Mechanisms in the size segregation of a binary granular mixture

Matthias Schröter*†, Stephan Ulrich*, Jennifer Kreft Pearce*‡, Jack B. Swift*, and Harry L. Swinney*

* Center for Nonlinear Dynamics and Department of Physics
The University of Texas at Austin
Austin, Texas 78712, USA

‡ Roger Williams University
Feinstein College of Arts and Sciences
Bristol, Rhode Island 02809, USA

† Max Planck Institute for Dynamics and Self-Organization
Dep. Dynamics of Complex Fluids
37077 Göttingen, Germany
e-mail: matthias.schroeter@ds.mpg.de

ABSTRACT

A vertically shaken binary granular mixture will in most cases segregate. The larger particles might either accumulate at the top of the sample, the so called the Brazil-nut effect "BNE"; or they accumulate at the bottom, the reverse Brazil-nut effect "RBNE". While this process is of great industrial importance in the handling of bulk solids, it is not well understood. In recent years at least ten different mechanisms have been suggested to explain when each type of segregation is observed. However, the dependence of the mechanisms on driving conditions and material parameters and hence their relative importance is only poorly understood. This talk will combine both experiments and matching simulations where both types of particles are made from the same material and shaken under low air pressure, which reduces the number of mechanisms to be considered to seven. We observe both BNE and RBNE by varying systematically the driving frequency and amplitude, diameter ratio, ratio of total volume of small to large particles, and overall sample volume.

We analyze the amount of segregation in our experiments quantitatively by counting the number of large spheres migrating to both the top and bottom of our comparatively shallow (2 and 4 layers deep at rest) samples. Using these data to calibrate our simulations, those allow us then to analyze the spatiotemporal evolution of granular temperature and density. We find that all our experimental and numerical results can be explained by a combination of three mechanisms: a geometrical mechanism called void filling, transport of particles in sidewall-driven convection rolls, and thermal diffusion, a mechanism predicted by kinetic theory. Additionally, we show that some suggested mechanisms are not present, even thought the setup and driving parameters should be suitable [1]. A closing remark will look into the at least in some configurations highly nonlinear effect of surface friction on segregation [2].

REFERENCES

[1] Matthias Schröter, Stephan Ulrich, Jennifer Kreft, Jack B. Swift, and Harry L. Swinney, "Mechanisms in the size segregation of a binary granular mixture", Physical Review E **74**, 011307 (2006)

[2] Stephan Ulrich, Matthias Schröter, and Harry L. Swinney, "Influence of friction on granular segregation", Physical Review E **76**, 042301 (2007)