Collisional Granular Flows with and without Gas Interactions in Microgravity
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We illustrate the convenience of a long-lasting microgravity environment for studying flows of granular materials with and without gas interaction. We consider collisional granular flows of nearly elastic spheres featuring a single constituent or binary mixtures in various bounded geometries. We review governing equations for these flows, illustrate their solutions and compare them with numerical simulations and data from microgravity experiments.

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I. EXTENDED ABSTRACT

The talk illustrates the convenience of a long-lasting microgravity environment for studying flows of granular materials with and without gas interaction.

We begin by considering collisional flows of nearly elastic grains featuring a single constituent of identical spheres or mixtures of two kinds of spheres that differ by mass or size at Stokes numbers large enough for the gas to play a negligible role.

At such high Stokes numbers, we carry out experiments and numerical simulations in two shear cells with a rectangular cross-section bounded by two flat walls and moving boundaries on which cylindrical bumps are affixed. One of the cells is shaped as a race track. The other is axisymmetric.

We outline the equations of the kinetic theory for the conservation of mass, momentum, fluctuation energy and species concentration in the granular phase [1] [2] [3]. We illustrate their solutions for shear flows in rectilinear or axisymmetric rectangular channels with or without a body force. We show that proper boundary conditions yield numerical solutions in good agreement with molecular dynamical simulations and with data from experiments carried out on NASA's KC-135 microgravity aircraft. [4]

Next, we describe future microgravity experiments with bounded shear flows of agitated, homogeneous, inelastic solid spheres colliding in a gas in the axisymmetric shear cell at finite particle Reynolds numbers, volume fractions between 0.05 and 0.4, and Stokes numbers large enough for collisions to determine the velocity distribution of the spheres. We briefly outline a continuum theory in which constitutive relations and boundary conditions for the granular phase are derived from the kinetic theory, and in which the gas contributes a mean drag force to the momentum of the grains and a viscous dissipation term to their fluctuation energy [5]. The theory underscores the role played by the walls in the balances of momenta and fluctuation energy, and predicts variations of volume fraction, mean and fluctuation velocities between the walls. We employ it to determine a set of experimental conditions suitable for recording the mean drag force and the viscous dissipation. Finally, we compare predictions of the theory to the recent Lattice-Boltzmann simulations of Verberg and Koch [6].

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