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Relaxation-Based Color Magnetic Particle Imaging for Functional Imaging

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Magnetic Particle Imaging (MPI) images the spatial distribution and concentration of magnetic nanoparticles (MNPs) by detecting their response to time-varying magnetic fields in the kilohertz range [1]. Due to Brownian and Néel relaxation dynamics, MNP magnetization does not align instantaneously with the applied drive field, resulting in a delayed response. These relaxation mechanisms are sensitive to both the intrinsic properties of the MNPs and their local environment, including factors such as temperature and viscosity. This sensitivity is encoded in the MPI signal and forms the basis for "color MPI" techniques, equipping MPI with additional capabilities such as temperature mapping, viscosity mapping, detection of MNP binding states, and differentiation of MNP types [2-5]. Furthermore, the sensitivity of the MPI signal to these properties can be tuned by adjusting the drive field properties [6] or by applying additional magnetic fields [7-8]. The functional imaging capabilities of color MPI offer promising applications in disease diagnosis (e.g., cancer, atherosclerosis), temperature monitoring during magnetic hyperthermia therapy, and point-of-care diagnostics.

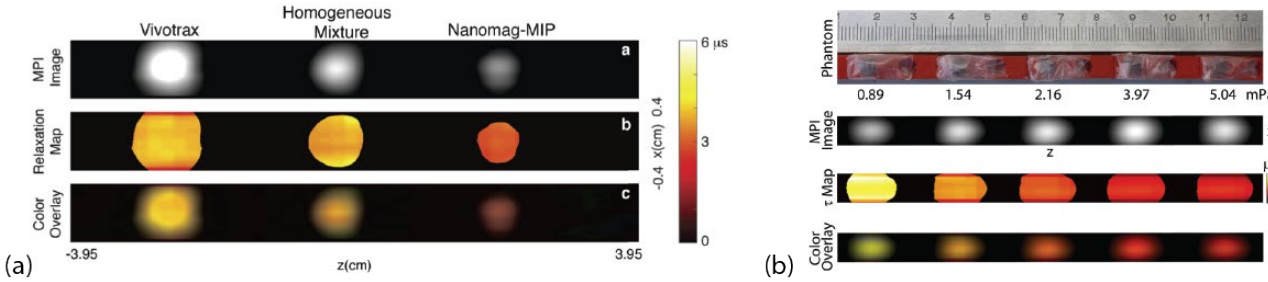

Fig. 1: Color MPI takes advantage of the differences in the magnetization and relaxation properties of MNPs, enabling a variety of functional imaging applications. The examples shown here are for (a) distinguishing different magnetic nanoparticle (MNP) and (b) viscosity mapping. Figures are from [4] and [5].

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