Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Mixing dynamics of cutting and shuffling for granular materials[1]
RICHARD M. LUEPTOW, ZAFIR ZAMAN, MENGQI YU, PAUL P. PARK, JULIO M. OTTINO, PAUL B. UMBANHOWAR, Northwestern University —
Chaotic dynamics has been shown to play a major role in fluid mixing, but the study of its relevance to granular flows has only recently begun. We utilize a simple 3D geometry, a half-filled spherical tumbler rotated alternately by $\leq \pi/2$ about two perpendicular horizontal axes, to develop a dynamical systems framework for granular mixing and non-mixing. In these systems, mixing can only occur during flow (from stretching due to shear and from collisional diffusion in the flowing layer) or by material separation intrinsic to the rotation protocol resulting from cutting and shuffling. In X-ray subsurface visualization experiments, surprisingly persistent (O(100) iterations) non-mixing elliptical regions and larger non-mixing barriers occur as predicted by both a continuum model and an idealized theoretical model (with an infinitely thin flowing layer) based on the mathematics of piece-wise isometries. In these models, the stretching in the flowing layer vanishes as the flowing layer thickness decreases to reveal the underlying skeleton of the mixing. This dynamical systems perspective provides insight into mixing and non-mixing phenomena unique to granular materials.

[1]Funded by NSF Grant CMMI-1435065.

Richard M. Lueptow
Northwestern University

Date submitted: 01 Aug 2016 Electronic form version 1.4