Exploratory Project 2019

Deep learning for particle-laden viscoelastic flow modelling

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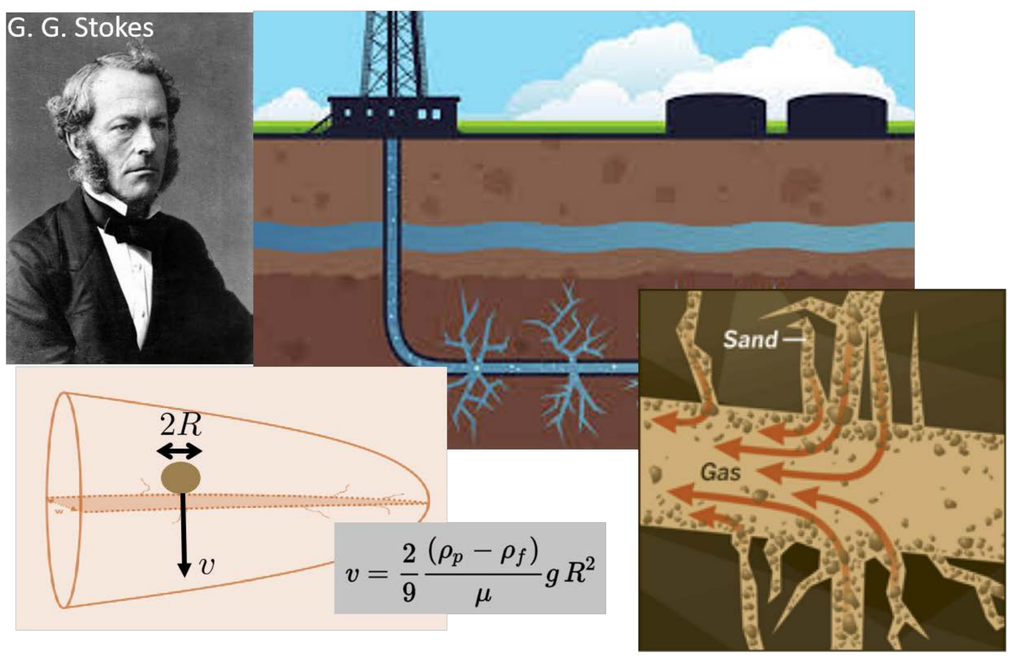
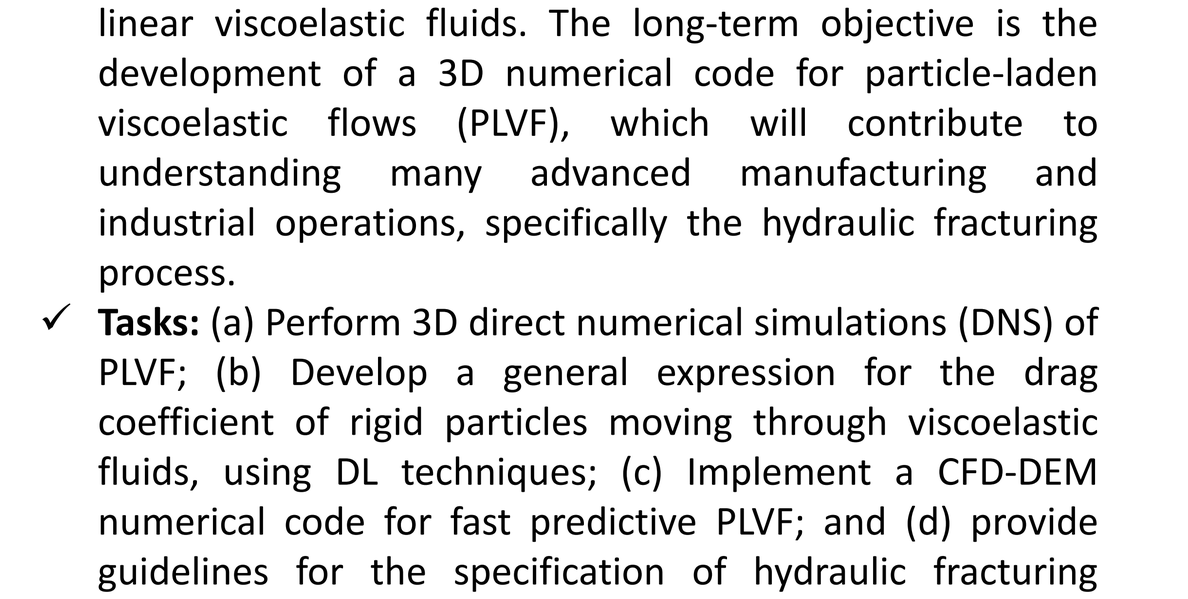
Project Overview



