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Cutting and shuffling of a granular mixture in a spherical tumbler
GABRIEL JUAREZ, RICHARD M. LUEPTOW, JULIO M. OTTINO, Northwestern University, ROB STURMAN, University of Leeds, STEPHEN WIGGINS, University of Bristol — Good mixing in a fluid system is usually associated with chaotic advection. For a granular system, good mixing can be achieved through an entirely different mechanism that is well-known to mathematicians and card-players, 'cutting and shuffling,' which has theoretical foundations in a relatively new area of mathematics known as "piecewise isometries", PWIs. Cutting and shuffling experiments are conducted in a spherical tumbler of diameter D=14cm that is half-filled with two colors of d=1mm glass beads and can be rotated by arbitrary angles periodically about each of two horizontal, orthogonal axes. In order to connect experimental results, which have a finite thickness flowing layer, with theoretical PWI mappings, which have a zero-thickness flowing layer, a continuum model with a variable flowing layer depth is utilized. The PWI theory accurately predicts the experimental mixing in this granular system demonstrating that PWI theory captures the essential kinematic features responsible for the mixing of granular materials in a three-dimensional tumbler. Furthermore, PWI results in mixing without stretching, a characteristic of chaotic mixing.

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