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Axially Moving Continua: Lagrangian Mechanics and Mathematical Modelling

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Practical relevance, technical difficulties in maintaining the desired regime of motion, non-trivial and even sometimes counter-intuitive behavior are coupled with challenges, intrinsic for the theoretical investigation of axially moving structures, see Refs. [1,2,3,4] for one-dimensional strings and beams, see also [5,6,7] for plates. The mathematical models traditionally feature a spatial (or Eulerian) description with unknown displacements, forces, moments, etc. considered as functions of a fixed coordinate in the axial direction with the boundary conditions applied at given points. On the other hand, the basic equations of structural mechanics are available in the Lagrangian form, when the mechanical fields are observed in material points [8].
The focus of the present talk lies in transforming the structural mechanics formulations to the spatial form using the principles of analytical mechanics and preserving the geometrically exact kinematic description. Non-material variational equations for large vibrations of axially moving strings and plates result in numerical schemes with material particles moving across the finite element mesh. Further, we address a shell model and treat the example of an endless steel belt, moving between two rotating drums. The dry friction contact, geometric imperfections and essentially nonlinear three-dimensional behavior make the latter problem particularly challenging for numerical analysis.

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