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Waves in granular flows down a vertical chute

The flow of granular materials in confined, gravity-driven chute systems is relevant to numerous industrial and geophysical processes. While transverse oscillations in short periodic chutes have been reported previously, their spatial structure and the influence of wall conditions on the characteristics of the waves remain to be investigated. This study examines the dynamics of granular particles in a vertical chute of square cross-section with nominal side of 50 mm under gravity. Using discrete element method simulations, we model the behaviour of 2 mm spherical particles that interact through the Hertz-Mindlin contact model. The channel has periodic boundaries in the lateral (x) and flow (y) directions and confinement is provided by vertical side walls (in the z direction) roughened using close-packed 2 mm spherical bumps. The size of these bumps serves as a control parameter, enabling systematic variation of wall bumpiness and its influence on the flow dynamics.

Our study indicates that at increased solid fractions the granular flow transitions to a wave-dominated regime as the particles descend under gravity. The occurrence and characteristics of these waves are strongly influenced by wall conditions. By extending the chute length, we observe that the previously observed oscillation corresponds to the spatially uniform limit of a travelling wave in streamwise direction. Space–time analysis of centre of mass fluctuations confirms the emergence of streamwise phase variation.

We also employed the extended kinetic theory to compute the flow variables as functions of both space and time, with the spatial coordinate taken across the chute. In our preliminary studies, we observed that kinetic theory is capable of predicting these cross-stream oscillations, and further investigations on this aspect are currently in progress.