A DISCONTINUOUS GALERKIN FINITE ELEMENT APPROXIMATION OF ELASTOVISCOPLASTIC FLUID FLOWS GOVERNED BY INTEGRAL CONSTITUTIVE LAWS

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ABSTRACT

Wall paint, bread dough and glass melts are all examples of complex fluids that unite elastic, viscous and plastic material properties. Microscopic descriptions of molecular interactions lead to constitutive laws in the form of integral equations for these fluids, which capture the full deformation history of the material. Only under restrictive limiting assumptions, these integral models simplify to constitutive models in differential form (such as Oldroyd-B or White-Metzner) or even in algebraic form (such as Bingham or Herschel-Bulkley).

In this talk, we consider integral constitutive laws for elastoviscoplastic fluids and couple them with the incompressible Navier-Stokes equations. The large storage requirements for the entire deformation history pose a major computational challenge and ask for a discretisation strategy focussed on economical use of degrees of freedom. To this end, we propose a low-order discontinuous Galerkin scheme applied to the full system of equations, which additionally respects the physical conservation laws inherent in incompressible fluid flow problems.

Computing times for simulations of elastoviscoplastic flows governed by integral constitutive laws remain multiple times larger than those of typical differential models. However, we are also able to study a much broader class of fluids, including rheologies based on microscopic theories rather than macroscopic heuristics.

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