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Dynamical theory of spin noise and relaxation - prospects for real time NMR measurements TIMOTHY FIELD, McMaster University — The dynamics of a spin system is usually calculated using the density matrix. However, the usual formulation in terms of the density matrix predicts that the signal will decay to zero, and does not address the stochastic dynamics of individual spins. Spin fluctuations are to be viewed as an intrinsic quantum mechanical property of such systems immersed in random magnetic environments, and are observed as "spin noise" in the absence of any radio frequency (RF) excitation. Using stochastic calculus we develop a dynamical theory of spin noise and relaxation whose origins lie in the component spin fluctuations. This entails consideration of random pure states for individual protons, and how these pure states are correctly combined when the density matrix is formulated. Both the lattice and the spins are treated quantum mechanically. Such treatment incorporates both the processes of spin-spin and (finite temperature) spin-lattice relaxation. Our results reveal the intimate connections between spin noise and conventional spin relaxation, in terms of a modified spin density (MSD), distinct from the density matrix, which is necessary to describe non-ensemble averaged properties of spin systems. With the prospect of ultra-fast digitization, the role of spin noise in real time parameter extraction for (NMR) spin systems, and the advantage over standard techniques, is of essential importance, especially for systems containing a small number of spins. In this presentation we outline prospects for harnessing the recent dynamical theory in terms of spin noise measurement, with attention to real time properties.

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