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levitodynamics with multi-stochastic forces and the simple applications on the dark matter detection in optical levitation experiment

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If the terrestrial environment is permeated by dark matter, the levitation experiences damping forces and fluctuations attributed to dark matter. This paper investigates levitodynamics with multiple stochastic forces, including thermal drag, photon recoil, feedback, etc., assuming that all of these forces adhere to the fluctuation-dissipation theorem. The ratio of total damping to the stochastic damping coefficient distinguishes the levitodynamics from cases involving only one single stochastic force. The heating and cooling processes are formulated to determine the limits of temperature change. All sources of stochastic forces are comprehensively examined, revealing that dark matter collisions cannot be treated analogously to fluid dynamics. Additionally, a meticulous analysis is presented, elucidating the intricate relationship between the fundamental transfer cross-section and the macroscopic transfer cross-section. While the dark damping coefficient is suppressed by the mass of the levitated particle, scattering can be coherently enhanced based on the scale of the component microscopic particle, the atomic form factor, and the static structure factor. Hence, dark damping holds the potential to provide valuable insights into the detection of the macroscopic strength of fundamental particles. We propose experimental procedures for levitation and employ linear estimation to extract the dark damping coefficient. Utilizing current levitation results, we demonstrate that the fundamental transfer cross section of dark matter can be of the order σ_T^{D}
$lsimcalO(10^{-26})\mathrm{cm}^2$

Collaboration (if any)

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