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Scale-Free Intermittent Flow in Crystal Plasticity

RICHARD LESAR, Iowa State University

Under stress, crystals irreversibly deform through complex dislocation processes – processes that intermittently change the microscopic material shape through isolated slip events. Using both model computer simulations and ultra-precise nano-scale measurements on nickel micro-crystals we directly determined the size of discrete slip events. The sizes range over nearly three orders of magnitude, and exhibit a shock and aftershock earthquake-like behavior over time. Analysis of the events reveals power-law scaling between the number of events and their magnitude, or scale-free flow. We show that dislocated crystals are a model system for studying scale-free behavior that is observed for many macroscopic systems. By analogy to plate tectonics, smooth macroscopic-scale crystalline glide arises from the spatial and time averages of disruptive earthquake-like events at the nano-scale.