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Bias induced drift and trapping on random combs and the Bethe lattice: fluctuation regime and first order phase transitions. (English) Zbl 07515917
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Summary: We study the competition between field-induced transport and trapping in a disordered medium by studying biased random walks on random combs and the bond-diluted Bethe lattice above the percolation threshold. While it is known that the drift velocity vanishes above a critical threshold, here our focus is on fluctuations, characterized by the variance of the transit times. On the random comb, the variance is calculated exactly for a given realization of disorder using a ‘forward transport’ limit which prohibits backward movement along the backbone but allows an arbitrary number of excursions into random-length branches. The disorder-averaged variance diverges at an earlier threshold of the bias, implying a regime of anomalous fluctuations, although the velocity is nonzero. Our results are verified numerically using a Monte Carlo procedure that is adapted to account for ultra-slow returns from long branches. On the Bethe lattice, we derive an upper bound for the critical threshold bias for anomalous fluctuations of the mean transit time averaged over disorder realizations. Finally, as for the passage to the vanishing velocity regime, it is shown that the transition to the anomalous fluctuation regime can change from continuous to first order depending on the distribution of branch lengths.

MSC:
82-XX Statistical mechanics, structure of matter
82D30 Statistical mechanics of random media, disordered materials (including liquid crystals and spin glasses)
82C44 Dynamics of disordered systems (random Ising systems, etc.) in time-dependent statistical mechanics
82C41 Dynamics of random walks, random surfaces, lattice animals, etc. in time-dependent statistical mechanics
60K50 Anomalous diffusion models (subdiffusion, superdiffusion, continuous-time random walks, etc.)
65C05 Monte Carlo methods

Keywords:
disordered media; random combs; anomalous transport; first return time; Monte Carlo methods

Full Text: DOI

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