Rare Events and Single Big Jump Effects in Ornstein-Uhlenbeck Processes (and Beyond)

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We study rare events in time-correlated stochastic processes, focusing on the emergence of single big jump effects. The main part of this contribution concerns time-integrated observables in the Ornstein-Uhlenbeck (OU) process. Using an excursion-based mapping to a continuous-time random walk, we analyze the statistics of $A = \int v^n(t)dt$ where $v(t)$ is the velocity following OU dynamics and $n > 0$ positive integer number. We show that the large-deviation properties of A are governed by the statistics of the area accumulated during a single excursion above the origin. The associated rate function exhibits anomalous scaling and reveals a dynamical phase transition between a regime dominated by typical Gaussian fluctuations and a rare-event regime controlled by a single large excursion. In the latter case, the tail of the distribution is fully captured by a single big jump mechanism, providing a clear physical interpretation of the breakdown of standard large-deviation scaling in correlated dynamics. We conclude by briefly outlining recent extensions of the single big jump framework beyond the OU process, where perturbative corrections to the big jump principle allow one to describe moderate deviations in systems with stretched-exponential statistics, bridging typical fluctuations and extreme events.