

# Weak Turbulence and Transitions to Chaos in Porous Media

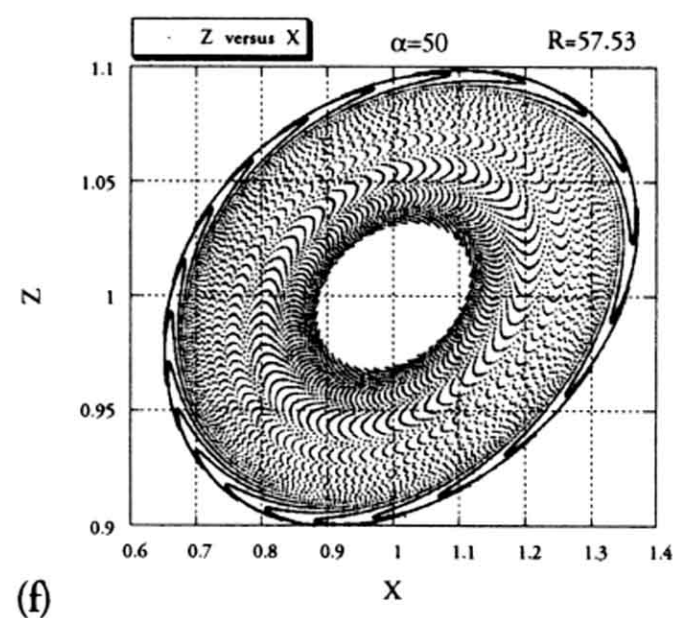
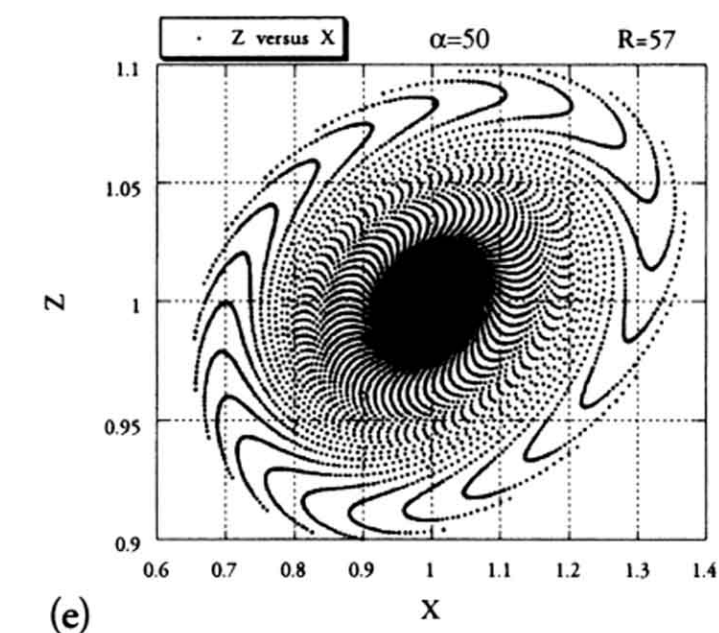
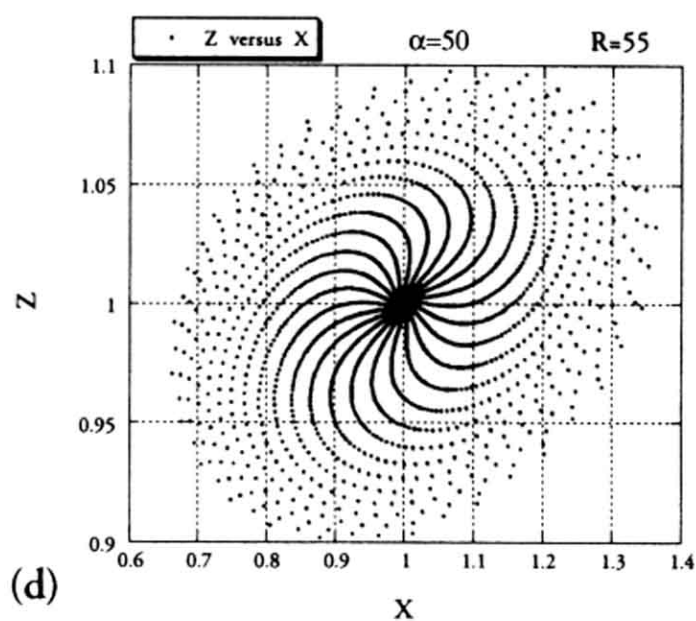
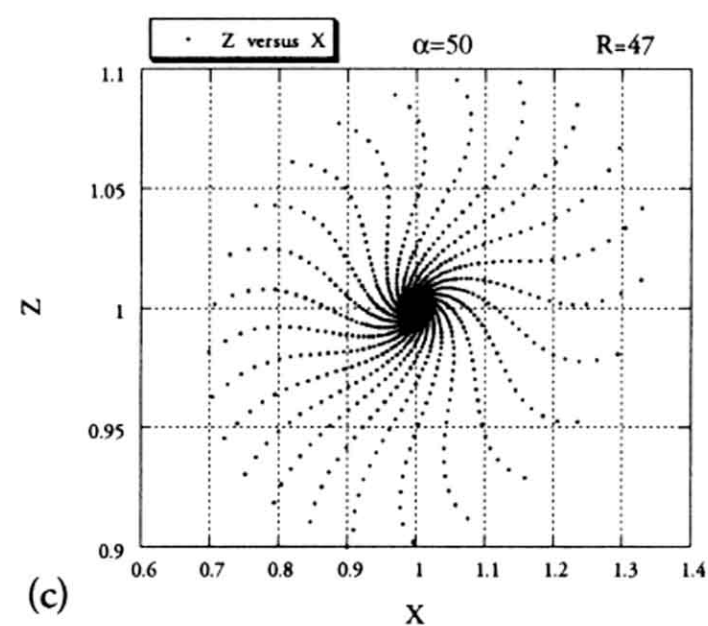
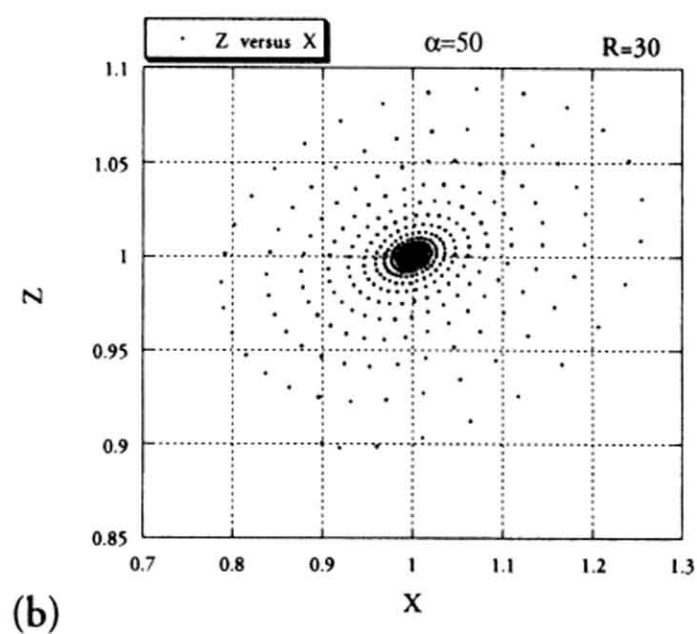
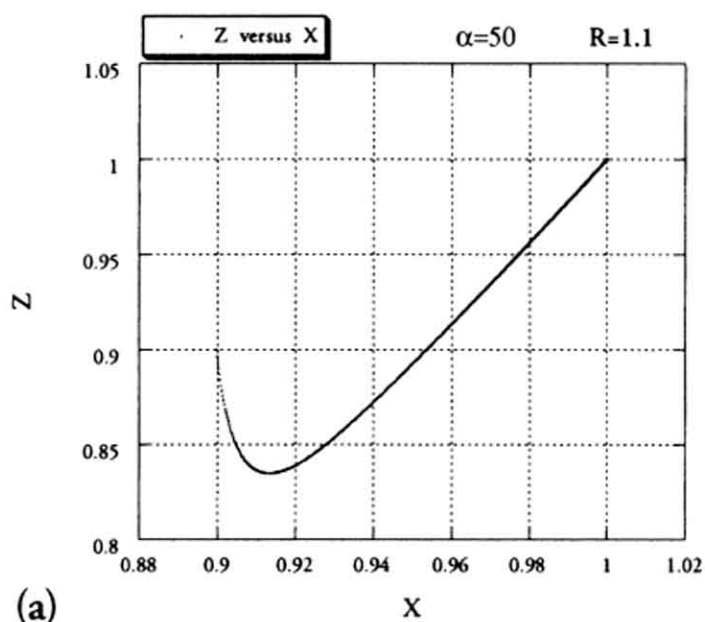
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## I. INTRODUCTION

