Multiple Spin Echoes and Instabilities in Hyperpolarized ^{3}He-^{4}He Solutions

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Hyperpolarized He mixtures, obtained by dissolution of laser polarized ^{3}He gas into liquid ^{4}He, offer a rich playground to investigate non-linear spin dynamics induced by long-range magnetic interactions. Such residual interactions, not averaged out by Brownian motion, are met in other systems (B-E condensates, sf ^{3}He, 2-D ^{1}H gas, and quantum entangled spin systems) but play a leading role in highly magnetized liquids where the so-called distant dipolar field, DDF, leads to spectacular effects: spectral clustering, precession instabilities, spin turbulence, etc. Our investigations combine low-field NMR (2.5 mT) on bulk polarized solutions (1 cm^3, $1-5\%$ ^{3}He, $0-30\%$ polarizations) at $1-4$ K and numerical 3D simulations on spin lattices. Instabilities triggered by single 90° pulses are now studied at DDFs up to a few mG with negligible radiation damping.[1] Transverse magnetization is stabilized by frequent rf-driven 'time reversal' to measure its residual damping rate and ultimately characterize the DDF-induced spatially inhomogeneous patterns. Following a $90° - 90°$ excitation DDF-induced multiple spin echoes (MSE) exhibit major differences with those observed in solid ^{3}He (mostly due to nearest neighbors).[2] Attenuation rates are compared to numerical predictions and to MSE data obtained in hyperpolarized ^{129}Xe at 300 K.

[1]Thanks to an active feedback scheme described in our companion report to LT26.
[2]G. Deville et al, Phys. Rev. B. **19**, 5666 (1979)