Microscopic chaos, fractals and diffusion: From simple models towards experiments

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Abstract

A century ago Einstein developed a theory of diffusion that is based on the assumption of *stochasticity* for a Brownian particle. On a molecular level, however, diffusion is generated by Newton's *deterministic* equations of motion, which typically are highly nonlinear. In my talk I will review, in a very tutorial manner, a theoretical approach that derives diffusion from first principles by starting from *microscopic deterministic chaos.* Simple models ranging from a deterministic random walk on the line to chaotic diffusion in potentials on periodic lattices will be studied analytically and by computer simulations. Surprisingly, the diffusion coefficients of these models turn out to be highly irregular, fractal functions of physical control parameters while simple random walk theory predicts monotonicity. This is due to memory in the deterministic single-particle dynamics. I will argue that this phenomenon should be seen in experiments on small systems, such as molecular diffusion in zeolite nanopores and diffusion of electrons in artificial graphene.

[1] R.Klages, *Microscopic Chaos, Fractals and Transport in Nonequilibrium Statistical Mechanics* (World Scientific, Singapore, 2007)

[2] R.Klages, W.Just, C.Jarzynski (Eds.), *Nonequilibrium statistical physics of small systems: Fluctuation relations and beyond* (Wiley-VCH, Weinheim, 2013)