27.3 Non-Newtonian Flows: Computational Methods

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Numerical Modeling of Non-Newtonian and Viscoelastic Flows using Central Moment Lattice Boltzmann Approach SAAD ADAM, KANNAN PREMNATH, University of Colorado Denver — Non-Newtonian fluid flows with nonlinear rheological behavior occur in a number of applications such as in chemical, biological and materials processing contexts. In addition, viscoelastic fluids exhibit peculiar normal stress and memory effects. Lattice Boltzmann (LB) methods involving the use of central moments provide improved numerical stability and better physical coherence. Here, first, we present a LB model based on central moments with extended moment equilibria involving strain rates and an adjustable parameter to represent non-Newtonian power-law fluids in three-dimensions, and its numerical validation for flows encompassing both shear thinning and shear thickening fluids. Next, we discuss a LB scheme using central moments and a source term to represent the evolution of the viscoelastic stresses modeled using the upper convected Oldroyd-B model, which transform objectively – a key physical requirement. The viscoelastic stresses are then coupled to the LB flow solver as additional contributions to the latter's second order moment equilibria in the collision step. The resulting scheme is validated for various viscoelastic benchmark flows for which prior analytical and/or numerical solutions available at different Weissenberg numbers and viscosity ratios.

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