-organization phenomena, such as synchronization, relaxation oscillations, self-organized criticality, or deterministic chaos. Moreover, it was found that variation of the testing conditions may lead to transitions between distinct dynamical regimes. Thus, on the one hand, investigations of self-organization phenomena in a plastically-deforming material become a key to the fundamental problem of the micro-macro scale transition in plasticity, i.e., prediction of the macroscopic behaviour of material from the dynamics of the microscopic careers of plastic deformation. On the other hand, the deforming sample provides a laboratory model for complex dynamics in various natural systems and may bring valuable information to scientists from different fields of research. The aim of this presentation is to outline the problem of collective dynamics of defects in crystals. Without seeking for an exhaustive description, the talk will highlight the complexity of plastic flow revealed with the aid of several complementary experimental techniques and data analysis based on the statistical and multifractal formalisms.

Keywords: Self-organization of dislocations, jerky flow, acoustic emission, digital image correlation, statistical analysis, multifractal analysis.