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Clustering in an externally vibrated particle-laden fluid in microgravity

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Particle transport in a fluid has many applications, from industrial practices to natural phenomena. Algae blooms, microplastic pollution, ash, and pollen deposition are examples of particle-laden flows in a fluid-gas interface. Literature for particle clustering at the fluid surface is divided into the influence of electromagnetic forces, and the capillary forces at rest. For applied scenarios, such as the previously mentioned natural phenomena, the harmonic forcing case should be included. These capillary forces on the particles can be divided into immersion forces (due to the wettability of the particles) and flotation forces (due to gravity). In an experimental study on Earth, these forces are entangled, thus making a systematic study of isolated immersion forces difficult. The need for microgravity experiments of a particle-laden externally vibrated fluid surface becomes strong and motivates this project, aiming to disentangle the immersion and flotation capillary forces on particle clustering. The experiments discussed utilize an open cylindrical container placed on a wave driver, providing external harmonic forcing, with particles populating the fluid surface. Particle tracking is achieved through 2D camera imaging for various cases of wave frequencies, particle densities, and fluid characteristics. Experiments were performed in the Dryden Drop Tower (DDT) facility at Portland State University, Oregon, United States. The DDT provides a unique microgravity environment for approximately 2 seconds. Microgravity tests are compared to 1-g lab bench tests. Probability density functions and Voronoi analysis are used to evaluate the clustering. DDT and bench test results show that extended time in zero gravity is necessary and supports the future work that will be performed on the International Space Station.

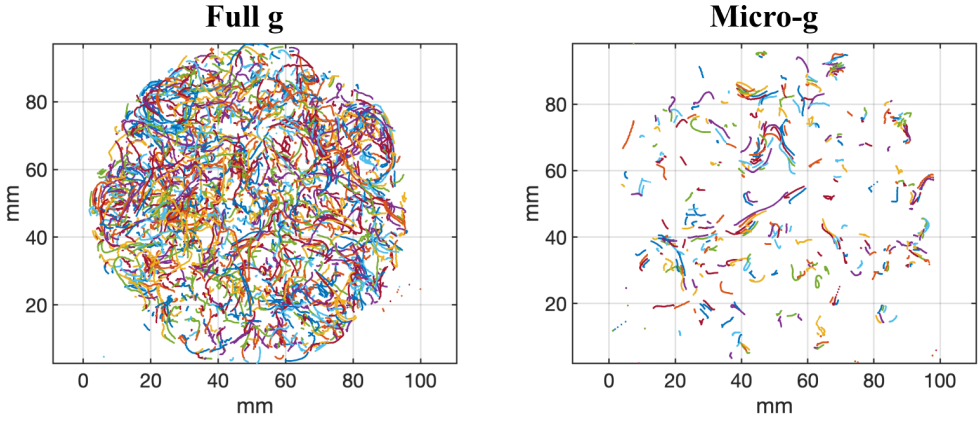

Figure 1: Sample particle tracking of the full g case and microgravity case. From this trajectory output, statistical velocity and acceleration information from the particles and clustering can be calculated.

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