Towards a controlled MASER by electronic radiation damping control in Dynamic Nuclear Polarization (DNP) experiments at cryogenic temperatures

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Résumé

Radiation damping is a phenomenon that is well-known to NMR spectroscopists and is a direct consequence of the coupling between the observed magnetization and the detection circuit. It gives rise to a radio-frequency (rf) field induced in the NMR coils of the detection circuit through the precession of the observed magnetization [1,2]. T his magnetization-dependent rf field brings magnetization back to its equilibrium direction. In certain circumstances, an initial inversion of the magnetization may give rise to multiple M / RASER pulses or multiple echoes [3]. It was recently shown in Dynamic nuclear polarization experiments performed at the temperature of liquid helium (1.2 K), where nuclear spins are hyperpolarized through microwave irradiation of the electron spins of paramagnetic impurities when the nuclear spins were polarized "negatively" (magnetization pointing towards the –z-axis) , multiple maser bursts could be observed at short times (100ms), followed by an induction signal persistent for tens of second [4] (a typical FID of frozen water would be no longer than a few hundreds of microseconds). This behavior was ascribed to a complex phenomenon resulting from the combined effect of RD and the repolarization of the 1H nuclear spins by the 2H spins present in the sample, through their couplings with the electron spins. This thermal mixing process can be qualitatively described by the Provotorov equations, coupled to the Bloch-Maxwell equations for radiation damping. [3]

In order to study this phenomenon, we have built an electronic feedback radiation damping control unit to install in 6.7 T DNP polarizer. This piece of instrumentation is designed to provide complete control of the radiation damping field produced by the highly polarized sample. Once operational, this control unit will be used to reproduce the conditions of sustained maser oscillations in a controlled way and to perform experiments that aim to better access the above aspects of the DNP process. In parallel, numerical simulations were undertaken in order to investigate the details of the sustained maser behavior, in a situation

*Intervenant

where the Bloch equations may not describe adequately the dynamics of an ensemble of dipolar coupled nuclear spins.

Preliminary experimental (feedback unit) and simulation results will be presented .

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