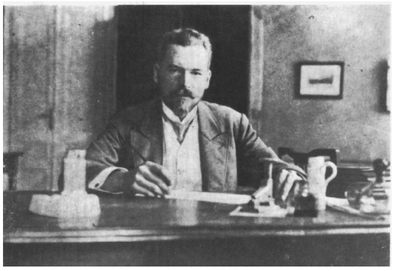

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Generation of rare events in stochastic systems

Monday, 25 September 2023 14:00 (40 minutes)

Rare events, although infrequently occurring, can have significant consequences in various fields such as epidemics, ecological dynamics, biological switches, chemical reactions, and natural disasters. Existing techniques like the Wentzel-Kramers-Brillouin (WKB) method and transition path sampling algorithms provide insights into rare event paths, but they have limitations. The WKB method only provides information about the most likely path, while transition path sampling methods require detailed balance and forward flux algorithms may produce statistically biased trajectories. Here I will consider the use of "stochastic bridges" to analyze the statistics of rare trajectories. Stochastic bridges are paths that pass through specified start and end points, and they have been utilized in various fields such as physics, finance, and information processing. I will show that the statistics of the target stochastic process can be obtained by associating a statistical weight with each stochastic bridge, enabling dedicated computational effort towards rare trajectories without introducing bias or interdependence. The proposed method for bridge generation is flexible and applicable to general target processes, without requiring detailed balance, small-noise approximation, or the introduction of artificial parameters like temperatures. The stochastic bridges produced capture the full statistics of the ensemble of transition paths between long-lived states, allowing for the sampling of fluctuations around the WKB instanton. This enables the assessment of the accuracy of the WKB approximation scheme at different levels of noise. I will show specific examples, such as extinction trajectories of a Susceptible-Infected-Susceptible model in the endemic regime, the distribution of first-passage times in a biased random walk, and noise-driven transitions from undifferentiated to differentiated cell states in a cell differentiation model. These analyses provide further insights into the dynamics and statistics of rare events in different systems.

Primary author: TORAL, Raul (IFISC)

Presenter: TORAL, Raul (IFISC)

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