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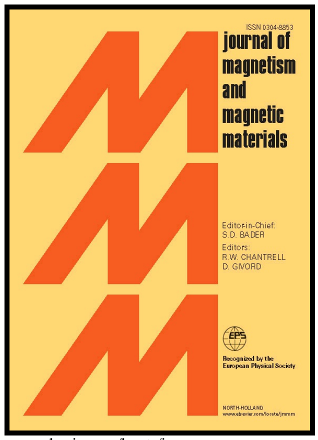

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Theoretical Predictions for Spatially-Focused Heating of Magnetic Nanoparticles Guided by Magnetic Particle Imaging Field Gradients

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Abstract

Magnetic nanoparticles in alternating magnetic fields (AMFs) transfer some of the field's energy to their surroundings in the form of heat, a property that has attracted significant attention for use in cancer treatment through hyperthermia and in developing magnetic drug carriers that can be actuated to release their cargo externally using magnetic fields. To date, most work in this field has focused on the use of AMFs that actuate heat release by nanoparticles over large regions, without the ability to select specific nanoparticle-loaded regions for heating while leaving other nanoparticle-loaded regions unaffected. In parallel, magnetic particle imaging (MPI) has emerged as a promising approach to image the distribution of magnetic nanoparticle tracers *in vivo*, with sub-millimeter spatial resolution. The underlying principle in MPI is the application of a selection magnetic field gradient, which defines a small region of low bias field, superimposed with an AMF (of lower frequency and amplitude than those normally used to actuate heating by the nanoparticles) to obtain a signal which is proportional to the concentration of particles in the region of low bias field. Here we extend previous models for estimating the energy dissipation rates of magnetic nanoparticles in uniform AMFs to provide theoretical predictions of how the selection magnetic field gradient used in MPI can be used to selectively actuate heating by magnetic nanoparticles in the low bias field region of the selection magnetic field gradient. Theoretical predictions are given for the spatial decay in energy dissipation rate under magnetic field gradients representative of those that can be achieved with current MPI technology. These results underscore the potential of combining MPI and higher amplitude/frequency actuation AMFs to achieve selective magnetic fluid hyperthermia (MFH) guided by MPI.