MA 27: PhD Focus Session: Biogenic spin phenomena (joint session MA/AKjDPG)

Time: Wednesday 9:30–12:40 Location: H38

5 min opening remarks

Invited Talk MA 27.1 Wed 9:35 H38

Magnetism in biomedicine: basics and applications — •Kannan Krishnan — Departments of Materials Science & Physics, University of Washington, Seattle, WA 98195, USA

Recent developments in synthesis and optimization of magnetite nanoparticles allows for reproducible control of their complex magnetic relaxation behavior even in *extreme* biological environments. This has enabled us to address two of the principal challenges in biomedicine, i.e. detecting disease at the earliest possible time prior to its ability to cause damage (imaging and diagnostics) and delivering treatment at the right place, at the right time whilst minimizing exposure (targeted therapy with a triggered release). Currently, our work is focused on Magnetic Particle Imaging (MPI), a tracer-based, whole-body imaging technology with high contrast (no tissue background) and nanogram sensitivity. MPI is linearly quantitative with tracer concentration, and has zero tissue depth attenuation; it is also safe and uses no ionizing radiation.

In this talk, I will introduce the underlying physics of MPI, and describe results in the development of highly optimized and functionalized nanoparticle tracers for MPI. I will then present state-of-the-art imaging results of preclinical in vivo MPI experiments of cardiovascular (blood-pool) imaging, stroke, GI bleeding, and cancer, all using rodent models. If time permits, I will introduce diagnostic and therapeutic applications of magnetic nanoparticles. Finally, this talk will highlight conceptual ideas that help bridge the gap for physical scientists interested in working on translational problems in biomedicine.

Invited Talk MA 27.2 Wed 10:15 H38

Spin-dynamics of a magnetic nanoparticle chain. — •Michael Winklhofer — Carl von Ossietzky Universitaet Oldenburg, Germany

Magnetic nanoparticle chains occur in nature as magnetosomes in magnetotactic bacteria. A typical magnetosome chain consists of 10-20 magnetite particles (Fe3O4, 35 - 60 nm particle size), whose individual magnetic dipolar moments add up to produce a stable intracellular compass needle that keeps the cell body of the bacterium aligned with the Earth' s magnetic field. The potential of magnetosomes isolated from bacteria for biomedical applications (magnetic hyperthermia and MRI) is due to the relatively large magnetic moment per particle (magnetic single-domains) and the biological membrane that surrounds each particle, thereby preventing phase separation and allowing for functionalization. Since the particles magnetically interact through dipolar coupling only, a magnetosome chain exhibits intriguing spin-wave dynamics. As will be shown here, both experimentally and theoretically, magnonic features such as band gaps depend on the geometric structure of the chain. Magnetic bacteria therefore have promising structures for applications in magnonics at the nanoscale.

Discussion (10:45 - 11:00)

Coffee Break (11:00 - 11:15)

Invited Talk MA 27.3 Wed 11:15 H38

Magnetic materials for biodetection — •Galina V. Kurlyandskaya[1,2] and Alexander P. Safronov[2] — [1]Departamento de Electricidad y Electrónica and BCMaterials, Universidad del País Vasco UPV-EHU, 48080 Bilbao, Spain — [2]Institute of Natural Sciences and Mathematics, Ural Federal University, Ekaterinburg 620002, Russia

Magnetic materials are at the leading edge of the rapidly growing field of biomedical applications. This work summarises recent developments of our groups in the area of magnetic nanomaterials potentially applicable in biomedicine. The main focus of the discussion is the magnetic biodetection. Magnetic biosensor is a compact analytical device incorporating a biological or biologically derived sensitive element, integrated in the physicochemical transducer employing a magnetic field and magnetic materials. Although existing devices allow a quantified evaluation of small changes in the magnetic susceptibility in the living system, or in magnetic field values created by the extracellular electric currents, there is a need to improve their sensitivity and specificity and further develop their design up to miniaturized analytical systems. Fabrication and characterization techniques for following magnetic nanomaterials used in biosensing devices will be discussed and examples of particular detection given: iron oxide nanoparticles obtained by electrophysical techniques and water-based ferrofluids and ferrogels on their basis, amorphous ribbons and thin film multilayered structures with high giant magnetoimpedance responses. This work was supported by the RSF grant 18-19-00090.

Invited Talk MA 27.4 Wed 11:35 H38

From synthetic to biological magnetic microswimmers — •Damien Faivre — Aix Marseille Univ, CEA, CNRS, BIAM, 13108 Saint Paul-Lez-Durance, France — MPI Colloids and Interfaces, 14424 Potsdam, Germany

Microswimmers have numerous applications varying from environmental remediation to medical work. One of the most promising design encompasses the use of magnetic components to obtain sustainable propulsion mechanisms and external controllability. These components can be of biological or synthetic origin. In my group, we have worked with both type: with magnetotactic bacteria on the one hand and with synthetic aggregate of random shape on the other hand. The bacteria typically form magnetic chain inside their body but are motile by means of rotation of their flagellar apparatus. I will show how these bacteria use their chain to orient. I will also show how given bacteria can reach unprecedented speed by a surprising mechanism. In turn, synthetic swimmers are typically inspired from bacterial flagella and therefore are formed via complicated and expensive route to obtained helical shapes. In my group, we went another line and studied random-shape microswimmers. I will show how these shapes can be chosen to obtain swimming behaviors barely possible otherwise, and how studying such microswimmers permit a better understanding of how shape and magnetic properties influence swimming.

Discussion (11:55 - 12:10)

Panel discussion Moderated by Michael Farle (U Duisburg-Essen) (12:10 - 12:40)