# Coupled Problems

**An energy-momentum consistent time integration scheme based on a mixed framework for non-linear electro-elastodynamics**

The present talk deals with a new approach to the design of energy and momentum (EM) consistent integration schemes in the field of non-linear electro-elastodynamics, see Ortigosa, Franke, Janz, Gil and Betsch (Comput. Methods Appl. Mech. Engrg., 339: 1-35, 2018). The importance of electro-active polymers (EAPs) in different applications such as actors and sensors, soft robotics or artificial muscles requires advanced simulation techniques to prognosticate the behavior of such smart materials. Typically, these materials are described as electro-static but nevertheless the consistent time-integration of the electro-mechanical model plays an important role concerning the numerical stability and accuracy. In this talk we present a new approach to the design of energy-momentum consistent algorithms motivated by the structure of polyconvex stored energy functions and tailor-made for the consistent space-time discretization of EAPs. The presented time-integrator is based on the internal energy of the system, which is in accordance with the concept of polyconvexity for nonlinear electro-mechanics, see Gil and Ortigosa (Comput. Methods Appl. Mech. Engrg., 302: 293-328, 2016). Based on a Hu-Washizu-type mixed variational framework with a novel cascade form of kinematic constraints a new algorithmic stress formula is proposed, see Betsch, Janz and Hesch (Comput. Methods Appl. Mech. Engrg., 335: 660-696, 2018), which is a typical feature of energy-momentum methods. Furthermore, a tensor-cross product operator for second order tensors is used, which greatly simplifies the algebraic formulation. In addition, the time-discrete weak form of the Gauss's law and Faraday's law along with the concept of partitioned discrete derivatives in the sense of Gonzalez (J. Nonlinear Sci., 6: 449-467, 1996), leads to an implicit one-step time integrator which consistently approximates the linear momentum, the angular momentum as well as the total energy. The resulting structure-preserving integrator shows superior numerical stability and robustness compared to alternative formulations. Moreover, the mixed variational framework makes possible a wide variety of alternative finite element formulations. Along with an appropriate combination of the interpolation spaces high performance finite elements can be generated. Serval numerical examples dealing with large strains and electric fields are shown. These examples demonstrate the advantageous properties of the newly developed structure-preserving discretization scheme.