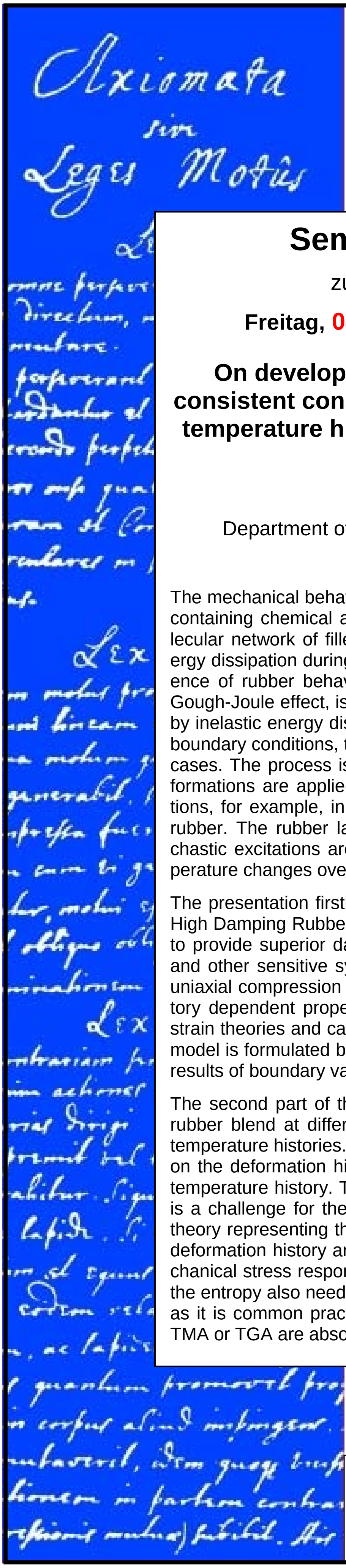

Friedrich-Alexander-Universität Erlangen-Nürnberg

Seminar über Fragen der Mechanik

zu folgendem Vortrag wird herzlich eingeladen

Freitag, 04.09.2009, 14:00 Uhr, Egerlandstr. 5, Raum 0.044

On developing a physically-based and thermomechanically-consistent constitutive theory for rubbers with special reference to temperature history effects: Some thoughts for the future studies

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The mechanical behavior of filler-reinforced rubber originates from a network of macromolecules containing chemical and physical crosslinks, entanglements and filler particles. The macromolecular network of filler-reinforced rubber exhibits rate-dependent behavior, hysteresis and energy dissipation during monotonic and cyclic deformations. In contrast, the temperature dependence of rubber behavior occurs due to two different phenomena. The first phenomenon, the Gough-Joule effect, is determined by the entropy elasticity, whereas the second effect is caused by inelastic energy dissipation or hysteresis. In dependence on both the loading history and the boundary conditions, the resulting process can be isothermal, adiabatic or in-between these limit cases. The process is adiabatic, if a rubber component has either a large geometry or the deformations are applied with a sufficient fast rate. This is a concern in many technical applications, for example, in base isolation bearings consisting of several layers of metal sheets and rubber. The rubber layers of these bearings experience a quasi-adiabatic process when stochastic excitations are applied. On the other hand, a rubber product is often exposed to temperature changes over its service life due to variations of the ambient temperatures.

The presentation firstly deals with the deformation history dependent mechanical behavior of a High Damping Rubber (HDR) under an isothermal condition. This special rubber was developed to provide superior damping property in base isolation bearings that protect buildings, bridges and other sensitive systems from destructive excitations, e.g. earthquakes or wind. Results of uniaxial compression and simple shear experiments generally show the strong deformation history dependent properties. A thermodynamically consistent constitutive model based on finite strain theories and capable of capturing the nonlinear viscoelasticity response is presented. The model is formulated based on the assumption that the HDR deforms isothermally. FE simulation results of boundary value problems are presented next.

The second part of the presentation deals with the recent experimental results obtained on a rubber blend at different ambient temperatures but after subjecting the specimens to various temperature histories. It is seen that the response from the tested rubber blend depends not only on the deformation history and the current thermodynamic temperature, but also on the entire temperature history. Temperature history effects on healing of Mullins effect are also clarified. It is a challenge for the future to develop a physically-based and thermomechanically-consistent theory representing the material behavior of rubber as a functional of two variables, namely the deformation history and the temperature history. In addition to the pure investigation of the mechanical stress responses, the thermal response functions like the internal or the free energy or the entropy also need to be investigated. To this end, not only testing the stress-stretch behavior as it is common practice in engineering but also additional experimental techniques like DSC, TMA or TGA are absolutely required.

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