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## Persistent Stability of a Chaotic System

Greg Huber<sup>1,2</sup>, Marc Pradas<sup>3,1</sup>, Alain Pumir<sup>4,1</sup> and Michael Wilkinson<sup>3,1</sup>

<sup>1</sup>*Kavli Institute for Theoretical Physics, Kohn Hall, University of California, Santa Barbara, California 93106, USA*

<sup>2</sup>*Department of Physics, University of California, Santa Barbara, California 93106, USA*

<sup>3</sup>*School of Mathematics and Statistics, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK*

<sup>4</sup>*Univ Lyon, ENS de Lyon, Univ Claude Bernard, CNRS, Laboratoire de Physique, F-69342, Lyon, France*

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### Abstract

We report that trajectories of a one-dimensional model for inertial particles in a random velocity field can remain stable for a surprisingly long time, despite the fact that the system is chaotic. We provide a detailed quantitative description of this effect by developing the large-deviation theory for fluctuations of the finite-time Lyapunov exponent of this system. Specifically, the determination of the entropy function for the distribution reduces to the analysis of a Schrödinger equation, which is tackled by semi-classical methods. The system has ‘generic’ instability properties, and we consider the broader implications of our observation of long-term stability in chaotic systems.

*Keywords:* Stochastic analysis methods, nonlinear dynamics and chaos, fluctuation phenomena, random processes, noise, Brownian motion, butterfly effect.

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### 1. Introduction

This Letter concerns a phenomenon illustrated by the peculiar nature of the trajectories  $x(t)$  of inertial particles (Fig. 1) in a one-dimensional model, which is described in detail later (Eq. (2)). The plot shows a very large number of trajectories, which start with a uniform initial density. The trajectories clearly show a strong tendency to cluster, and the plot is color-coded (online version) using a logarithmic density scale to illustrate the very intense accumulation of

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