Physical Mesomechanics; Its Theoretical Basis and Applications

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Physical Mesomechanics is a recent theory of deformation and fracture of solid-state materials. The most intriguing feature of physical mesomechanics is its capability of handling all the stages of deformation, from the elastic stage to fracturing stage, on the same theoretical basis. This feature comes from the field (gauge) theoretical treatment that the theory is based on; physical mesomechanics views materials under deformation as a collection of finite volume elements (called the deformation structural element), as opposed to a point masses as the conventional continuum mechanics views, and allows each deformation structural element deform differently. At the same time, however, physical mesomechanics requests local (gauge) symmetry in the governing dynamics. This leads to field equations that describe all the stages of deformation comprehensively. The irreversibility of plastic deformation can be formulated as dynamics where elastic stress contributes to flow of defects, rather than elastic strain, causing the associated mechanical energy to be dissipated. Fracture can be interpreted as the final stage of plastic deformation where the material becomes completely dissipative. These ideas have led us to define physical mesomechanical criteria of plastic deformation and fracture. Using these criteria, it is possible to identify the plastic zone in the pre-fracturing stage and to infer the loading history of a material. Recent experiments show evidence that validates these criteria.

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