Some links between micromorphic, gradient and phase field approaches to nonlinear material behaviour

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ABSTRACT

The introduction of one or several internal lengths in the constitutive modelling of complex materials becomes necessary in the context of strain and damage localization and phase transformation. It is possible within the framework of generalized continuum mechanics. Micromorphic, gradient and phase field models represent three types of enhancement of continuum mechanics that have attracted strong interest of the community in the recent years. These theories share several common features and a unifying theoretical framework will be presented that establishes bridges between the different approaches. The micromorphic approach can be regarded as a relaxation of gradient theories widely used in plasticity and damage modelling [1,2,3]. It has computational advantages in the versatility of the introduction of additional degrees of freedom like microstrain or microdamage variables, and can be used as a substitute for gradient models stricto sensu. Phase field parameters arising for instance in the modelling of microstructure evolution in phase transforming media, can be regarded as micromorphic degrees of freedom when they are related to mechanical properties like in the phase field approach to damage and fracture [4,5]. The thermodynamically consistent structure of these theories is essentially the same and differences are to be found in the specific choices of free energy potential functions [6]. Examples of applications will be given in the case of crack initiation and propagation in the deformation of metallic single crystals based on an anisotropic micromorphic model [7].

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