Antipersistent Random Walk in a Two State Flashing Magnetic Potential

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I. ABSTRACT

Self-diffusion of colloidal particles arises due to continuous transfer of momentum by the solvent molecules, and it is characterized by a mean square displacement (MSD) proportional to time.[1] In complex environments, like in crowded suspensions of hard spheres, granular materials, viscoelastic media, and in many biological systems, diffusion is often anticipated by subdiffusion, where the exponent of the power law in the MSD is less than one. Subdiffusion is usually attributed to trapping or obstruction, and understanding its origin is crucial in both fundamental and applied research.

When dealing with individual colloids in simple fluids, the absence of interacting neighbors excludes subdiffusion a priori, which, however, can be observed by placing traps or obstacles along the particle path via chemical modification or physical actuation. In the first case, for instance, one can functionalize the particle surface and a nearby substrate with complementary strands of DNA making them ‘‘sticky’’ at a temperature close to the melting of the DNA.[2] On the other hand, there are many ways to manipulate colloidal particles via external fields that may be employed to confine or release the particles via remote control. In particular, magnetically patterned substrates have shown such capabilities with magnetic colloids,[3] opening up the possibilities to induce anomalous kinetics in systems showing otherwise conventional diffusion.

In this talk I will report on the (sub-)diffusive behavior of paramagnetic colloids moving through a flashing potential obtained via external modulation of the stray field of a magnetic bubble lattice. Depending on the applied field parameters, we observe different regimes of motion ranging from trapping to enhanced (non-thermal) diffusion. In particular, we observe robust subdiffusive motion, with MSD growing as $\sqrt{t}$ and lasting in some cases, up to three orders of magnitude in time. In the subdiffusive regime, the particles perform an antipersistent random walk with an astonishing similarity to the random walk on a random walk (RWRW) model introduced in,[4] as a nontrivial example of correlated RW. Our results also demonstrate that flashing potentials, which often have been employed to ratchet molecules and colloids in the presence of non-negligible thermal fluctuations, can be used to induce and conveniently control the diffusive properties of the particles.[5]

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