Physikalisches Institut
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SONDERKOLLOQUIUM

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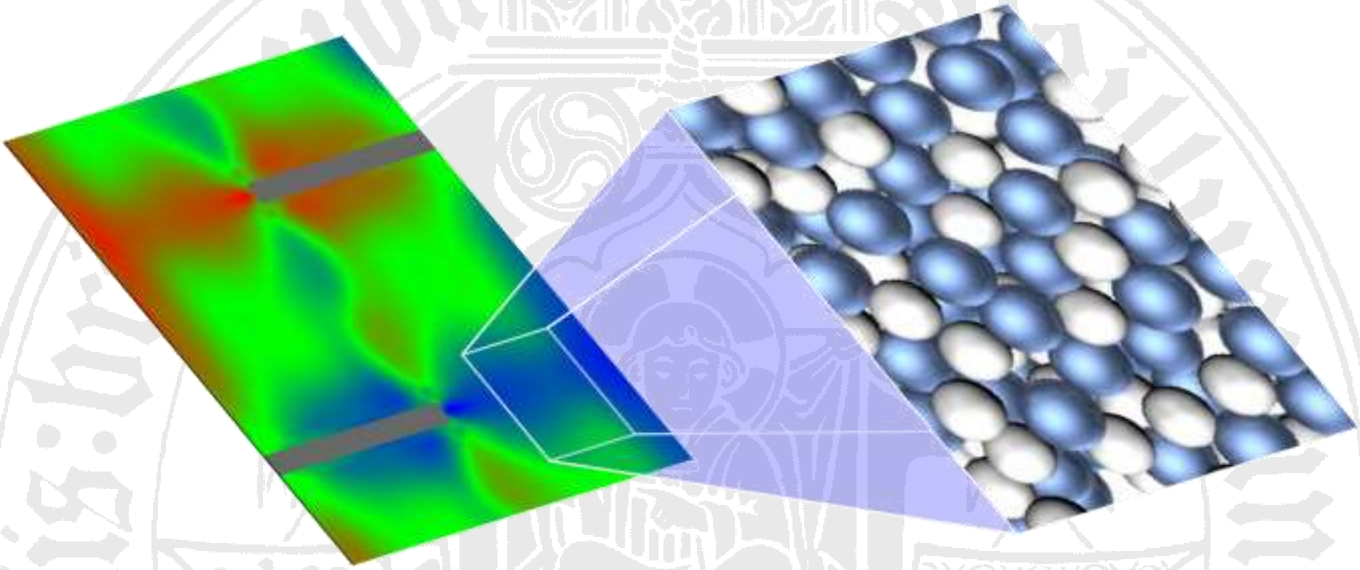
IM SEMINARRAUM, GUSTAV-MIE-HAUS



Nonlinear-Response Theory of Process-Dependent Material Properties

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The processing history often has a decisive impact on the properties of materials produced from the melt. Empirical material laws express this knowledge for applications on the macroscopic scale, but still, there is little systematic understanding of the underlying microscopic processes far from equilibrium and under time-dependent strong external fields, and how to derive material laws from first principles.

I will discuss how we use theoretical statistical physics of nonlinear-response phenomena to establish guiding principles for material laws of viscous fluids, amorphous solids, and related soft materials. Coupling of the microscopic theory to the macroscopic scale gives rise to material laws (constitutive equations for continuum mechanics) that are intrinsically nonlinear and non-Markovian, encoding the absence of a clear separation of scales. Thus there arise qualitatively new phenomena that we address using hybrid theory-and-simulation techniques (combining mode-coupling theory and Navier-Stokes solvers).

As a specific application I will discuss the emergence of residual stresses in glassy materials, a true nonequilibrium phenomenon that impacts for example the strength of glasses or the stability of polymer films. Other examples include the microscopic growth kinetics of crystals under strong flow, and the theoretical-physics principles applicable for microswimmers, the building blocks of active materials.