Shadowgraph Investigation of Free-Diffusion of Aqueous Solutions of Glycerol Using a Cylindrical Flowing-Junction Cell

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Mass diffusion is the physical phenomenon driven by the random walk of the fluid molecules in the presence of a concentration gradient. The behaviour of the fluid is also witnessed by non-equilibrium fluctuations that occur at all scales from the microscopic to the mesoscopic and macroscopic ones in the presence of a concentration gradient in the bulk of an isothermal fluid mixture. In this work, we investigate non-equilibrium concentration fluctuations by means of dynamic shadowgraph during a free-diffusion process in order to measure the transport properties of the mixture. On ground, fluctuations are affected by diffusion and buoyancy forces depending on the wave number q. For large wave numbers (small fluctuations), diffusion is more efficient than gravity and the decay time is the typical diffusive one, proportional to $1/(Dq^2)$, D being the mass diffusion coefficient of the mixture. For small wave numbers (large fluctuations) gravity dominates and the decay time is proportional to q^2 (Croccolo et al. 2006). By fitting the decay times to the theoretical model, one can get a precise measurement of the mass diffusion coefficient (Croccolo et al. 2012). In order to prepare the initial step concentration profile where a layer of water is superposed to a layer of a glycerol solution, we developed (Croccolo et al. 2019) a revised cylindrical Flowing-Junction Cell (c-FJC). In our device, the two fluids are injected radially and symmetrically on the top and bottom of the cell. The remixed fluid is radially and symmetrically delivered through a thin slit at mid-height of the cell. Thus, a sharp interface between the two fluids is maintained both in stable (denser fluid at the bottom side of the cell) and in unstable conditions (denser fluid at the top side of the cell).The device has been also tested in micro-gravity conditions during a parabolic flight.

References

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