

## Ornstein-Uhlenbeck Process Driven by Multiple Dichotomous Noises

Silvio Kalaj<sup>1,2</sup>, Dongho Lee<sup>3</sup>, Enzo Marinari<sup>2,4</sup>, Jae-Hyung Jeon<sup>3,5</sup>, Pascal Viot<sup>1</sup> and Gleb Oshanin<sup>1,5</sup>

<sup>1</sup>*Theoretical Physics of Condensed Matter, Sorbonne University, Paris, France*

<sup>2</sup>*Department of Physics, La Sapienza University of Rome, Italy*

<sup>3</sup>*Department of Physics, Pohang University of Science and Technology, Republic of Korea*

<sup>4</sup>*Nanotech-CNR, Rome, Italy*

<sup>5</sup>*Asia Pacific Center for Theoretical Physics, Pohang, Republic of Korea*

We discuss the stationary properties of a generalized Ornstein--Uhlenbeck process driven by a superposition of  $K$  independent dichotomous noises with arbitrary fixed amplitudes and switching rates. Unlike the classical Ornstein--Uhlenbeck process driven by equilibrium Gaussian white noise, the present system is governed by bounded non-equilibrium fluctuations with finite correlation times. We obtain exact expressions for the stationary position distribution and all cumulants, and show that the stationary state possesses an unexpectedly rich structure, including compact support, algebraic branch-point singularities, edge divergences, and multiple extrema. We establish a mapping onto a heterogeneous random-flight process with bounded jumps, yielding a transparent probabilistic interpretation of the stationary measure. We further analyze several limiting regimes, including the crossover to Gaussian statistics for large numbers of noise sources. For ensembles with exponentially-distributed quenched amplitudes, we derive exact disorder-averaged stationary distributions and show that disorder fundamentally alters the stationary state, producing exponential tails decorated by algebraic prefactors, with exponents non-trivially dependent on the switching rates.