KTH SOLID MECHANICS KEYNOTE SEMINAR; Thursday, November 14th, 16.15; https://kth-se.zoom.us/j/66031042622

Christian Hellmich
"Up and downscaling revisited: a fresh look at multiscale solid mechanics"

Christian Hellmich is a full professor at the Vienna University of Technology (TUW) and heads the Institute for Mechanics of Materials and Structures. He holds PhD (1999) and habilitation (2004) from TUW, was postdoctoral fellow at MIT (2000 to 2002) and served as short-term visiting professor in France, Italy and Germany. His research focuses on (micro)structural bio-chemo-mechanical models – adressing theoretical foundations, computational imple-mentation and experimental validation for various biological and man-made systems. In addition, Hellmich is trained violinist and works at the interface of science and art. With a Google scholar h-index of 57, Hellmich made a huge scientific impact and serves as (co-)editor for several peer-reviewed journals, including Journal of Engineering Mechanics (ASCE), Mechanics of Materials and AIP Applied Physics Reviews. He has served in many boards and technical commitees (EMI-ASCE, IA-CONCREEP, ESB, MRS, ÖAW) and his activities have been recognized by several national and international awards and grants (Zienkiewicz Prize, ERC, Walter L. Huber Research Prize, etc).

Multiscale modeling has become one of the key trends in solid mechanics and its neighboring fields, having opened new avenues and showing great potential for understanding and solving pressing engineering problems. However, there are still important questions pending, both on the theoretical foundations of scale transitions, in particular so concerning the partially overlapping realms of force field-based molecular mechanics and its coarse-grained variants, and on homogenization theory within continuum mechanics. As a contributing to a better understanding of the theoretical pillars of multiscale mechanics, the seminar re-visit the (micro-)stress and (micro-)strain average rules governing the representative volume elements (RVEs) of continuum micromechanics: In order to avoid ad hoc definitions to the highest possible degree, Hashin's strain boundary conditions and geometric compatibility considerations (implying validity of the strain average rule) will be opened towards the virtual velocity realm, allowing for the introduction of force duals (virtual power densities) which naturally yield body force and stress average rules. Applying the same reasoning to discrete (atomistic) systems leads to a very natural and simple derivation of the so-called internal virial stress tensor, a concept which can be traced back to the eminent 19th century physicist Josef Finger. Extending this homogenization concept to beam-type macromolecules helps to understand the mechano-biology of DNA. Returning to classical composite mechanics, we also re-visit, and overcome, the fundamental limitations of the probably most popular Eshelby problem-based homogenization scheme, namely that of Mori and Tanaka, with respect to anisotropic multiphase-multishape composites. In more detail, we adopt the explicit symmetrization of the macroscopic elasticity tensor proposed by Sevostianov and Kachanov.