On a Ghost Artifact in Ultra-Low Field Magnetic Resonance Relaxation Imaging

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Abstract – Nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) are widely used techniques across numerous disciplines. While typically implemented at magnetic fields > 1 T, there has been continuous interest in the methods at much lower fields for reasons of cost, material contrast, or application. There have been numerous demonstrations of MR at much lower fields (from 1 μT to 1 mT), the so-called ultra-low-field (ULF) regime. Approaches to ULF MR have included superconducting quantum interference device (SQUID) sensor technology for ultra-sensitive detection and the use of pulsed pre-polarizing fields to enhance the signal strength. There are many advantages to working in the ULF regime. However, due to the low strength of the measurement field, acquisition of MRI at ULF is more susceptible to ambient fields that cause image distortions. Imaging artifacts can be caused by transients associated with non-ideal field switching and from remnant fields in magnetic shielding, among other causes. In this paper, we introduce a general theoretical framework that describes effects of non-ideal measurement field inversion/rotation due to presence of these transient fields. We illustrate imaging artifacts via simulated and experimental examples.

Keywords – Nuclear magnetic resonance, magnetic resonance imaging (MRI), ultra-low-magnetic-field (ULF), SQUID, sensor, pulsed pre-polarizing field, MRI imaging, imaging artifact, switching transient, remnant field, magnetic shielding