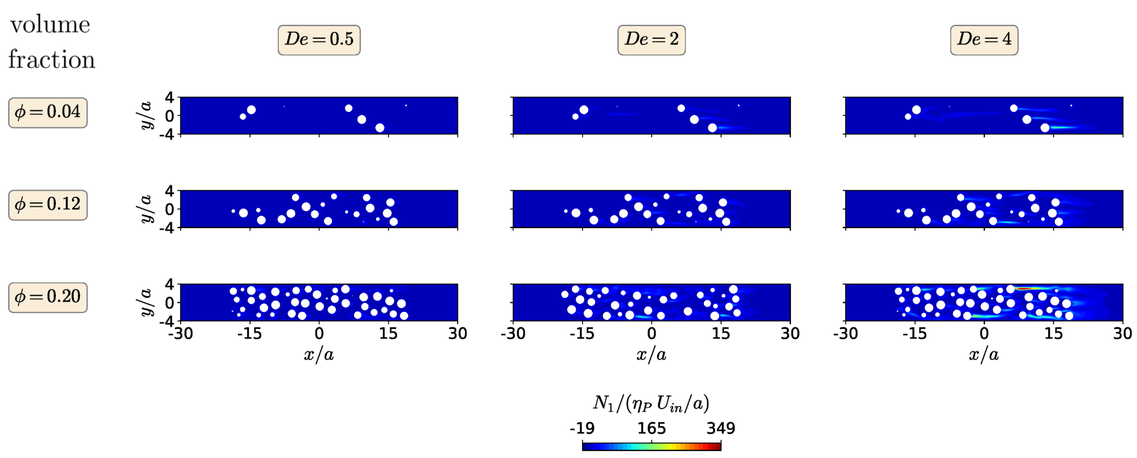
- ✓ **Objetives:** explore the possibility of using Deep Learning (DL) techniques to evaluate the drag coefficient of small non-Brownian particles translating and settling in non-linear viscoelastic fluids. The long-term objective is the development of a 3D numerical code for particle-laden viscoelastic flows (PLVF), which will contribute to understanding many advanced manufacturing and industrial operations, specifically the hydraulic fracturing process.
- ✓ **Tasks:** (a) Perform 3D direct numerical simulations (DNS) of PLVF; (b) Develop a general expression for the drag coefficient of rigid particles moving through viscoelastic fluids, using DL techniques; (c) Implement a CFD-DEM numerical code for fast predictive PLVF; and (d) provide guidelines for the specification of hydraulic fracturing fluids.

Drag coefficient of *a sphere*[1,2]



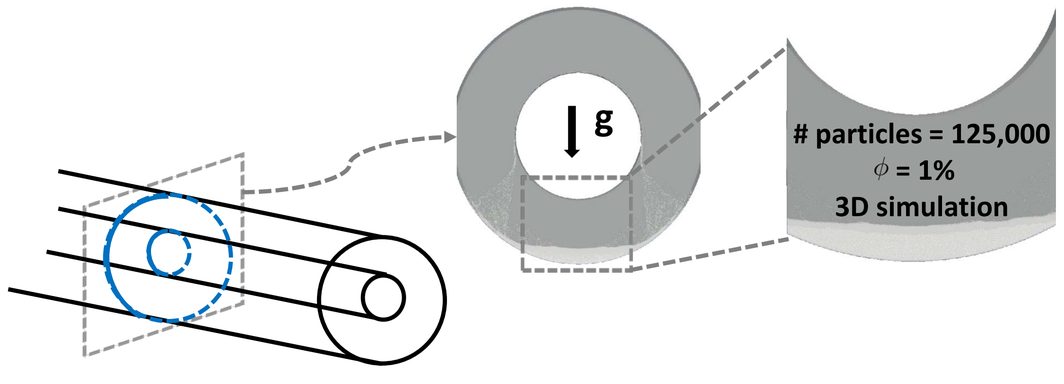
This is for the quasi-linear viscoelastic Oldroyd-B model (with relaxation time τ and viscosity η_0), but what happens for the non-linear viscoelastic Giesekus model?

Drag coefficient of *random arrays of spheres*



These are DNS of the normal stress difference, $N_1(\mathbf{x}, De, \phi, Re) = \tau_{xx} - \tau_{yy}$, for random arrays of spheres immersed in a fluid following a quasi-linear viscoelastic Oldroyd-B model. What is the drag law for dense systems? And, for the non-linear viscoelastic Giesekus model?

CFD-DEM viscoelastic code



This is particle sedimentation for a Newtonian fluid, but how would it look like for a viscoelastic fluid?

Future Plans

- ✓ Develop a *closure model* to enable self-consistent computation of the drag coefficient of a sphere immersed in a Gisesekus viscoelastic fluid**,** using DL techniques;
- ✓ Extend the dilute drag models to dense systems;
- ✓ Perform fast-predictive CFD-DEM viscoelastic simulations to investigate the performance of hydraulic fracturing fluids.

References

1. S.A. Faroughi, C. Fernandes, J.M. Nóbrega, G.H. McKinley, *J. Non-Newton. Fluid Mech.*, **2020**, 277, 104218.
2. C. Fernandes, S.A. Faroughi, O.S. Carneiro, J.M. Nóbrega, G.H. McKinley, *J. Non-Newton. Fluid Mech.*, **2019**, 266, 80.