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Chaotic Advection in a Bounded 3-Dimensional Potential Flow
GUY METCALFE, CSIRO Materials Science & Engineering, LACHLAN SMITH, DANIEL LESTER, CSIRO Mathematics, Informatics & Statistics — 3-dimensional potential, or Darcy flows, are central to understanding and designing laminar transport in porous media; however, chaotic advection in 3-dimensional, volume-preserving flows is still not well understood.[1] We show results of advecting passive scalars in a transient 3-dimensional potential flow that consists of a steady dipole flow and periodic reorientation. Even for the most symmetric reorientation protocol, neither of the two invarients of the motion are conserved; however, one invarient is closely shadowed by a surface of revolution constructed from particle paths of the steady flow, creating in practice an adiabatic surface. A consequence is that chaotic regions cover 3-dimensional space, though tubular regular regions are still transport barriers. This appears to be a new mechanism generating 3-dimensional chaotic orbits. These results contast with the experimental and theoretical results for chaotic scalar transport in 2-dimensional Darcy flows.[2,3]

[1]Wiggins, J. Fluid Mech. **654** (2010).
[2]Metcalfe et al, Phil. Trans. R. Soc. **A368** (2010a,b).
[3]Lester et al, Phys. Rev. **E80** (2009), **E81** (2010).

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