

The ring of Brownian motion: The good, the bad and some simply silly

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Since the turn of the 20-th century Brownian noise has continuously disclosed a rich variety of phenomena in and around physics. The understanding of this jittering motion of suspended microscopic particles has undoubtedly helped to reinforce and substantiate those pillars on which the basic modern physical theories are resting: Its formal description provided the key to great achievements in statistical mechanics, the foundations of quantum mechanics and also astrophysical phenomena, to name but a few. – Brownian motion determines the rate limiting step in most transport phenomena via escape events that help to overcome obstructing bottlenecks [1], does trigger firing events of neurons and in ion channels or, more generally, induces oscillatory dynamics in excitable media [2]. More recent progress of Brownian motion theory involves (i) the description of relativistic Brownian motion and its impact for relativistic thermodynamics [3], or (ii) its role for fluctuation theorems and symmetry relations that constitute the pivot of those recent developments for nonequilibrium thermodynamics beyond the linear response regime, i.e. those various nonlinear fluctuation relations [4]. Although noise is usually thought of as the enemy of order it in fact also can be of constructive influence. The phenomena of Stochastic Resonance [5] and Brownian motors [6] present two such archetypes wherein random Brownian dynamics together with unbiased nonequilibrium forces beneficially cooperate in enhancing detection and/or in facilitating directed transmission of information. The applications range from innovative information processing devices in physics, chemistry, and in physical biology to new hardware for medical rehabilitation. Particularly, those additional nonequilibrium disturbances enable the rectification of haphazard Brownian noise so that quantum and classical objects can be directed around on a priori designed routes (Brownian motors). Despite its thrilling manifold successes Brownian motion is, nevertheless, not the "Theory of Everything", as is revealed by some more doubtful applications. We conclude with an outlook of future prospects and unsolved issues.

References

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