

ULTRAFAST MULTIDIMENSIONAL LAPLACE NMR FOR A RAPID AND SENSITIVE CHEMICAL ANALYSIS

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Laplace NMR (LNMR) consists of relaxation and diffusion measurements which provide detailed information about molecular rotation and diffusion, explore interactions of nuclei with their microscopic environments, and can ultimately provide complementary chemical resolution. [1]

As with traditional NMR, the resolution and information content of Laplace NMR can be significantly improved by using a multidimensional approach [1]. However, the duration of such experiments becomes very long, typically taking from minutes to hours, restricting the applicability of the method. In ultrafast, multidimensional Laplace NMR [2, 3] the encoding in the second dimension is done in a spatially depended manner, also known from conventional ultrafast NMR spectroscopy [4], and thereby experimental time is reduced by several orders of magnitude. Such a dramatic speedup of measurement technique enables the investigation of transient phenomena previously out of reach of traditional multidimensional NMR. Such systems could include, for example, gel formation, phase changes of ionic liquids and liquid crystals. Furthermore, it is possible to collect the entire data space after a single excitation pulse, and apply the method even to hyperpolarized spin systems otherwise out of reach of multidimensional NMR. Hyperpolarization techniques improve the sensitivity of NMR up to 10^5 orders of magnitude, and thus enable NMR experiments even from very dilute concentrations

In this presentation we explain the principles of ultrafast multidimensional LNMR and present several different measurement schemes together with experimental demonstrations and simulations. We show that multidimensional Laplace NMR experiments are capable of bringing chemical resolution to systems, which may lack it in traditional NMR spectra: For example, it is possible to resolve signals arising from different physical environments of a fluid inside a porous medium. In addition, it is possible to resolve hydrocarbons of different size, which have completely overlapping NMR spectrum. We also demonstrate that the method is applicable to hyperpolarized substances, and that we can carry out ultrafast relaxation correlation experiments even with portable, single-sided low field instruments [5].

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