Mesomechanics 2009

Mesomechanics 2009 Foreword:

Dissipation and damage across multiple scales in physical and mechanical systems

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The annual international meetings in the Mesomechanics series are sponsored by the International Society of Mesomechanics with the long term mission to enhance the design and fabrication of engineering systems, large or small.

Addressing energy efficiency and environmental concerns require science and engineering to stand on equal footing. Within the scope of this general theme, the Mesomechanics 2009 conference being the 11th in the series will be hosted by the University of Oxford, and co-organised by Imperial College London, and Lehigh University, USA. The conference is concerned with the “Dissipation and Damage across Multiple Scales in Physical and Mechanical Systems”. The meeting will take place in Oxford, United Kingdom, on 24-26 June 2009.

Non-linearity of the system response to externally applied loads and physical fields is associated with the presence of various dissipative and/or irreversible processes. Dissipative processes are synonymous with the concept of ‘damage’. Damage induces modification and degradation of system properties, and also determines the durability of the system, i.e. the time and conditions for the onset of catastrophic failure.

In many physical and mechanical systems the precise nature of dissipative processes varies depending on the scale of consideration. At the macroscopic, or continuum scale these
phenomena are represented through the introduction of complex constitutive laws. These continuum quantities reflect the consequences of dissipative processes that take place at lower structural scales, e.g. intergranular and intragranular deformation in metallic polycrystals, interfacial decohesion processes in ceramic aggregates, crystalline and amorphous phases in polymers.

The advent of nanotechnology has drawn attention to the difference between the behavior of large and small bodies that are governed, respectively, by the bulk (global) and microscopic (local) material properties. The physical laws are also different. Simply put, the volume governs the large and the surface controls the small. The distinction is particularly important for evaluating the energy dissipation. Although the scheme of unloading a tensile specimen may be adequate for large bodies, it is inappropriate for small bodies. Testing a small part of an inhomogeneous material microstructure is not sufficient for complete characterization. Relating the microstructure constituents and the behavior across the different scales is indeed a formidable task. Of particular concern are the uncertainties associated with interfaces, whether they define grain boundaries or atomic clouds. Yet, these are precisely the locations where energy dissipation is dominant. Describing the accumulation of dissipated energy from the micro- to the macro-scale involves crossing the divide between the large and the small. Newtonian/Einsteinian mechanics does not concern itself with attempting to reconcile the descriptions at the level of quantum mechanics (the extremely small) and gravitational theory (the extremely large). Ignoring the arrow of time in the quantum gravity theory is equivalent to neglecting energy dissipation.

The arrow of time implies that the description of damage should proceed from the small to the large: pico→nano→micro→macro. Transitional thresholds need to be defined for connecting the segmented scales. Processes in real materials that experience ageing and damage entail energy dissipation, a manifestation of the development and existence of inhomogeneities and interfaces. Effective understanding and use of nanocomposites requires bridging the gap from the nano-scale behavior to that at the macro-scale, and ultimately the structural scale.

The introduction of mesoscale considerations provides a connection between detailed fine scale analyses and large scale, coarse-grained, homogenized treatments. Multi-scale analyses aim to link the scales by establishing frameworks for communicating the necessary quantities between different levels of description.

It is with these objectives in mind that the theme of Mesomechanics 2009 in Oxford was selected. The fact that the contributors to the conference proceedings volume address energy dissipation across the range of scales in relation to mesomechanics considerations is the indication of success of this choice.

The proceedings of this conference will be of interest to researchers and practitioners concerned with the analysis of damage and dissipation in various engineering and physical systems, and seeking to identify and establish better predictive procedures for designing reliable systems and structures.
The editors of this volume wish to express their gratitude to the authors for their contributions, and sincerely hope that, with the help of the Mesomechanics 2009 meeting, we have moved one step closer to understanding the elusive nature of assessing energy dissipation with account taken of material microstructure effects. We hope that this spirit will continue to grow to new strengths, and will be carried over into Mesomechanics 2010.

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