The fundamental understanding of the transition from laminar to turbulent convection in porous media is far from being conclusive. While major efforts are under way, there is still a significant challenge in front of the scientist and engineer to uncover the complex behavior linked to this transition. In pure fluid (nonporous domain) shear flows the time-dependent and three-dimensional form of turbulence is well established experimentally and numerically. It is caused by the nonlinear terms in the isothermal Navier–Stokes equations. In isothermal flow in porous media no experiments identifying the three-dimensional nature of a transition from the Darcy regime, via an inertia-dominated regime, towards turbulence are available. In particular, this detailed description of turbulence is missing in the problem of porous media convection where an additional nonlinear interaction appears as a result of the coupling between the equations governing the fluid flow and the energy equation. The latter can typically cause a transition to a nonsteady and nonperiodic regime at much lower values of the parameter controlling the flow when compared to the corresponding isothermal system. It is for this reason that the nonsteady and nonperiodic convective regime associated with a reduced set of equations is referred to as weak turbulence (Choudhury 1997).

The wide variety of engineering applications of transport phenomena in porous media provide the solid practical motivation for this investigation. The distinction between modern applications of convection in porous



**Figure 15.** The evolution of trajectories over time for  $\alpha = 50$  ( $Pr_D = 987$ ), and for increasing values of Rayleigh number (in terms of  $R$ ) corresponding to  $R \geq 1.1$  and  $R \leq 57.73$ . The graphs represent the projection of the solution data points (not connected) onto the  $Z$ - $X$  plane. (Courtesy: Kluwer Academic Publishers.)