LAGRANGIAN CHAOS AND MIXING IN POROUS MEDIA

Daniel Lester, Commonwealth Scientific and Industrial Research Organisation, +61 3 92526195, daniel.lester@csiro.au

1. Dr Daniel R L ester, Division of Mathematics, Informatics and Statistics, Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Quantification of transport in porous media is a long-standing problem complicated by the inherent complexity of the pore-space geometry. As such, up-scaling methods are used to describe macroscopic transport which often utilizes averaging over many pore volumes. However, such averaging can neglect important pore-scale phenomena which can influence macroscopic transport.

Pore-scale fluid mechanics are described by Stokes flow, which are typically considered to be non-mixing flows. However, the advection equations describing motion of a non-diffusive tracer in Stokes flow represent a dynamical system which is capable of exhibiting chaotic dynamics. This dynamical behavior - termed Lagrangian chaos or chaotic advection - can impart rapid, complete mixing in steady laminar flows similar to that of turbulent dispersion.

We demonstrate that Lagrangian chaos is inherent to steady 3D flow in porous media due to the non-trivial branching and recombination of flow paths, and this phenomenon has important implications for both dispersion and chemical reaction in porous media. In conjunction with molecular diffusion, Lagrangian chaos acts to exponentially accelerate dispersion, and so is thought to play a significant role in the generation of hydrodynamic dispersion. Chaotic advection can also govern state selection in chemical reactions with multiple equilibria, and so can play an important role in reactive transport modeling. Finally we consider mechanisms by which chaotic transport can occur at larger scales, and the implications for macroscopic transport.