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Subensembles of magnetized particles in random electric fields

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Transport processes of a passive scalar in random velocity fields are observed in plasma systems, atmosphere, oceanic currents, etc. The task of the theoretical description is to reproduce the temporal evolution of an ensemble of particles moving in such a field based on the known statistical characteristics of the velocity or force fields. The most known example is Brownian motion, the feature of which is the presence of two time scales. That is, the time of collisions, or the time of correlations of random fields, is much shorter than the time of system, or the particle distribution function, evolution. Then, as is known, the mean squared displacement of the particles, or the second moment of the distribution function, is proportional to the system evolution time. The distribution of particles, which at the initial moment of time were concentrated at the origin of the coordinates, preserves the Gaussian shape, which evolves according to the mean squared displacement, and the particle diffusion coefficient in such fields is a constant value.

More complicated and more interesting is the transport of particles in random fields, the correlation time of which is not small compared to the time of evolution of the system. An example of such a system is charged particles drifting in a random electric field across a constant magnetic field. The equations of motion become statistically nonlinear, and the evolution of dispersion from a short initial ballistic regime, namely quadratic dependence on time, changes asymptotically to a fractional power law. Accordingly, the distribution of particles is not Gaussian, and the diffusion coefficient changes over time.

The feature of such a system is that the two-dimensional drift of particles occurs along equipotential lines or streamlines. The presence of such an integral of motion allows for dividing the complete ensemble of particles into separate groups named subensembles, which are concentrated near streamlines with a certain value of potential. Observation of subensembles allows a better understanding of how the transport occurs as a whole. In this work, the behavior of the moments of the particle distribution function was studied using simulation for subensembles with the same initial value of the random potential, in particular, the mean squared displacement and excess kurtosis were calculated. It is shown that in each subensemble there are particles that travel far from the initial position and that remain close to it. The distribution of the displacement of particles depending on the initial value of the potential was found, and the average displacements and velocities for the sub-ensembles were calculated. It was found that the mean square displacement of the entire ensemble of particles is formed from the partial contributions. The obtained statistical characteristics of particle motion are useful for the verification of analytical models.

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