International Journal on Magnetic Particle Imaging
Vol 2, No 1, Article ID 1610000, 2 Pages

Infinite Science Publishing

Guest Editorial

From Magnetic Nanoparticle Spectroscopy to Imaging Methodology

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Received 05 October 2016; Published online 07 October 2016

Abstract

This first issue of the second volume of the novel International Journal on Magnetic Particle Imaging (IJMPI) mainly focuses on two topics, magnetic nanoparticle spectroscopy and magnetic imaging methodology. A high potential of improvement of magnetic particle imaging (MPI) with respect to its sensitivity is seen in the optimization of tailored nanoparticles. However, even commercial particle systems available today are not fully understood. Therefore, spectroscopic approaches to characterize the particles are in the center of interest of many research groups. The second focus of this issue is on imaging methodology. This splits up into instrumentation, where efficient coil concepts for focus-field based measurements are demonstrated, and reconstruction mathematics, where sparse sensing concepts are applied to MPI image calculation.

Within this article, the key ideas of first eight regular research articles published in the novel International Journal on Magnetic Particle Imaging (IJMPI) [1] will be summarized. In the very first research paper, Löwa et al. [2] underline in their article "Concentration Dependent MPI Tracer Performance" that a frequently used assumption for the image reconstruction process in MPI is the independence of the dynamic magnetization behavior of the actual nanoparticle concentration. However, they found in their study that Resovist (Bayer Health-Care, Germany) and its precursor Ferucarbotran do not behave in the expected way, when analyzed with magnetic particle spectroscopy (MPS). Instead, for Resovist they found a strong concentration dependence of the MPS signal, whereas for Ferucarbotran no concentration dependence of the dynamic magnetic behavior could be observed even though the initial concentration is two-fold higher. Therefore, calibration and reconstruction methods should incorporate the specific dynamic magnetic behavior that may alter at higher concentrations. In the contribution "Diffusion-Controlled Synthesis of Magnetic Nanoparticles" Heinke et al. [3] state that the future success of MPI relies on the development of MPI tracers with a high imaging performance. In their article, the authors focus on biogenic iron oxide nanoparticles manufactured through the application of biomimetic synthesis routes. They present a diffusion-controlled synthesis of magnetic nanoparticles, mimicking certain in-vitro aspects of biomineralization. Schmidt et al. [4] present a new type of MPS methodology. In their article "Imaging Characterization of MPI Tracers Employing Offset Measurements in a two Dimensional Magnetic Particle Spectrometer" they present a new method for the characterization of the imaging performance of MPI tracers. The approach is based on the example use of FeraSpin R (nanoPET GmbH, Berlin) and the application of measurement data from an MPS at different static magnetic field offsets in combination with virtual MPI measurements. The approach aims at predicting the potentially achievable image resolution for real MPI measurements. On an alternative route, Colombo et al. [5, 6] focus on the methodology of atomic magnetometry for the characterization of magnetic particles. In "M(H) Dependence and Size Distribution of SPIONs Measured by Atomic Magnetometry" they demonstrate how a quasistatic recording of the magnetic excitation function of superparamagnetic iron oxide nanoparticle suspensions by an atomic magnetometer allows for a precise determination of the iron mass content as well as the particle size distribution. In their contribution "MPS and ACS with an Atomic Magnetometer", they go into detail and explain how a single atomic magnetometer in a magnetically unshielded environment can be used to perform MPS and AC susceptometry on liquid-suspended magnetic nanoparticles. A further approach to learn more about particle characteristics is presented by Vilter et al. [7] in "Numerical Simulations of 3D Rotational Drift". In their approach the rotational drift spectroscopy aims at detecting the properties of magnetic particles in liquid suspensions. It is based on the motional behavior of the particles inside an external rotating magnetic field. The behavior of particles with and without motional restriction is studied in numerical simulation. It is demonstrated that the particles either follow the external field with a locked phase lag or exhibit a rotational drift.

In addition to the articles that are rather focused on particle characteristics, two articles with respect to imaging methodology were published in this very issue. Mrongowius et al. [8] present in their "Studies on the Optimization of Efficient Selection and Focus Field Coil Configurations" a further improvement of a power efficient generation of magnetic fields for MPI. Due to technical and medical limitations, the FOV that can be covered in MPI is very limited. However, the authors demonstrate in their article that by combining the features of a classical Maxwell coil setup and a single-sided coil arrangement it is possible to overcome the technical limitations caused by the electrical power loss and thus to enlarge the FOV. Finally, in this issue, Maass et al. [9] report on the "Optimized Compression of MPI System Matrices Using a Symmetry-Preserving Secondary Orthogonal Transform". The authors studied the compression of the MPI system matrix. They proposed a new method to obtain better transforms for compressed sensing that retain the required symmetry properties.

References

[1] T. Knopp. Launching the new journal on magnetic particle imaging. *International Journal on Magnetic Particle Imaging*, 1(1):1510001, 2015. doi:10.18416/ijmpi.2015.1510001.

[2] N. Löwa, P. Radon, O. Kosch, and F. Wiekhorst. Concentration dependent mpi tracer performance. *International Journal on Magnetic Particle Imaging*, 2(1):1601001, 2016. doi:10.18416/ijmpi.2016.1601001.

[3] D. Heinke, N. Gehrke, D. Schmidt, U. Steinhoff, T. Viereck, H. Remmer, F. Ludwig, M. Pósfai, and A. Briel. Diffusion-controlled synthesis of magnetic nanoparticles. *International Journal on Magnetic Particle Imaging*, 2(1):1603001, 2016. doi:10.18416/ijmpi.2016.1603001.

[4] D. Schmidt, M. Graeser, A. von Gladiss, T. M. Buzug, and U. Steinhoff. Imaging characterization of mpi tracers employing offset measurements in a two dimensional magnetic particle spectrometer. *International Journal on Magnetic Particle Imaging*, 2(1):1604002, 2016. doi:10.18416/ijmpi.2016.1604002.

[5] S. Colombo, V. Lebedev, Z. Grujic, V. Dolgovskiy, and A. Weis. M(h) dependence and size distribution of spions measured by atomic magnetometry. *International Journal on Magnetic Particle Imaging*, 2(1):1604001, 2016. doi:10.18416/ijmpi.2016.1604001.

[6] S. Colombo, V. Lebedev, Z. D. Grujic, V. Dolgovskiy, and A. Weis. Mps and acs with an atomic magnetometer. *International Journal on Magnetic Particle Imaging*, 2(1):1606002, 2016. doi:10.18416/ijmpi.2016.1606002.

[7] A. Vilter, M. A. Rückert, T. Kampf, V. J. F. Sturm, and V. C. Behr. Numerical simulations of 3d rotational drift. *International Journal on Magnetic Particle Imaging*, 2(1):1607001, 2016. doi:10.18416/ijmpi.2016.1607001.

[8] J. Mrongowius, C. Kaethner, and T. M. Buzug. Studies on the optimization of efficient selection and focus field coil configurations. *International Journal on Magnetic Particle Imaging*, 2(1):1606001, 2016. doi:10.18416/ijmpi.2016.1606001.

[9] M. Maas, K. Bente, M. Ahlborg, H. Medimagh, H. Phan, T. M. Buzug, and A. Mertins. Optimized compression of mpi system matrices using a symmetry-preserving secondary orthogonal transform. *International Journal on Magnetic Particle Imaging*, 2(1):1607002, 2016. doi:10.18416/ijmpi.2016.1607002.

10.18416/ijmpi.2016.1610000