MULTISCALE BEHAVIOR OF MATERIALS AND STRUCTURES: ANALYTICAL, NUMERICAL AND EXPERIMENTAL SIMULATION

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Foreword

This is the eighth International Conference of Mesomechanics sponsored under the auspices of the International Society of Mesomechanics that was established in 1996. The meeting was organized by and held at the Faculdade de Engenharia da Universidade do Porto, Portugal, 19-22 July, 2006. The main objective has been focused on establishing a common ground for which material and structural engineers can genuinely feel comfortable and understand each other, most importantly to appreciate the research efforts from both camps that at times seem to be far distanced. The aircraft designer pays little attention to the behaviour of a cluster of dislocations while the electron microscopists have little or no concern for testing the fatigue life of an aircraft wing or fuselage. Nanotechnology of the mid 1950s has showed that lower scale constituents can influence the macroscopic behaviour of materials. The scientists and engineers have since found the need to meet at mid way and discovered that there always seem to be a region where the conventional theories and methodologies do not quite apply for the large and small bodies. This meso-size region seems to arise most frequently in mutiscale research where neither continuum mechanics nor quantum mechanics would be adequate. Mesoelectronics, Mesomechanics, Mesofracture, etc. are just a few of the fields that have been identified with the “Meso” prefix. Even the theoretical physicists may soon relinquish their long hope for a theory of unification now that one of the leading candidates Steven Hawkins has started to wonder whether it is possible to formulate a single theory of the universe despite the on going efforts made to develop the string theory.

To understand and quantify the evolution of material damage from the atomic to the macroscopic scale is no less challenge than then behavior of the black hole. The undertaking involves connecting the results at the different scale level from the very small to the very large. Since theories, computational schemes and experimental methods are scale specific, new approaches and ideas are required to overcome many of the hurdles encountered in the application of multiscaling. Already, the researchers in fatigue crack growth are becoming more conscience with scale specificity and beginning to find why the macroscopic parameter models fail to apply in regions where the damage is microscopic. This will normally occur when the characteristic length dimensions start to differ by one or two orders of magnitude on the lineal scale.
Quantitative assessment of the abundance of well documented test data involving dislocations, void nucleation, micro-cracking, etc. over the wide scale range present the main difficulty. Continuum mechanics theories are overly short ranged; their connections from segments to segments should be encouraged. In this context, Mesomechanics has brought a revival interest to the examination of material and structure damage at the different scales. The results from one scale to another must also be connected without delving into the difficulties associated with using non-equilibrium theories in thermomechanics. The feeling is that each Meso- mechanics conference has probed into new areas of unknowns and the need to learn more.

Some of the topics identified for Meso 2006 are

- different size and time scales of material damage;
- fracture mechanics for very small specimens;

- characterization of non-homogeneous materials;
- physical mechanisms of material behavior at different scales;
- inter- and intralaminar fracture of composites;
- multifunction materials;
- discrete scaling in constrast to continuum averaging;
- influence of transient state temperature on scaling;
- dependency of material properties on time and size scales;
- engineering applications of Mesomechanics; and
- new modeling strategies.

The continue success of the mesomechanics meetings rely on the interaction of researchers from the different fields. Such a trend is encouraged but it is easier said then it is done. For this reason, the number of attendees need to be selective. To iterate of what has been said earlier, ideas from another field can be most rewarding to guide the development of multiscale models in material science or mechanics. A quantum description of gravity in string theory has found negatively curved spacetimes. The configuration for constant negative curvature is a hyperbolic space. A lower dimension version of such a relation would be a hyperbolic curve which prevails for the energy density versus distance decay of a homogeneous system. The material microstructure is highly non-homogeneous and would be characterized by non-hyperbolic relations. Since energy density when used with a characteristic length (or characteristic area for higher dimensions) apply in general to physical systems, it is safe to conjecture that the current spacetime theories are restricted to homogeneous systems. The relation between the local and global properties is part of the problem in multiscaling. Keep in mind that there is always another dimension that remains smaller but yet to be detected. There are still plenty of rooms left for speculation not until the Planck's length 10-33 cm is challenged. The combined discipline of material science and mechanics should be less involved with hindsight.

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