Simulation of GMR in Granular C/Co Nanoparticles in Agarose

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Abstract

As the importance of nanoparticles is growing more and more, controlling and understanding the properties of nanoparticles became a focus of research. In this field Meyer at al. [1] are researching the GMR effect in granular gels to develop magnetoresistive sensors. The GMR in granular gels is simulated to investigate the physical processes in those systems. As soon as the models coincide with experimental results it will be possible to predict the behavior of the gels and improve on sensor design.

For the simulation it is assumed, that the GMR origins from changes in the electric conductivity of the C/Co nanoparticles. It is also assumed, that all effects contributing to the GMR are describable as an effective electrical resistivity.

COMSOL Multiphysics® is used to implement the simulation. To realize a 3D model with a huge amount of nanoparticles (represented by steady geometry spheres), the COMSOL Multiphysics® API to Java is used. By programming Java it is possible to automatize the building of the geometry, which may persist of a few hundred of nanoparticles. In contrast to build this in the COMSOL Multiphysics® interface, a lot of time is saved and the model may be changed flexibly. The nanoparticles are for reasons of simplicity all of the same size and are aligned in linear chains, but it is also possible to variegate the size distribution and space distribution of the particles. The resistance and electric flux are modeled and calculated by the "Electric currents" module with a stationary solver. Furthermore a parametric sweep calculates the performance of the system for different applied magnetic fields and the field's influence on the resistance of the gel. To this point there are no studies on the effective resistance of single nanoparticles and therefore, the parameters for the simulation are chosen to match experimental results for macroscopic studies.

First results show, that the current is dependent on the effective resistivity of the particles and the models could be used to simulate general GMR effects found by Meyer et al. [1]. Furthermore, a Java class was created to automatically build arbitrary size and space distribution of particles.

Reference

[1] Meyer, J., Rempel, T., Schäfers, M., Wittbracht, F., Müller, C., Patel, A. V., & Hütten, A. (2013). Giant magnetoresistance effects in gel-like matrices. Smart Materials and Structures, 22(2), 025032.

Figures used in the abstract

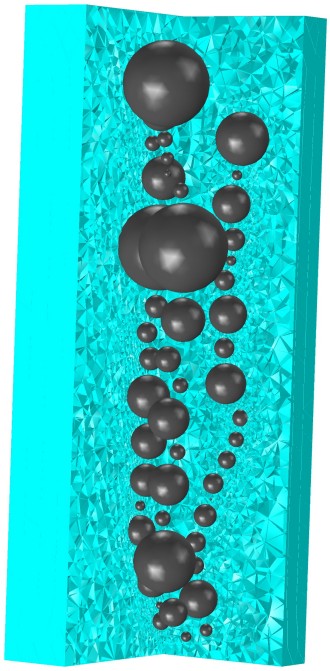

Figure 1: Example geometry with randomly genrated particle chains

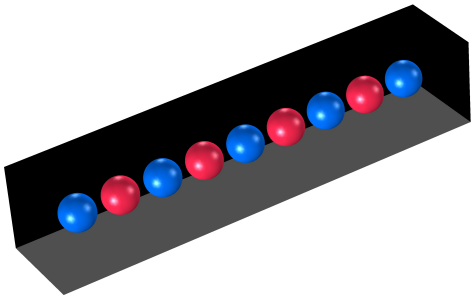

Figure 2: Conductivity of a chain of particles with antiparallel magnetisation

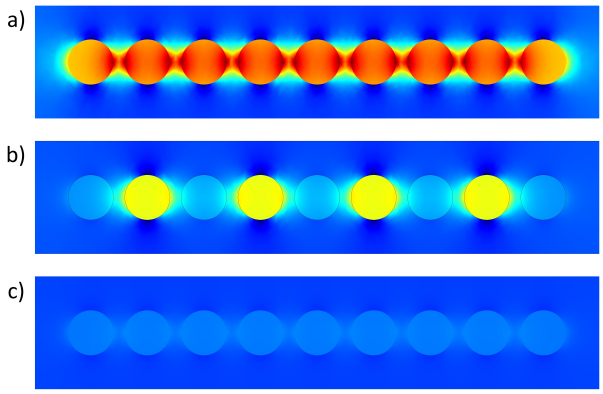

Figure 3: Comparision of the electric currents of spin polarised flow, where a)particle magnetisations and electron spins are parallel b)particle magnetisations and electron spins are alternating between parallel or antiparallel orientation c)particle magnetisations and electron spins are antiparallel