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Transient anomalous diffusion in ratchet systems

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Anomalous diffusion can be detected in various systems. We show that anomalous diffusion may emerge in a straightforward, one dimensional classical nonequilibrium dynamics of a Brownian particle moving in a ratchet potential and driven by both an unbiased time-periodic force and thermal fluctuations of Gaussian nature. In a tailored parameter regime for which the deterministic counterpart of the system is non-chaotic, the mean square deviation of the Brownian particle coordinate evolves in three following stages: initially as superdiffusion, next as subdiffusion and finally as normal diffusion in the asymptotic long time limit. The lifetimes of superdiffusion and subdiffusion can be controlled by system parameters and can last many many orders longer than characteristic times of the system, thus being comfortably detectable experimentally. The findings are distinct from existing knowledge and suggest reconsideration of generally accepted opinion that anomalies are due to large and rare fluctuations that are characterized by broad distributions with power-law tails.
We explain the underlying mechanism standing behind the emergence of diffusion anomalies and control of their regimes which are related to ergodicity of the system and ultraslow relaxation of the particle velocity towards its non-equilibrium stationary state.

Primary author: LUCZKA, Jerzy (University of Silesia)

Co-authors: SPIECHOWICZ, Jakub (University of Silesia); HANGGI, Peter (University of Augsburg)

Presenter: LUCZKA, Jerzy (University of Silesia)

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