Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Connecting 3D granular segregation patterns to piecewise isometries[1] THOMAS LYNN, MENGQI YU, JULIO OTTINO, RICHARD LUEPTOW, PAUL UMBANHOWAR, Northwestern University — One of the simplest 3D systems for mixing granular materials is a half-filled spherical tumbler repeatedly rotated about one horizontal axis and then another. Despite its simplicity, complex flow structures appear, including non-mixing islands, chaotic mixing regions, and barriers to transport, each sensitive to the amount of rotation about each axis. For size-disperse granular material, larger particles segregate to the surface of the thin flowing layer and the tumbler periphery. For certain rotation pairs, large particles either accumulate in and around non-mixing islands due to weak axial drift or remain trapped in isolated mixing (chaotic) regions. The complex dynamics that create barriers to transport are explored using a continuum model and particle simulations. Going further, an approximation of the system in the limit of an infinitely thin flowing layer offers new insight into barriers to transport even in the absence of segregation. By treating the infinitely thin flowing layer system as a sequence of cut-and-shuffle actions, the tumbler 'flow' can be mathematically described as a piecewise isometry (PWI). The PWI dynamics can be split into invariant subsets and non-mixing islands corresponding to chaotic regions and segregation regions in the tumbler, respectively.

[1]Partly funded by NSF grant CMMI-1435065

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Date submitted: 04 Aug 2020 Electronic form version 1.4