"NMR investigations of correlations between longitudinal and transverse displacements in flow through random structured media"

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Numerical simulations and experimental results employing two-dimensional pulsed field gradient nuclear magnetic resonance (PFG-NMR) for fluid undergoing either self-diffusion or flow under a constant external pressure gradient are discussed and particle displacement statistics in orthogonal directions are compared for different sample geometries. While the spreading of the probability density of displacements (propagator) both along the flow axis (Z) and perpendicular to it (X) is described in recent literature, and average quantities such as the diagonal elements of the dispersion tensor are being investigated routinely, no results are available which quantitatively link the interdependence of displacements in orthogonal directions. The same is true for self-diffusion which also produces correlations between displacements in the presence of obstacles. PFG-NMR provides a tool which allows simultaneous encoding of particle motion in arbitrary directions in order to perform an analysis of the correlation between these quantities. The dependence of the second moment of transverse displacements on the longitudinal displacement, integrated over varying time scales being accessible by the NMR experiment, are chosen as one possible way to describe this connection. Results obtained for random or partially ordered porous systems are compared to model situations in which the correlation can be described analytically. The findings include power-law behaviour of the form $< X(Z)^2 > \sim Z^\gamma$ with spreading exponents γ being indicative for the properties of the pore space in