TEMPERATURE-ABNORMAL DIFFUSIVITY IN SPACE-PERIODIC SYSTEMS DRIVEN BY EXTERNAL FORCES

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The phenomena of diffusion and transport over a potential energy landscape play a key role in a number of processes in physics, chemistry and biology. Josephson tunneling junctions, superionic conductors, phaselocked-loop frequency control systems, charge density waves are a few examples of systems in which these processes in periodic potential are important [1].

In this talk a set of original theoretical results on diffusion enhancement of underdamped Brownian particles in 1D symmetric space-periodic potential due to external forcing is presented [2-6]. In [2-3] we demonstrated that depending on the value of the constant external force in underdamped space-periodic systems different functional dependences of the diffusivity on the temperature were realized. It was shown that in certain interval of applied external force values diffusivity grows with temperature decreasing. We called this phenomenon "temperature-abnormal diffusivity" (TAD). This phenomenon is explained by exponential increase in correlation time at temperature tending to zero. We showed that the transport of particles in space-periodic potentials in the underdamped case can be treated as overdamped motion of Brownian particles in velocity space with a double-well potential.

A study of diffusion enhancement of underdamped Brownian particles in 1D symmetric space-periodic potential due to external symmetric time-periodic forcing with zero mean was presented in [4-6]. We showed that the diffusivity can be enhanced by many orders of magnitude at appropriate choice of the forcing amplitude and frequency. The diffusivity demonstrates TAD, abnormal (decreasing) temperature dependence at forcing amplitudes exceeding certain value. At any fixed forcing frequency Ω normal temperature dependence of the diffusivity is restored at low enough temperatures $T < T_{TAD}(\Omega)$ — in contrast with the problem with constant external forcing.

The effects investigated allow for simple experimental verification. Diffusion of particles on solid body surface is one natural arena for this. Such systems are characterized by low dissipation. Another field to study TAD in is in propagation of magnetic particles on non-magnetic substrate, acted upon with electromagnetic fields. Abnormal diffusion enhancement could be manifested in, e.g., enhanced growth of islands of the new phase at decreasing temperatures.

TAD effect can find applications in a number of new technologies: in sorting of particles, manufacturing surface structures with required properties, controlling penetration of particles through biological and artificial membranes, in memristors, devices with charge density waves, etc.

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