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Segregation force in granular flows: From single intruders to bidisperse mixtures RICHARD M. LUEPTOW, YIFEI DUAN, LU JING, JULIO M. OTTINO, PAUL B. UMBANHOWAR, Northwestern University — Recent studies have focused on the size segregation force on a single large intruder particle in granular flows. However, a generalized scaling of the force is still lacking for combined size and density segregation as well as for mixtures (rather than a single intruder). Here we first measure the segregation force on a single intruder in DEM simulations using a spring-based force meter and provide a universal scaling law of the segregation force that predicts whether the intruder will rise or sink depending only on the size and density ratios. Interestingly, the scaled force does not increase monotonically but decreases at large size ratios, explaining experimental observations that very large intruders sink. Then we extend the measurement to bidisperse particle mixtures of varying concentration. The resulting scaling law enables prediction of the segregation direction (rise or sink) of each particle species for varying size ratio, density ratio, and species concentration. Surprisingly, the segregation may invert as the species concentration changes because the segregation force depends on the species concentration. The predictions are validated with DEM simulations and experiments in various flow configurations.

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