Geophysical Research Abstracts
Vol. 20, EGU2018-11275, 2018
EGU General Assembly 2018

Chaotic Fluid Advection in 3D crystalline granular porous media

Régis Turuban (1), Daniel Lester (2), Tanguy Le Borgne (1), and Yves Meheust (1)

(1) Geosciences Rennes, University of Rennes 1, CNRS, Rennes, France , (2) School of Engineering, RMIT University, Melbourne, Australia

We study the Lagrangian dynamics of steady three-dimensional (3D) Stokes flow over granular media consisting of simple cubic (SC) and body-centered cubic (BCC) lattices of closed-packed spheres, and uncover the mechanisms governing chaotic fluid advection. Due to the cusp-shaped sphere contacts, the topology of the skin friction field is fundamentally different from that of continuous (non-granular) media (e.g. open pore networks), with significant implications for fluid advection. Weak symmetry breaking of the flow orientation with respect to the lattice symmetries imparts a transition from regular advection to strong chaotic advection in the BCC lattice, whereas the SC lattice only exhibits weak advective mixing. Using a numerical simulation of the flow at various flow orientations, we quantify the strength of chaotic mixing from the Lyapunov exponent, and examine how it is distributed over the parameter space of mean flow orientation [1]. We furthermore analyze the flow topology and show that the occurrence of chaotic advective mixing is controlled by the existence within the flow of transverse intersections between stable and unstable manifolds originating from the spheres [1]. These insights are used to develop accurate predictions of the Lyapunov exponent distribution over possible flow orientations [2]. The difference of behavior observed for the SC and BCC lattices, which share the same symmetry point group, results from their different space group symmetries: a glide symmetry of the BCC lattice allows the occurrence of chaotic advection [1]. These results point to a general theory of advective mixing and dispersion based upon the inherent symmetries of arbitrary crystalline structures.

References:

[1] R. Turuban, D. R. Lester, T. Le Borgne, Y. Méheust (2017), Space-Group Symmetries Generate Chaotic Fluid Advection in Crystalline Granular Media, *Phys. Rev. Lett*, in press.
[2] R. Turuban, D. R. Lester, T. Le Borgne, Y. Méheust (2017), Chaotic Mixing in Close-Packed Sphere Lattices, in preparation.