Simulation of magnetoviscous effect in a ferromagnetic colloid

Dmitry Zablotsky[1,2], Elmars Blums[2], Hans Jürgen Herrmann[1]

[1]Computational Physics for Engineering Materials, IfB, ETH Zurich, Schafmattstrasse 6, CH-8093 Zurich, Switzerland

[2] Institute of Physics, University of Latvia, 32 Miera iela, Salaspils, LV-2169 Latvia

e-mail: dmitrijs.zablockis@gmail.com

The emerging applications of ferromagnetic colloids in biomedicine - in magnetic drug targeting, magnetic hyperthermia or imaging - require the understanding of the rheology of these materials in the conditions of the simultaneous influence of shear flow and magnetic field. It is known from previous studies that the ferrocolloids show strong magnetoviscous effect – the dependence of their viscosity on the magnetic field. The presence of relatively minor amount of magnetic nanoparticles can lead to a dramatic increase of shear viscosity by up to several orders of magnitude [1-3].

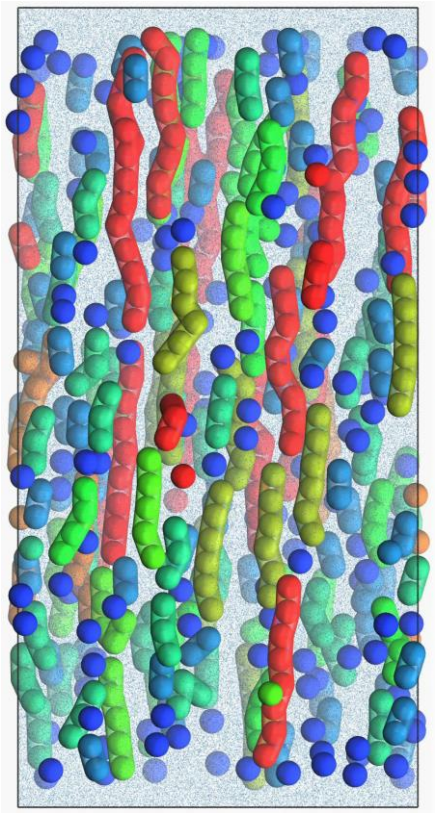

Fig.1 Simulation snapshot: structure of the ferrocolloid under shear and vertical magnetic field. Particles colored by cluster size.

We will present the results of numerical simulations of the structure and rheology of ferromagnetic colloids in the presence of magnetic field. Using molecular dynamics and stochastic rotation dynamics we observe the assembly of suspended magnetic nanoparticles in linear chains (Fig. 1) due to strong dipole-dipole interaction and the eventual destruction of chains under shear flow. We determine the shear viscosity of the colloid, which shows significant shear thinning owing to the change of internal structure. Finally, we will present a quantitative comparison of our results with theoretical models and some of the experimental data published by different groups over the previous years.

References

1. J. Nowak et al., JMMM 354, 98 (2014)
2. M. T. Lopez-Lopez et al., Langmuir 28, 6232 (2012)
3. D. I. Santiago-Quinonez et al., Soft Matter 8, 5327 (2012)