Dynamics of spheres falling in quiescent flows

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Despite the apparent simplicity of a single sphere falling in a quiescent flow, far enough from Stokes conditions a rich dynamics has been found. Simulations have shown the existence of several particle trajectory regimes in a quiescent flow, whose onsets are determined by particle-fluid density ratio (ρ_s/ρ_f) and Galileo number $Ga = \sqrt{|\frac{\rho_s}{\rho_f} - 1|gd^3}/\nu$, where ρ_s is the particle density, d the particle diameter, ρ_f the fluid density, ν the fluid kinematic viscosity and g the gravity acceleration [1]. Figure 1 (right) shows the regions in the parameters space (density ratio - Galileo number) that have been explored by numerics. Previous works have experimentally explored particles with values of density ratio below 1.2 [2, 3]. Anyhow, an experimental validation is needed for heavy particles.

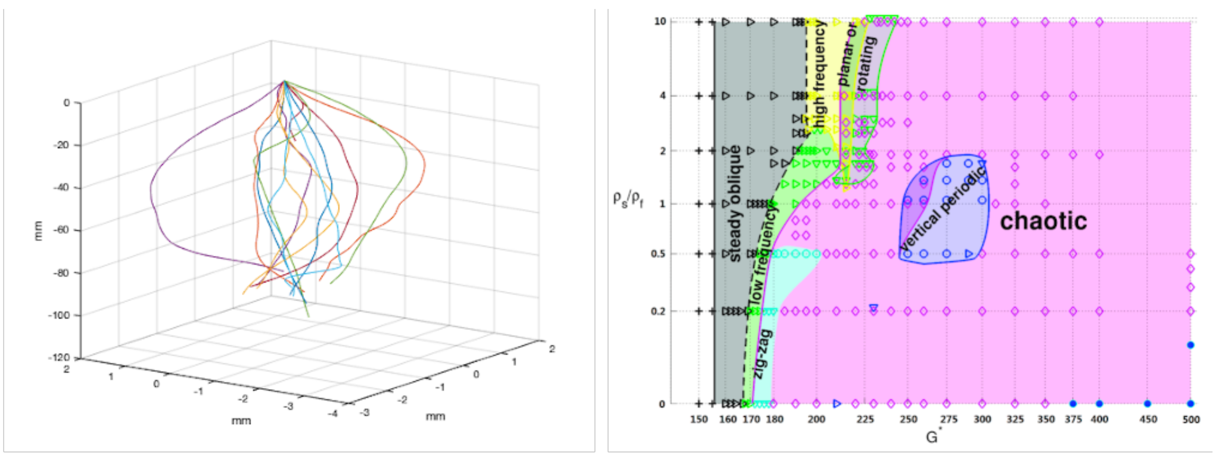

Figure 1. (Left) Measured trajectories for a chaotic regime. (Right) Space parameter explored numerically in the past [1].

Here, the dynamics of heavy spheres with particle-fluid density ratios between $(1.1, 10)$ and Galileo numbers between $(150, 400)$ has been studied experimentally. We have performed an exploration of the different regions modifying Ga by changing the viscosity and using particles with the following density ratios: $\rho_s/\rho_f \approx 1.1$ (polyamide), $\rho_s/\rho_f \approx 1.4$ (polyacetal), $\rho_s/\rho_f \approx 2.2$ (glass) and $\rho_s/\rho_f \approx 9$ (stainless steel).
Figure 1 (left) shows several 3D trajectories of a sphere with $\rho_s/\rho_f = 2.2$ and $Ga = 254$. The measured trajectories have a chaotic behavior as predicted by numerics. The existence of the different regimes and its onsets were compared with previous numerical results.

References

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