Nuclear magnetic relaxation induced by superparamagnetic nanoparticles: simulations

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Superaparamagnetic nanoparticles are used as negative contrast agents in Magnetic Resonance Imaging (MRI). Their great magnetization produces magnetic inhomogeneities which shorten the relaxation times. Their efficiency can be quantified by their relaxivities, i.e. their relaxation rates normalized by the iron concentration.

Nuclear magnetic relaxation relies on the interaction between the proton spins and their fluctuating magnetic environment. In the case of superparamagnetic nanoparticles, proton relaxation is induced by the dipolar magnetic field produced by these particles [1]. The Redfield formalism is usually used to predict the relaxation times and involves non intuitive and long stochastic quantum calculus.

Another approach for the understanding of the relaxation is to work with the equivalent classical equations of the magnetic moment. Similar mathematical expressions for the relaxation times can be analytically derived. This paradigm also leads to a simple simulation algorithm which has the advantage not to depend on approximations.

Simulation results of proton relaxation induced by superparamagnetic particles will be presented. Nuclear magnetic relaxation dispersion curves of aqueous samples containing superparamagnetic nanoparticles in and out of the Redfield condition were simulated [2-3]. More complex systems as NPs entrapped in cells are also studied.

References:

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