MACROSCOPIC MODELING OF ANOMALOUS TRANSPORT ON HETEROGENEOUS LATTICE NETWORKS

Peter Kang, MIT, 617-999-6905, pkkang@mit.edu

1. Peter K. Kang, Massachusetts Institute of Technology
2. Marco Dentz, Spanish National Research Council
3. Tanguy Le Borgne, Universite ́ de Rennes 1
4. Ruben Juanes, Massachusetts Institute of Technology

We study stochastic transport through a lattice fracture network with quenched disorder, and evaluate the limits of predictability of the transport behavior across realizations of spatial heterogeneity. We consider a two-dimensional regular fracture network model characterized by a constant fracture length and fracture orientation. We assign independent and identically distributed random transmissivities to the fractures and we solve the flow equation on the fracture network assuming a Darcy equation along the fractures and enforcing mass conservation at fracture intersections. Flow through lattice networks with heterogeneous transmissivity exhibits strong correlation in the velocity field, even if the link transmissivities are uncorrelated. This feature, which is a consequence of the divergence-free constraint in the velocity field, induces anomalous transport of passive particles carried by the flow. We propose a Lagrangian statistical model that takes the form of a continuous time random walk (CTRW) with correlated velocities derived from a genuinely multidimensional Markov process in space. The model captures the anomalous (non-Fickian) longitudinal and transverse spreading, and the tail of the mean first passage time observed in the Monte Carlo simulations of particle transport. We show that reproducing these fundamental aspects of transport in disordered systems requires honoring the correlation in the Lagrangian velocity.