Study of diffusion dynamics from multi-point correlation functions

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Diffusion is governed by Laplace equation. The boundary conditions reflect the structure of pore space. Thus diffusion dynamics is an important tool to study the microstructure of a wide range of porous materials, including geological formations and biological tissues. When the pore size and diffusion distance are close, the diffusion behavior can non-Gaussian. This non-Gaussian behavior is often characterized by the fourth order cumulant, Kurtosis. However, the apparent non-Gaussian behavior may also arise from pore size heterogeneities. These two scenarios can't be identified by only the two-point correlation function, such as PDF of displacement.

We have shown that the use of multi-point correlation functions allows the identification of different diffusion dynamics and developed the corresponding NMR experiments. For example, bulk diffusion and restricted diffusion can be identified by a correlation of displacement of different diffusion times. Kurtosis exhibits a unique 4-cycle sinusoidal modulation of the 4-point correlation function and easily distinguished from pore size distribution. We will discuss both theoretical understanding of the diffusion dynamics in term of these correlation functions and feasibility of experimental implementation.

MRI experiments tend to be time-consuming and the quality of the result dependent on many experimental parameters. We will discuss our recent work to accelerate/optimize the MRI experiments based on the concepts of machine learning and Bayesian analysis.