Abstract:

The response of many materials (metals, alloys, composites, etc.) to external loading may essentially be influenced by an existing or emerging internal structure of materials at smaller scales. Over the past five decades, a number of advanced generalized continuum theories have been introduced for modeling the structural internal inhomogeneities on the macroscopic behavior of materials. We have found that the concept of internal variables is sufficiently general for modeling waves in such microstructured solids. • The models are based on Mindlin-type (micromorphic) theory but the thermodynamical considerations are added. The formalism includes the material (canonical) balance equations for material momentum and energy, while the internal structure is described by internal variables with the governing equations derived from the dissipation inequality. In such a way, internal fields of microdeformation and/or microtemperature can be taken into account. An essential generalization from the theoretical side is that the resulting governing equations for microstructure are not limited to first-order diffusion equations but can be hyperbolic. • The general nonlinear 3D theory is presented but for explanations, the 1D models are analysed in detail. In this case the basic model is a system of two second-order equations which takes the coupling of macro- and microstructure into account. This system allows several modifications: the full fourth-order equation, the approximated hierarchical equation, and the one-wave evolution equation. The fourth-order equation is of the Boussinesq type which allows to bridge solid mechanics with the fluid dynamics. The further modifications allow to model multiscale problems (scale within a scale) and internal temperature fields. • The dispersion analysis has revealed many explanations about the distortion mechanisms of wave profiles, the solutions of nonlinear Boussinesq-type equations and evolution equations (by the pseudospectral method) have demonstrated the emergence and interaction of solitary waves in microstructured solids and the distortion of their profiles which is due to the nonlinear properties of a microstructure. The direct computations (by the finite volume method) permit to compare the wave motion in regular (laminated) materials with microstructured solids modeled by continuum theories. Several numerical results will be shown to illustrate the various aspects of the modeling including the solving of inverse problems. • The talk gives an overview on research in CENS over the last years.