Einladung zum Vortrag

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Thema: Domain derivative methods and goal functions for continuum growing bodies

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Abstract

A model for the growth of living tissues is established, describing the living organism as a solid material body receiving extra matter from an assumed reservoir and undergoing stresses. The basic principles of continuum mechanics (principle of virtual power; first and second principle of thermodynamics) are first formulated, accounting for the change of the domain occupied by the material points, due to the continuous change of mass of the body. The internal energy of the material is postulated from a volumic energy density, depending upon a strain measure and time, and a surface density, the argument of which being a surface deformation tensor, the normal to the surface on which exchange of matter occurs, and time. The tools of differential geometry of surfaces are involved in order to evaluate the domain derivatives of surface and volume integrals that intervene into the different balance laws. Thermodynamic forces conjugated to irreversible fluxes are next identified from the writing of the intrinsic dissipation, which is seen to involve volumic, surfacic and lineic conjugate contributions.

In biological systems, the coinage teleonomy analyzed by the famous biologist F. Jacob is associated to the notion of finality, which still bears some mystery, since it seems to contradict the assumed causality prevailing in physics. The search for a goal function of a living organism is one the key point in the understanding and modelling of these systems. It is here thought that the growth and evolution follow some organisation principles regarding both the spatial and the temporal dimensions: we herewith envision the flow of metabolic processes as occurring within a structured well-chosen space-time manifold.

The growth and evolution of continuum solids representing biological systems is here considered from the point of view of finding the best configuration of the growing body. Adopting a new representation space that includes time as an ordinary coordinate, the material points of the body are spread over a surface at each instant. The four dimensional continuum is structured in the form of isogrowth surfaces, the evolution of growth being described as a motion from one slice to the next one. A metric field having both a temporal and spatial contribution is associated to the slicing of the space-time into these isogrowth surfaces, the spatial part of the metric being the metric field attached to a given surface. In a second step, a lagrangian formalism is established in the space of metric, whereby both the geometrical and physical contents of the growing solid are considered. Adopting this higher level of description, the finding of the best metric field for the growing solid then resumes to the finding of the optimum value for the action integral, written as a functional of the metric field. The variation of the total action integral renders the dynamics of the metric field, while the kinematic compatibility condition expressed as a constrained on the metric field prescribes its spatial form.