Preface

This volume gives an introduction into the novel imaging technique *magnetic particle imaging* (MPI), which was invented by Bernhard Gleich in 2001 at Philips Research, Hamburg. MPI allows to determine the spatial distribution of magnetic nanoparticles, which can be used as tracers for medical imaging. The method provides a unique combination of features, which makes it a promising method for several clinical applications. It provides high spatial and temporal resolution, high sensitivity and is inherently quantitative. In contrast to several clinically used imaging methods, MPI is free of ionizing radiation and is thus considered to be safe even under long-term considerations.

Since MPI was made public in 2005, several groups started research on MPI. As MPI is inherently a tracer-based method, since the beginning, the research foci lay on both the tracer material and the scanner instrumentation. Research groups in Dartmouth, Washington, Eindhoven, and Lübeck started to develop optimized nanoparticles for MPI and investigated particle physics. In the field of scanner instrumentation, the researchers at Philips continuously improved their scanner hardware and up-scaled the first small animal scanner with a bore diameter of 32 mm to a pre-clinical scanner with a bore diameter of 12 cm. Alternative MPI scanners targeting special applications, for instance, cell tracking and interventional MPI, were developed in Berkeley and Lübeck.

This book originates from a close collaboration between the MPI groups at Philips Research, Hamburg, and the University of Lübeck, which started in 2007 and resulted in several publications and patents. The book covers the most important developments of MPI from 2001 until 2010 and summarizes them in a unified notation. Recent developments initiated in 2011 are also sketched. The book is written for students and researchers with a background in biomedical engineering, medical engineering science, medical physics, medicine (radiology), mathematics, physics, and electrical engineering.

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They developed the first MPI scanners, and measured the first in vivo images, and we are glad that we had the opportunity to collaborate with them at these early steps. Several parts of this book are inspired by insights that have been obtained during our collaboration. Additionally, Jörn Borgert and Bernhard Gleich also contributed directly to this book. They contributed substantial parts of the sections about the focus field and hybrid MPI/MRI systems and to the chapter on medical applications of MPI.

From Philips Research we further thank Jürgen Rahmer for fruitful discussions about reconstruction algorithms and MPI in general. Last but not least, among the colleagues from Philips we thank our friend Michael Kuhn for continuously supporting the MPI activities at the University of Lübeck.

We thank our colleagues from the University of Lübeck Timo F. Sattel, Marlitt Erbe, Sven Biederer, Maren Bobek, and Kerstin Lüdtke-Buzug, who made our research group what it is today. This book could not have been written without the uncountable enlightening discussions we had since the group was initiated in 2007. All shown MPI simulation and reconstruction results have been computed with a software framework that was developed by Timo F. Sattel, Sven Biederer, and Tobias Knopp. The book section on single-sided MPI is based on publications, which were written under the auspices of Timo F. Sattel. Marlitt Erbe contributed several ideas to the section about field-free line imaging. We thank Henrik Rogge for the insights he gave us into the field of particle physics, which have influenced the section about relaxation effects. Furthermore, we thank our colleague Andreas Mang for various discussions about MPI and medical imaging in general, which often opened new perspectives for our research.

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