Design study of triplet-resonance circuit to polarize ^{13}C spins utilizing dynamic nuclear polarization and cross polarization

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Techniques to polarize nuclear spins can be applied not only in the field of nuclear/particle physics for polarized targets but also in the field of chemistry and medicine. [1] In this decade, dynamic nuclear polarization (DNP) has attracted a lot of attention for analytical science. DNP is the method of transferring the electron spin polarization to nuclei using microwave irradiation. For example, polarized pyruvate is used for metabolic imaging.[1] The transition from pyruvate to alanine or lactate in the body can be imaged using magnetic resonance imaging (MRI) systems.

For the above-mentioned application, ^{13}C spins are useful. All organic molecules contain carbon. In addition, chemical shift difference (distinguishability of molecules in the spectrum) is larger than the ^{1}H spins and the spin-lattice relaxation time (T_1: shooting time) is also longer than ^{1}H. However, ^{1}H spins are ideal for DNP because of faster spin diffusion. The gyromagnetic ratio of a ^{1}H spin is 4 times larger than that of ^{13}C spin.

Our strategy involves the following. First, ^{1}H is polarized using DNP. Subsequently, the polarization is transferred from the ^{1}H spins to ^{13}C spins using a cross polarization (CP) technique. The CP is the polarization transfer sequence between heteronuclear spins using radio-frequency irradiation. In this report, we designed a resonator with a cylindrical cavity for DNP and a double-resonance LC-circuit for CP.

The cylindrical cavity was designed using on electromagnetic simulator (CST Microwave Studio). The frequency was 18 GHz, which resonated with electron spins at 0.65 T. Details of the double-resonance circuit are described in Ref. 2. The circuit is tuned for ^{1}H and ^{13}C spins with a frequency of 28 and 7 MHz, respectively. Both circuits are still under development.

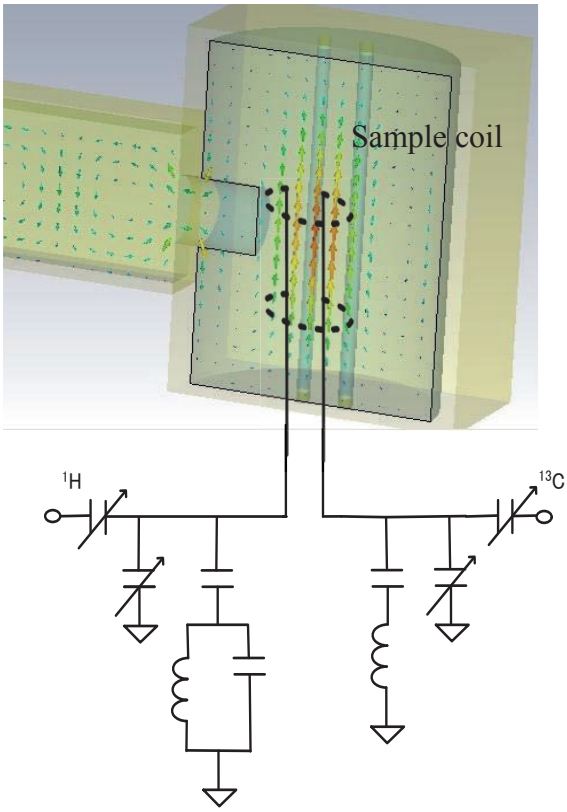

Fig. 1. Design of triplet-resonance resonator (e/^{1}H/^{13}C) to combine with DNP and CP. The coil for double-resonance LC-circuit is inserted in the cylindrical cavity. The resonance frequency is 18000/28/7 MHz, respectively.

Many polarized nuclei, such as ^{1}H, ^{2}H, ^{13}C, ^{15}N, ^{19}F and so on, are used for chemical and medical applications. To this end, our polarization transfer scheme is quite useful. Nuclear spins can be polarized by changing the double-resonance LC-circuit for CP.

References

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