SPREADING FRONTS AND FLUCTUATIONS IN SEDIMENTATION: PART I EXPERIMENTS

Laurence Bergougnoux*, Sébastien Ghicini*, Élisabeth Guazzelli*, John Hinch**
**IUSTI - CNRS, Polytech'Marseille, Technopôle de Château Gombert, 13453 Marseille Cedex 13, France.*
***DAMTP, Centre for Mathematical Sciences, Cambridge CB3 0WA, UK.*

Summary The problem of velocity fluctuations in a sedimenting suspension is investigated by laboratory experiments. We examine how the sedimentation front spreads and how this affects the velocity fluctuations. The influence of the size of the container is also examined.

The problem of velocity fluctuations in a sedimenting suspension is still unresolved. Theories [1, 2] with randomly positioned monodisperse particles predict that the fluctuations diverge with the size of the container. Unfortunately experiments find differently [3, 4]. There have been a number of theoretical and numerical attempts to explain this discrepancy [5, 6, 7, 8, 9, 10, 11].

The objective of the present work is to examine by laboratory experiments how the sedimentation front spreads, how this affects the velocity fluctuations, and whether a steady state is reached. Experiments were undertaken at very low Reynolds number ($Re < 10^{-4}$) and volume fraction ($\phi = 0.3\%$) using small but non-Brownian spherical particles (of radius 149 ± 8 μm). Two types of experimental measurements were performed. The spreading of the sedimentation front was measured using the attenuation of light through the suspension. The particle velocities were measured using particle image velocimetry (PIV).

First, experiments were performed in a glass walled cell of square cross section 20×20 cm^2 with a filled height of 40 cm [12]. The cell width, L, and height, H, were then large compared to the particle radius and to the mean interparticle spacing.

The width of the front was found to grow linearly in time. Most of the growth could be explained by a polydispersity of the particle size. The extra growth came from a faster fall of the denser iso-concentration planes. No diffusive growth like the square root of time, due to hydrodynamic dispersion, was seen. Hindered settling also played no role in the very dilute suspension.

The behavior of the particles was found different in the front. We observed that the mean particle velocity and its fluctuations decreased as the front arrived in the observation window. Using a window which excluded the front and the sediment, the mean velocity remained constant near to the Stokes value and the fluctuations attained a steady value after an initial rapid transient.

Secondly, the influence of the size of the container was investigated by reducing the lateral size. It was again found that the velocity fluctuations reached a steady state away from the front.

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