**Competition of inertia and deformability: motion of deformable particles in channel flow**

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**Motivation**

The motion of deformable particles in a planar Poiseuille flow has not been entirely understood. On the one hand, it is known that the deformability of particles (expressed by the capillary number \( \text{Ca} \), the ratio of viscous fluid and elastic particle stresses) promotes a migration towards the centerplane of the flow in the absence of inertia (zero Reynolds number, \( \text{Re} = 0 \)). On the other hand, inertia effects are responsible for an outward migration of rigid particles (\( \text{Ca} = 0 \)) close to the centerplane [1, 2]. Although the behavior of single deformable capsules in channel flow at finite \( \text{Re} \) has been studied recently [3, 4, 5], not much is known about deformable particle suspensions for varying capillary and Reynolds numbers. We present 3D simulation results for systems with both finite \( \text{Ca} \) and \( \text{Re} \) at intermediate volume fractions and discuss inertia and deformability effects on the lateral particle distribution and apparent viscosity.

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**Numerical methods**

1) Fluid solver: lattice Boltzmann method (LBM), D3Q19 LBGK [6, 7]
2) Elastic capsules: finite element method (FEM) [8, 9, 10]
3) Fluid-structure interaction: immersed boundary method (IBM) [11, 12]

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**Setup and parameter space**

Semi-dilute suspension of deformable capsules, \( \phi = 0.1 \)
Force-driven flow in confined channel, \( \chi = 2r/H = 0.2 \)
Three control parameters:
- Fluid viscosity \( \eta \), capsule elasticity \( \kappa_s \), external forcing \( f \)

Characteristic dimensionless numbers:
- Reynolds number \( \text{Re} = \frac{\bar{u} H}{\eta f} \)
- Capillary number \( \text{Ca} = \frac{\eta f}{\kappa_s} = \frac{f H r}{4 \kappa_s} \)
Investigated parameter range: \( 3 < \text{Re} < 333, 0.003 < \text{Ca} < 0.3 \)
What is the effect of these two parameters on the suspension properties?

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**Results**

One observes significant effects due to deformability and inertia on:
1) microstructure (particle clustering)
2) lateral particle distribution (depletion layer width)
3) viscosity (transport efficiency)
4) velocity fluctuations

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**Conclusions**

A wide range of \( \text{Re} \) and \( \text{Ca} \) has been investigated (covering quasi-Stokesian and inertial regimes as well as quasi-rigid and strongly deformed particles). A significant particle clustering is observed for quasi-rigid particles at intermediate Reynolds numbers (\( \text{Re} = 50 \)). Inertia plays different roles, depending on deformability:
1) low \( \text{Ca} \) (quasi-rigid): inertia opposes depletion and increases viscosity.
2) high \( \text{Ca} \) (deformed): inertia supports depletion and decreases viscosity.

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**References**


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