**Magnetic Guiding with Permanent Magnets**

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**Abstract:**

A new concept of using permanent magnet systems for guiding superparamagnetic nano-particles (SPP) or macroscopic ferromagnetic objects on arbitrary trajectories over a large volume is presented [1]. The same instrument can also be used for magnetic resonance imaging (MRI) using the inherent contrast of the SPP [2].

The basic idea is to use one magnet system, which provides a strong, homogeneous, dipolar magnetic field to magnetize and orient the particles, and a second constantly graded, quadrupolar field, superimposed on the first, to generate a force on the oriented particles. As a result, particles are guided with constant force and in a single direction over the entire volume.

Prototypes of various sizes were constructed to demonstrate the principle in two dimensions on various nanoparticles which were guided over centimeters [2] or under mircoscopes [3]. The latter also allowed controlled movements of cells with incorporated SPPs. Furthermore, a more advanced system with two quadrupoles is presented which allows canceling the force, hence stopping the SPP and moving them around sharp edges. This system also allows for MRI and some first experiments are presented.

This concept was also combined with liquid crystalline elastomers with incorporated SPP to create “micro-robots” whose coarse maneuvers are performed by a permanent magnet-system while there microscopic actuation is controlled either by light or temperature [4].

1. P. Blümler, Cells **10** (2021) 2708 doi: 10.3390/cells10102708

2. O. Baun, P. Blümler, J. Magn. Magn. Mater. **439** (2017) 294-304. doi: 10.1016/j.jmmm.2017.05.001

3. P. Blümler et al. Nanotechnology, Science and Applications **14** (2021) 91-100. doi: 10.2147/NSA.S298003

4. D. Ditter, et al. Adv. Functional Mater. 1902454 (2019) doi: 10.1002/adfm.201902454

**Biography of presenting author**

Dr. Peter Blümler studied chemistry and medicine at the University of Mainz, Germany. He completed his Ph.D. in 1993 with Prof. Spiess at the MPI for Polymer Research. After one year of postdoctoral studies at IBM Almaden in San Jose, USA, he joined Prof. B. Blümich at the RWTH Aachen. In 1999 he was appointed senior lecturer of physics at the University of Kent at Canterbury, UK. In 2001 he rejoined the group of Prof. Spiess and in 2004 he was headhunted by Prof. Ulrich Schurr, Research Center in Jülich. Since 2009 he is a senior scientist at the institute of physics at the University of Mainz. He has published more than 100 research articles and 12 patents.

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