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How roughness emerges from nonlaminar plastic flow

Most natural and man-made surfaces appear to be rough on many length scales. There is presently no unifying theory of the origin of roughness or the self-affine nature of surface topography. One likely contributor to the formation of roughness is plastic deformation, which underlies many processes that shape surfaces such as machining, fracture, and wear. In this talk, I will demonstrate how self-affine roughness emerges from basic plastic deformation mechanisms. Molecular dynamics calculations show that self-affine surface roughness emerges even on homogeneous materials [1]. Self-affinity of the surface is connected to the spatial correlation of deformation events occurring within the bulk that are intrinsically non-affine. Additional continuum calculations with laminar plasticity models confirm, that non-laminar flow is necessary for self-affine roughness to emerge. Such non-laminar subsurface plastic flow patterns are directly observed in the deformation of composite materials, where deformation can be directly traced at buried interfaces. Molecular simulations here show, that the discreteness of the crystal lattice and the microscopic deformation mechanism is responsible for non-laminar, non-affine flow [2]. These results have implications for the formation of surface roughness, for example for sliding frictional contacts that often evolve towards a steady-state roughness, as well as for the strength of composite materials.

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