Summary: The Langevin equation describing Brownian motion is considered as a contraction from the more fundamental, but still phenomenological, description of an incompressible fluid governed by fluctuating hydrodynamics in which a Brownian particle with stick boundary condition is immersed. First, the derivation of fluctuating hydrodynamics is reconsidered to clarify certain ambiguities as to the treatment of boundaries. Subsequently the contraction is carried out. Since Brownian particles of arbitrary shape are considered, rotations and translations are in general coupled. The symmetry of the $6 \times 6$ friction tensor $\gamma_{ij}(t)$ is proved for arbitrary shape without appeal to microscopic arguments. This symmetry is then used to prove that the fluctuation-dissipation theorem on the contracted level (nonwhite noise in general) follows from the corresponding statement on the level of fluctuating hydrodynamics (white noise). The condition under which the contracted description reduces to the classical Langevin equation is given, and the connection between our theory and related work is discussed.

MSC:

82C70 Transport processes in time-dependent statistical mechanics
82C40 Kinetic theory of gases in time-dependent statistical mechanics

Keywords:

Brownian motion; fluctuating hydrodynamics; Langevin equation; fluctuation-dissipation theorem; autocorrelation functions

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References:


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