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Direct Numerical Simulations of Hard Particle Suspensions in Planar Elongational Flow

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We present a new direct numerical simulation technique for non-Brownian hard particle suspensions in planar elongational flow in 2D, by introducing the extensional bi-periodic frame concept such that a single unit cell with a small number of particles could represent suspensions of the infinite number of particles. The extensional frame is a material frame that stretches and contracts affinely with the given elongational flow and it defines the computational domain of the work. A standard velocity-pressure formulation of the finite-element method has been combined with the DLM-like fictitious domain method for the implicit treatment of the hydrodynamic interaction between particle and fluid. The extensional bi-periodic computational domain concept is introduced with the constraint equation with the Lagrangian multiplers and implemented by the mortar element method. Concentrating on 2-D disk particles, we demonstrate numerical examples of single-particle, two-particle and 100 particle problems in an extensional bi-periodic frame. Through the example problems, we discuss the effects of the solid fraction and the particle configuration on the elongational viscosity of the suspension. The extension to the viscoelastic fluid media will be discussed as well.

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