

## Particle-size segregation and diffusive remixing in shallow granular avalanches

Gray J., Chugunov V.

*Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia*

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### Abstract

Segregation and mixing of dissimilar grains is a problem in many industrial and pharmaceutical processes, as well as in hazardous geophysical flows, where the size-distribution can have a major impact on the local rheology and the overall run-out. In this paper, a simple binary mixture theory is used to formulate a model for particle-size segregation and diffusive remixing of large and small particles in shallow gravity-driven free-surface flows. This builds on a recent theory for the process of kinetic sieving, which is the dominant mechanism for segregation in granular avalanches provided the density-ratio and the size-ratio of the particles are not too large. The resulting nonlinear parabolic segregation-remixing equation reduces to a quasi-linear hyperbolic equation in the no-remixing limit. It assumes that the bulk velocity is incompressible and that the bulk pressure is lithostatic, making it compatible with most theories used to compute the motion of shallow granular free-surface flows. In steady-state, the segregation-remixing equation reduces to a logistic type equation and the 'S'-shaped solutions are in very good agreement with existing particle dynamics simulations for both size and density segregation. Laterally uniform time-dependent solutions are constructed by mapping the segregation-remixing equation to Burgers equation and using the Cole-Hopf transformation to linearize the problem. It is then shown how solutions for arbitrary initial conditions can be constructed using standard methods. Three examples are investigated in which the initial concentration is (i) homogeneous, (ii) reverse graded with the coarse grains above the fines, and, (iii) normally graded with the fines above the coarse grains. Time-dependent two-dimensional solutions are also constructed for plug-flow in a semi-infinite chute. © 2006 Cambridge University Press.

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