Velocity field structuration for particle suspensions in an oscillatory channel flow

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The motion of individual particles has been tracked experimentally in a non-Brownian suspension of non-buoyant spheres (volume fraction ϕ between 0.15 and 0.4) subject to a square-wave oscillatory flow in a Hele-Shaw cell of aperture $H = 1$ mm at low particulate Reynolds numbers (< 0.05). We investigated the evolution of the velocity field of the particles and of their trajectories as a function of ϕ and of the amplitude A and period T of the oscillating flow.

Initially, the flow is parallel with a blunted velocity profile resulting from an increased particle concentration at the center of the channel, consistent with previous results and shear-induced migration models. The reversibility of the motion of the particles from one period to the next is strong in the center region but much weaker close to the walls.

Then, one observes an instability marked by an initially exponential growth of a transverse velocity component v_y: The structure of v_y is spatially and temporally periodic with a wavelength λ increasing with the deformation per half period A/H and with no clear dependence on ϕ. The appearance of the transverse velocity reduces the reversibility of the motion of the particles in the center of the channel. The ratio T/τ (τ = characteristic growth time) varies linearly with A/H above a threshold value ≈ 1 and up to $A/H \approx 5$. The slope of the variation increases significantly with ϕ, reflecting a faster development of the instability. Structuration has been observed up to the highest values of $A/H \approx 25$ investigated.

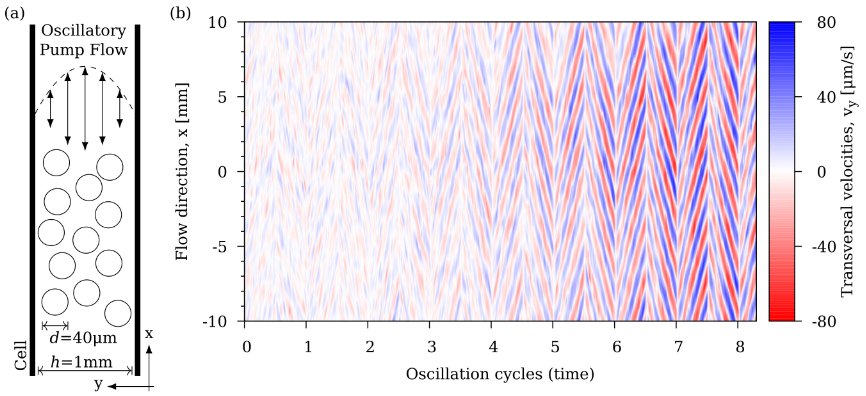

Figure 1: a) Schematic view of the experimental flow channel. b) Spatio-temporal diagram displaying as a function of the distance x along the flow and of the time the growth of the velocity component v_y transverse to the main flow and its periodic structure.