Dynamics of ellipsoidal particles in colloidal suspension

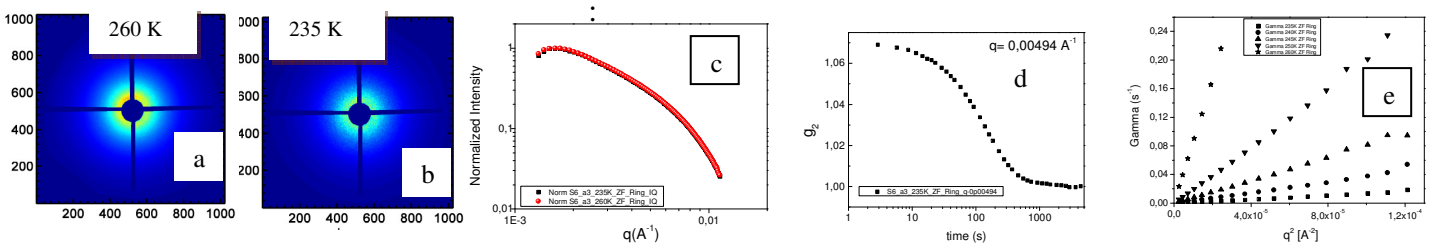
Proposal HD-430

The slow dynamics of glass forming systems close to the glass transition results in different relaxation mechanisms [1]. X-Ray photon correlation spectroscopy (XPCS) is a well established technique [2,3] to investigate the dynamics of concentrated suspensions in the supercooled state, moreover this technique allows to probe the "high q" regime, which is not achievable by light scattering techniques.
Anisotropic hematite particles are of special relevance due to their properties to align perpendicularly to a magnetic field. This alignment under magnetic field leads then to the quench of one degree of motion.

<u>Results of previous own work:</u> (Beamtime ID 10, March 2010, HD 430)

In our experiment, the dynamics of the particles is slowed down by decreasing the temperature close to the glassy state. XPCS allows us to extract the dynamic structure factor of the system ($f(q,t) \propto \sqrt{g_2 - 1}$);
intensity correlation function: $g_2 - 1 \propto (contrast) \times e^{-(\Gamma \times t)^{\beta}}$)

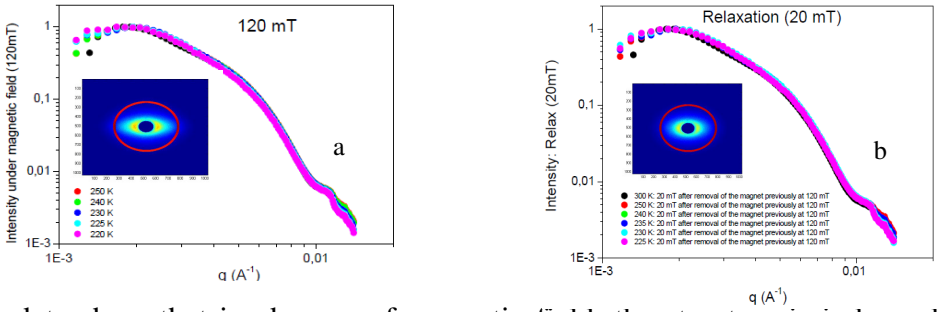
<u>Zero Field measurements</u>:



The static properties are independent on the temperatures whereas the dynamic heterogeneities increase strongly when decreasing the temperature. In the highest range of temperature investigated, the dynamics is diffusive ($\Gamma \alpha q^2$, fig 1.e)

1. <u>Measurements under magnetic field (sample chamber [4])</u>

The structural state (static data) is independent of the temperature provided the samples have the same "magnetic history".
Figure 1 shows measurements at different temperature. The measurements under a magnetic field B=120 mT are followed by a relaxation (corresponding to a B=20mT). We proceed as follows: the temperature is cooled down from the room temperature under a magnetic field of 120 mT until reaching the chosen temperature. The sample is then let to equilibrate and measured (Fig. 1a). After the measurement at 120 mT, the magnet is set at 20 mT, the sample is let to equilibrate again and the measurement is performed (Fig. 1b).



The statics data show that in absence of magnetic field, the structure is independent of the temperature (a).When a field is applied, the particles align perpendicular to the magnetic field and a further decrease in

temperature does lead to a more oriented structured system (b). When the magnet is released (residual field: B=20 mT [4]) the particles remain oriented. The magnetic susceptibility of the hematite particle is large enough to keep the particles oriented after releasing the magnet (B_residual: 20 mT), the particles relax but never reach their „zero field state“.

2. Comparison “Magnetic field” vs “Zero field”:

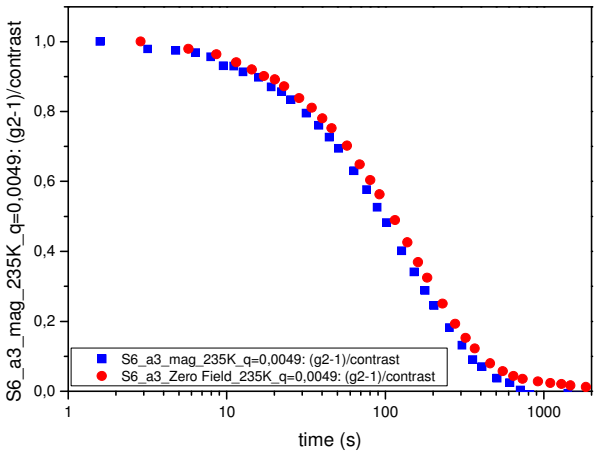


Fig 3: Comparison of the correlation functions at 235K: in zero field and under a magnetic field B=120 mT

The magnetic field increase the diffusion of the particles. The correlation function measured under B=120 mT (Figure 3; blue square) and without magnetic field (red dots) shows that the relaxation time under B is faster that when no magnetic field is applied.

Conclusion:

During this beamtime we have measured colloidal suspensions of anisotropic particles of different aspect ratio. While the static properties are independent of the temperatures, the dynamic heterogeneities increase drastically when decreasing temperature.

Related references:

[1] M.D. Edinger, C.A. Angell, and S.R. Nagel, J. Phys. Chem. **100**, 13 200 (1996)
[2] D. Riese, W. Vos, G. Wegdam, F.Poelwijk, D. Abernathy, G. Grübel, Phys. Rev. E 61, 2 (2000)
[3] G. Grübel, D. Abernathy, D. Riese, W. Vos, G. Wegdam, J. Appl. Cryst., 33, 1 (2000)
[4] R. Steinmann, Y. Chuskin, C. Caronna, J. Chanvanne, A. Madsen, Rev. Sci. Inst 82, 025109 (2011)