Independence of superdiffusion in random low-density Lorentz gas on geometrical properties of moving scatterers

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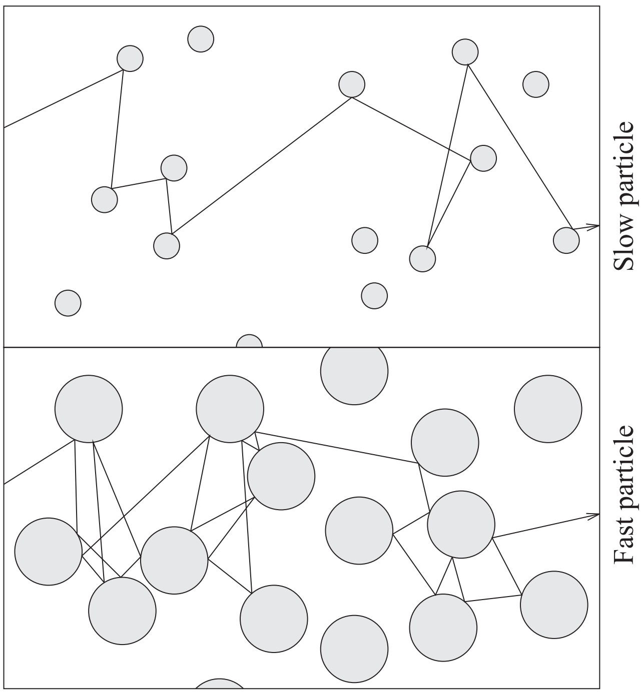

FIG. 1. Random Lorentz gas with different size of scatterers.

A random Lorentz gas with time-dependent boundaries is a two-dimentional system containing a set of heavy discs (scatterers) distributed randomly. Particles move freely among these discs. The boundaries of the scatterers oscillate. The unlimited linear growth of particle velocity in these systems is called the Fermi acceleration phenomenon**?** . Even for periodical and correlated motion of boundaries the influence of this motion on particle can be considered as noise, because the moments of particle collisions with the scatterers are random. Langeving equation can be used to calculate particle dynamics**?** .

Fermi acceleration leads to anomalous transport**?** . Dependence of mean square displacement on time is linear $\sqrt{x^2} = kt$. The constant of proportionality k increases with the increase of amplitude of boundary velocity and can be called the coefficient of superdiffusion. This parameter has a dimension of velocity.

The great number of investigations in billiards-like systems proved strong dependence of their transport properties on geometry of Lorentz gas. At the same time thermodynamics interpretation and analogy with ideal gas suppose independence on the size and concentration of the scatterers. These parameters define the mean free path. The only parameters of the model are amplitude of boundary velocity and the mean free path. There are no parameters with time dimension. Therefore, we cannot construct coefficient of superdiffusion using parameters of length.

The unsolved problem was: does the coefficient of superdiffusion k depend on geometrical properties of random low-density Lorentz gas. To solve the problem we have calculated the coefficient of superdiffusion analytically, taking into account Fermi acceleration. We have also performed computer simulation of particle motion. The theoretical and numerical results are in good agreement. The coefficient of superdiffusion k is defined only by amplitude of boundary velocity and dimensionless coefficient describing the kind of scatterers motion, which can be random or periodical. The explanation of this independence on the mean free path comes from the fact that the usual diffusion coefficient linearly increase with this path. At the same time Fermi acceleration, on the contrary, decreases. Fig. **??** illustrate this fact. On the top picture the mean free path is relatively large, but Fermi acceleration is relatively small due to the low rate of the collisions. On the bottom picture, on the contrary, the mean free path is relatively small and Fermi acceleration is relatively large. Therefore, the two factors that influence the diffusion of particle compensate each other, and the coefficient of supperdiffusion does not depend on geometrical properties of random low-density Lorentz gas.

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[1] A. Kargovsky, E. Anashkina, A. Krasnova, O. Chichigina, Phys. Rev. E **87**, 042133 (2013).

[2] A. Loskutov, O. Chichigina, A. Krasnova, I. Sokolov, EPL **98**, 10006 (2012).