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What Einstein did not Know: Anomalous Diffusion, from Pilot Balloons to Hydrology

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Robert Brown reported the jiggling motion of micron-sized pollen granules observed in his microscope in 1828. Since this first observation of diffusion, experimental techniques have been advanced massively. Today, for instance, individual molecules diffusing in living biological cells can be followed at the resolution of few nanometres at millisecond intervals. Such measured trajectories reveal a lot about the physical properties of their environment.

To extract this information, dedicated models need to be established and analysed. This is at the core of modern non-equilibrium statistical physics. In my talk I am going to address several aspects of what we call anomalous diffusion, when the measured dynamics deviates from that of normal Brownian motion. The earliest example is so-called Richardson diffusion in turbulent media, as measured by pilot balloos experiments in 1926. Other examples include motion characterised by energetic trapping and processes with long-range correlations.

The physical phenomena addressed in the talk include (weak) non-ergodicity, non-exponential relaxation, long-time retention effects in hydrology, non-Gaussian behaviour, and boundary effects.

Presenter: METZLER, Prof. Dr. Ralf

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