CHAPTER B3

Basic Spin Properties and the Bloch Equations

INTRODUCTION

MR imaging can provide image contrasts between different tissues thanks to the four primary MR-related tissue parameters: spin density, T_1, T_2, and T_2^*. The signal in conventional MR imaging represents the spatial distribution of spin density for a given volume of interest with T_1, T_2, and T_2^* relaxation effects.

In MR imaging, spin density is the effective spin density, defined as a measure of the number of spins per unit volume combined with other constants, such as gyromagnetic ratio, absolute temperature, electronic gain, and magnetic field.

In reality, spins are not isolated; instead, they interact with each other and their environment. The interaction of the spins with their surroundings leads to important modifications in their behavior. The experimentally determined spin-lattice relaxation time, T_1, characterizes how quickly the longitudinal magnetization can grow back to its maximum value along the magnetic field direction. In contrast, T_2 and T_2^* are experimentally determined characteristic times describing the vanishing rate of the transverse magnetization. The T_2 decay of signal is time-dependent and cannot be recovered, whereas part of the time-independent T_2^* effect can be reversed by spin echo experiments.

The empirical Bloch equations model the change of magnetization in an external magnetic field including relaxation effects. The solutions of the Bloch equations are the key to the understanding of MR signal behavior.

UNIT B3.1 discusses the four primary sources of signal variation in a standard MRI sequence (spin density, T_1, T_2, and T_2^*) as well as the modification of the Bloch equations that govern the motion of the magnetization.

Hongyu An and Weili Lin

Contributed by Hongyu An and Weili Lin

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