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Brownian particle in a Poisson-shot-noise active bath: exact statistics, effective temperature, and inference

We study the dynamics of an overdamped Brownian particle in a thermal bath that contains a dilute solution of active particles. The particle moves in a harmonic potential and experiences Poisson shot-noise kicks with specified amplitude distribution due to moving active particles in the bath. From the Fokker-Planck equation for the particle dynamics we derive the stationary solution for the displacement distribution along with the moments characterising mean, variance, skewness, and kurtosis, as well as finitetime first and second moments. We also compute an effective temperature through the fluctuation-dissipation theorem and show that equipartition theorem holds for all zero-mean kick distributions, including those leading to non-Gaussian stationary statistics. For the case of Gaussian-distributed active kicks we find a re-entrant behaviour from non-Gaussian to Gaussian stationary states and a heavy-tailed leptokurtic distribution across a wide range of parameters as seen in recent experimental studies. Further analysis reveals statistical signatures of the irreversible dynamics of the particle displacement in terms of the time asymmetry of cross-correlation functions. Fruits of our work is the development of a compact inference scheme that may allow experimentalists to extract the rate and moments of underlying shot-noise solely from the statistics the particle position.

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