Thermal ratchets with rough potentials

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Contrary to what would be intuitive, a mechanism working in the Brownian domain, namely a ratchet, can still produce directed motion even though the periodic forces are null on average. Typically, ratchets can be of three types: pulsating (the potential is switched on and off), tilting (with the addition of fluctuating forces), and temperature ratchets. We work with thermal ratchets in the overdamped regime for a particle of unity mass in a spatially periodic potential with a tilting process, both unbiased on average. The net flux vanishes for any combination of potential and tilting which are both symmetric or both supersymmetric. Otherwise, a net flux arises. While features like spatiotemporal asymmetries and nonequilibrium fluctuations have been extensively studied, the role of roughness in the periodic potential has been less explored. As spatial inhomogeneities or impurities can yield deviations from a smooth ratchet profile, we investigate the impact of the introduction of roughness in the potential by adding perturbations of short wavelength superimposed on the periodic potential. Varying the amplitude and wavelength of these perturbations, we monitor the net directed current, as well as the efficiency, for a wide range of intensities of the time-varying forces. We show that perturbations do not always spoil but, depending on the ratchet parameters can enhance the performance, an effect that is not present in the deterministic limit and indicates the interplay between noise and roughness.

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