Memory-driven run and tumble deterministic dynamics

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Walking droplets show unique properties thanks to their peculiar feature: the wave path-memory [1]. The original experiment involves an oil millimetric droplet bouncing periodically on a vertically shaken liquid surface [2]. The successive impacts of the droplet create standing waves, keeping track of its previous positions and propelling it along the surface. Thanks to the Faraday instability, the wave time of persistence can be remotely controlled. One has a unique physical system: a particle evolving in synergy with its self-generated wavefield which acts as a memory of tunable duration.

We focus here on the regime of extremely long persistence time from a numerical point of view, which exhibits a macroscopic diffusive behavior as seen in Fig.1. The diffusive dynamics is composed of two successive phases: straight line motion interspersed with chaotic exploration of small areas. This behavior mimics dynamics encountered in biology in the case of foraging animals [3] or for the run and tumble motion of bacteria [4]. We show that the overall dynamics is driven by a Shil'nikov-type chaos in the velocity space. We also discuss the diffusive dynamics of the walker, where the memory duration tunes its superdiffusive behavior. This is the first evidence of controlled and tunable diffusive motion of a single particle ruled by deterministic dynamics and driven by memory effects.

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