Boycott effect in two-dimensional sedimentation with diffusion

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In this work we consider a two-phase mixture model which was obtained in [1]. The first phase is granular fluid and the second phase is viscous Newtonian fluid. The granular phase is described by the model of Cosserat continua, in which each material point is treated like a rigid body with 3 translational and 3 rotational degrees of freedom. In Cosserat continua the angular momentum conservation law is not trivial and should be added to determine angular velocities of particles.

Within the framework of such model two-dimensional sedimentation problem has been considered. The sedimentation problem was solved numerically under the assumption that heat flow and rotation of particles can be neglected. The mass concentration c of particles satisfies nonhomogeneous transport equation with diffusion flux in the right-hand side, which can be determined from generalized Fick law [1]

$$\frac{\partial c}{\partial t} + \operatorname{div}(c\mathbf{v}) = -\operatorname{div}\mathbf{l}, \quad \mathbf{l} = -\left(\gamma_1 \nabla c + \gamma_2 \nabla p + \gamma_3 \nabla (\mathbf{v}_1 - \mathbf{v}_2)^2\right) + cB\mathbf{g} \tag{1}$$

where p — pressure, $\mathbf{v}_i$ — velocity of i-th phase, $\mathbf{v} = \rho_1 \mathbf{v}_1 + \rho_2 \mathbf{v}_2$ — velocity of the mixture, c — mass concentration of particles, $\mathbf{g}$ — gravity acceleration, B — mobility coefficient.

The problem was solved using finite element method (FreeFEM++) and projection method. It was shown that the sedimentation process occurring at a more rapid rate in the inclined cell rather than in vertical cell, which corresponds to Boycott effect. Also the convergence of method has been investigated numerically.

References

[1] Shelukhin V. V. *Thermodynamics of two-phase granular fluids.* J. Non-Newtonian Fluid Mech. 2018 V. 262. P. 25–37.