Introducing nuclear spin-noise spectroscopy

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INTRODUCING NUCLEAR SPIN-NOISE SPECTROSCOPY

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NMR spectra are usually obtained by exciting, through a rf field, the nuclear magnetization and then by monitoring the induction, it creates. An alternative approach, named spin noise, exists: it consists in searching for correlations in the noise signal at the probe detection output, a concept up to now used for only a single spin species [1]. Here, we report its extension for looking to small signals in the presence of a major one and show that this technique allows sensitivity enhancement for their detection, in particular when the temperature of detection coil is lower than that of the sample. Signals resulting from small species appear as bumps, superimposed on the dip which results from the main component contribution.

For the description and the processing of the experimental spectra, a new analytical equation is introduced. Its derivation is based on fluctuating rf fields due to the preamplifier and coil resistances and magnetization fluctuations and coherent rf field due to the feedback field (radiation damping). Its generality allows analytical explanation of the difference of tuning conditions [2,3] and the treatment of static magnetic field inhomogeneity, which has an enhanced spectral signature in spin-noise spectra and provides a chemical shift reference.

We have combined all these aspects and proved the enhanced detection capability of the nuclear spin-noise approach for characterizing secondary isotopic effect [4], proving the opening of a new "spin-noise" spectroscopy. Perspectives of this work in terms of classical NMR in the presence of radiation damping but also in terms of unconventional detection scheme will be discussed.

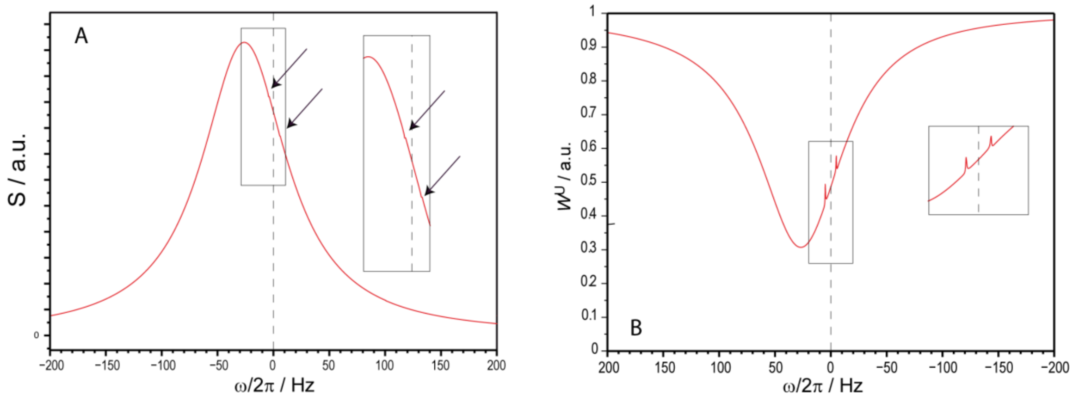

Fig. 1. Numerical simulation of a pulsed (A) and spin-noise spectra (B) for a spin system including three species: a main one and two minority components shifted by ± 5 Hz with a relative intensity of 0.5%. (A) The main line is broadened and shifted by feedback field and secondary contributions are essentially undetectable. (B) the nuclear spin-noise spectrum unambiguously shows fine and well resolved peaks related to minority components.

References

[1] M.A. McCoy, R.R. Ernst, *Chem. Phys. Lett., 1989,* **159**, 587.
[2] M.T. Pöschko, J. Schlagnitweit, G. Huber, M. Nausner, M. Hornicàkovà, H. Desvaux, N. Müller, *ChemPhysChem, 2014,* **15**, 3639.
[3] G. Ferrand, G. Huber, M. Luong, H. Desvaux, *J. Chem. Phys. 2015,* **143**, 094201.
[4] M.T. Pöschko, V.V. Rodin, J. Schlagnitweit, N. Müller, H. Desvaux, *Nat. Commun., 2017,* **8**, 13914.