Galilean invariance for stochastic diffusive dynamics

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Galilean invariance is a cornerstone of classical mechanics. It states that the equations of motion are the same in different inertial frames, meaning they do not change under a Galilean transformation. Inertial frames, in turn, are reference frames describing closed systems where the frame-internal physics is not affected by frame-external forces. The description of real world systems, however, usually requires coarse-grained models integrating complex internal and external interactions indistinguishably as friction and stochastic forces, which intrinsically violates Galilean invariance. Starting from the Kac-Zwanzig Hamiltonian for a tracer particle in a heat bath of harmonic oscillators generating Brownian motion, we show how Galilean invariance is broken during the coarse graining procedure when deriving stochastic Langevin dynamics. We argue that traces of Galilean invariance survive for stochastic dynamics yielding a set of alternative rules, which we call weak Galilean invariance.

[1] A.Cairoli, R.Klages, A.Baule, *Weak Galilean invariance as a selection principle for stochastic coarse-grained diffusive models*, submitted