Visibility to discern local from nonlocal dynamic processes

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Visibility to discern local from nonlocal dynamic processes

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Abstract

We compare using visibility the usual Kardar-Parisi-Zhang (KPZ) universality class and a fractional Edward-Wilkinson (EW_f) equation with correlated noise, which share the same kinetic roughening exponents. The KPZ universality class is described by an equation in terms of the usual derivatives, uncorrelated noise and therefore is intrinsically local. The second model includes fractional powers of the Laplace operator and correlated noise, both of which are nonlocal. From their scaling properties, one could be tempted to conclude that both dynamics belong to the same universality class, specifically, to the KPZ universality class. However, this is a wrong conclusion that calls the attention against the indiscriminate application of this approach in real systems without taking into consideration basic physical assumptions (e.g. locality). These examples reveal the necessity of finding new algorithms for detecting characteristics that remain unnoticed to classical scaling analysis, where only the two first moments of the interface distribution (mean and variance) are used to classify the dynamics. We show that visibility and, in particular, the kinetic roughening exponents of the visibility interface, are able to distinguish between these two dynamics which are confused by standard techniques.

Keywords: rough interfases, fractional PDEs, visibility, scaling analysis
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1. Introduction

The evolution of a broad variety of physical systems is characterized by either temporal series or rough interfaces. In both cases, we are handling with a set of data whose analysis, we certainly assume, will provide valuable information about the underlying dynamics (see [1, 2]). Statistical approaches seek for correlations to discern essential properties as time irreversibility or spatial locality. Under some assumptions, scaling analysis and renormalization group techniques are able to classify the dynamics of non-equilibrium growing interfaces into dynamical universality classes according to a set of critical parameters. This analysis has been applied in many papers to determine the dynamics of empirical interfaces (see, e.g. [2, 3, 4, 5]). However, the computation of the critical exponents of experimental growing interfaces does not enable the rigorous assignment of their dynamics and, consequently, to explain the physical processes that are operating microscopically.

Local dynamics, that can be described in terms of classsical derivatives, yield a finite set of critical exponents. However, if the dynamics is given in terms of fractional differential equations (which are

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