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NMR diffusion in porous media approached by a fractional Langevin model: applications to petrophysics

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This work is concerned with some of the complex range of phenomena resulting from the combined effects of Nuclear Magnetic Resonance (NMR) diffusion and restricted geometries in porous media. Although diverse, they are all connected by the common importance of the microstructure in determining the physical, chemical, and biological properties of the medium. The motion of spin-bearing molecules in a porous media is restricted even for short diffusion times. In the 1990s, a series of papers (1) was devoted to accounting for the contribution of nuclei whose motion were restricted by boundaries of the confining medium. One of the main results established (at the short-time limit) is a relation between the NMR signal with the surface-area-to-pore-volume ratio, an intrinsic characteristic of a porous medium which plays an important role in the oil industry. (2) Even though the basic theory of diffusion dynamics can be formulated and evaluated, proper interpretation of experimental results from real materials remains challenging and requires the development of theoretical models that connect the NMR signal to relevant features of porous media microstructure. Pereira-Alves, Soares-Pinto and Paiva (3) describe the NMR signal for anomalous diffusion governed by the generalized Langevin equation for all times, where a memory kernel that decays as a power law was chosen based on systems that unveil subdiffusion, notably in porous media, and a non-trivial dependence of the signal on the fractional exponent emerges. The knowledge of the NMR signal for both short and long-time limits, as well as intermediate times, offers interesting possibilities with regard to the extraction of parameters in the area of porous media. Therefore, the results presented in this work aims for arriving at a better understanding of how the properties of the rock surrounding the oil well are reflected in the NMR measurements that one can perform in practice, to better guide its application and be aware of its limitation.

Palavras-chave: Nuclear magnetic resonance. Diffusion. Porous media.

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