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Quantification of the effect of dipole-dipole interaction on non-linear magnetic response of structurally different aggregates of magnetosomes

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Due to its large core size and high quality of the crystal structure magnetosomes, nat-urally formed by magnetotactic bacteria, here Magnetospirillum gryphiswaldense, rep-resent a very promising class of magnetic nanoparticles (MNP) for MPI and MPS (magnetic particle imaging / spectroscopy) and magnetic hyperthermia. Aggregation of these large MNP may alter the dynamic magnetic response and thus MPI and hy-perthermia effect considerably.
In this study we immobilized 3 samples of magnetosomes, MS1, MS2, MS3 with mean core size of 19 nm, 29 nm, 38 nm, respectively, in polyacryl amide (PAam) and gelatine matrix. While MS1 and MS2 show no aggregation in PAam, moderate clus-ters of about 20 MNP develop in gelatine.
The non-linear magnetic response of modelled random aggregates (RA) and diffusion limited colloidal aggregates (DLCA, interaction considered) was calculated by inte-gration of the Landau-Lifshitz-Gilbert (LLG) equation applying the determined struc-ture of MS1-3. While DCLA describes the MPS-data quite well, the RA-clusters match better the structure of MS2 in gelatine, represented by PDDF (Figure). The calculated intrinsic loss power (ILP) of hyperthermia for DLCA is two times higher than for RA, showing that the magnetic response of even isotropic aggregates of the same size can differ substantially depending on the inner structure. For chains we calculated about one order of magnitude higher ILP.

Aggregates of MNP with large moments show a wide variety of non-linear magnetic responses which can be explained by modelling of clusters applying carefully deter-mined structure parameters quantitatively.

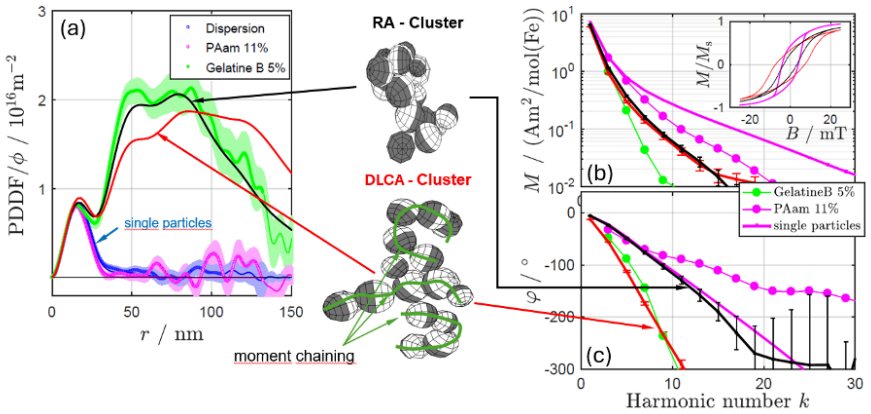

Figure: Pair distance distribution functions (PDDF, ϕ-vol. frac.) derived from SAXS-data (a), amplitude and dyn. hysteresis (b) and phase (c) of MPS measured (symbols) and calculated (lines) for modelled clusters of magnetosomes with mean core diameter of 29 nm.

Figure 1: Pair distance distribution functions (PDDF, ⊠-vol. frac.) derived from SAXS-data (a), amplitude and dyn. hysteresis (b) and phase (c) of MPS measured (symbols) and calculated (lines) for modelled clusters of magnetosomes with mean core diameter of 29 nm.

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