**Multiscale and third medium approaches in topology optimization**

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The talk will be divided in two parts: 1) multiscale topology optimization based on homogenization and novel de-homogenization approaches, and 2) leveraging of external and internal contact in topology optimization problems by a so-called third medium approach.

1) Bendsøe and Kikuchi founded topology optimization based on a multiscale homogenization approach. This approach was later abandoned in favor of the simpler density (SIMP) approaches due to complexity, both of algorithms as well as results. Lately, however, homogenization approaches have been “resurrected” due to the emergence of so-called dehomogenization approaches that map the homogenization results to finite scale. Dehomogenization is based on computer graphics techniques and thus extremely efficient algorithms that perform the optimization on coarse meshes and subsequently map to fine scale and highly efficient structures have been developed. This part of the talk gives an overview of recent activities within multiscale and dehomogenization techniques that take stiffness, strength as well as local and global buckling stability of multiscale lattice structures into account.

2) Topology optimization for problems with internal or external contact represents a seeming paradox: if the topology is initially unknown, how can one identify contact boundaries? And further: even if boundaries are known and well-described, it is complicated and logistically complex to administrate contact points or surfaces and their associated Lagrange multipliers. Both challenges can be alleviated using so-called Third Medium Approaches (TMAs), where contact forces are transferred through “void” domains with tailored elastic properties that generate high ultimate stiffness when directionally compressed but zero stiffness in shearing. TMAs have obvious strong benefits for inverse design problems but also represent a viable alternative to traditional contact analysis in non-linear elasticity. This part of the talk discusses and demonstrates recent advances in applying TMAs: 1) improved computational stability through better finite element discretizations; 2) extensions to three dimensions, 3) extensions to multiphysics settings including thermoelectric contacts and 4) inclusion of friction effects by a crystal plasticity framework.