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Numerical investigation of chaotic advection in porous media at the Pore and Darcy scales

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Solute transport in porous media plays a significant role in industrial and natural processes, since porous materials are ubiquitous on Earth. Modelling transport is important for various applications, including soil moisture dynamics, groundwater pollution, and oil recovery. Previous research suggested that chaotic mixing [1], e.g. the exponential elongation of fluid elements by advection, strongly depends on lattice geometries, flow direction [2] and packing density [3]. However, a universal understanding of chaotic advection at Pore and Darcy scales is still missing. Here, we present a numerical study of 3D Pore and Darcy scale flows through various representative elementary volumes. In this instance, we consider the impact of impermeable inclusions on the mixing dynamics of homogeneous Darcy flow. We computed Stokes and Darcy velocities for constant pressure gradient in mono-dispersed bead packs with body-centered cubic (BCC), face-centered cubic (FCC), and random lattices. By computing periodic trajectories, we then estimate the magnitude of the largest Lyapunov exponent in all these flows fields, and compare them with a new predictive model. Our results provide original perspectives on the control of chaotic mixing by the porous structure.

Participation

In-Person

References

[1] D. Lester, G. Metcalfe, and M. Trefry, “Is chaotic advection inherent to porous media flow?,”Physical Review Letters, vol. 111, no. 17, pp. 174101–1 –174101–5, 2013.
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