S N BOSE NATIONAL CENTRE
FOR BASIC SCIENCES
Block JD, Sector III, Salt Lake, Kolkata 700 106

DEPARTMENTAL SEMINAR

Physics of Complex Systems

4th December, 2025 **4.00 PM** **ONLINE / FERMION**

SPEAKER

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TITLE OF THE TALK

Inference of Time Delay in Stochastic Systems

ABSTRACT

Time delay plays a crucial role in many real-world systems and laboratory experiments. It can arise naturally (e.g., due to finite reaction times) or be intentionally introduced (e.g., for chaos control). A key challenge in theoretical modeling and data analysis is determining whether a time delay is present, in what form it appears, and how it influences the system's dynamics. This involves detecting its presence, characterizing and quantifying its effects, and estimating the delay time.

Here, we focus on overdamped stochastic systems and investigate time delay introduced through linear and nonlinear time-delayed feedback forces that depend on a discrete delay time. Such feedback can significantly influence transport properties or give rise to unusual dynamical behaviors, including persistent motion [1] and emergent collective phenomena [2]. By analyzing the power spectral density (PSD), we find that certain features characteristic of analytically tractable linear systems persist in the PSDs of specific nonlinear systems, enabling the inference of time delay. Moreover, even when only a few short temporal trajectories are available, a probing approach combined with deep learning techniques can successfully infer the delay time from stochastic trajectories [3].

References:

[1] R. A. Kopp and S. H. L. Klapp, Persistent motion of a Brownian particle subject to repulsive feedback with time delay, Phys. Rev. E 107 (2023) 024611.

[2] R. A. Kopp and S. H. L. Klapp, Spontaneous velocity alignment of Brownian particles with feedback-induced propulsion, EPL 143 (2023) 17002.

[3] R. A. Kopp, S. H. L. Klapp, and D. Gupta, Inference of time delay in stochastic systems, arXiv:2507.10429 (2025).

HOST FACULTY

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